Toxics Use Reduction Institute

SUMMARY OF POLICY ANALYSIS

Higher Hazard Substance Designation Recommendation:
Cadmium (CAS # 7440-43-9) and Cadmium compounds

1. State of the Science

Cadmium and its compounds are confirmed human carcinogens and potential reproductive hazards.

2. Number of facilities affected

We estimate that the 1,000 pound reporting threshold that would apply to a higher hazard substance would add approximately 30 new facilities to the existing 3 facilities that are required to report use of cadmium and cadmium compounds. These new facilities are expected to be found primarily in SIC codes related to production of colorants, resins and plastics. Other SIC codes are expected to be minimally affected.

3. Opportunities for New Filers

Use of cadmium and cadmium compounds among TURA filers has decreased significantly over the life of the program. The significant reduction in use of cadmium and cadmium compounds by current TURA filers indicates that toxics use reduction options may be available for many applications, and that Massachusetts companies are taking advantage of those opportunities.

Information is available on cadmium alternatives for soldering, plating, and stabilizers and pigments used in plastics. Of these, the principal application in which cadmium is still being used is in pigments used in plastics. A variety of alternatives are available for cadmium in pigments. For example, researchers have developed inorganic pigments that provide colors similar to those achieved with cadmium, and offer comparable stability.

4. Regulatory context

Due to its serious adverse effects on human health and the environment, cadmium is subject to multiple regulations at the state, federal, and international levels. It is a reportable Toxics Release Inventory (TRI) chemical, is listed as a hazardous air pollutant under the Clean Air Act, and is regulated by OSHA standards in the workplace as a carcinogen, among other provisions. California regulates cadmium and its compounds as carcinogens and male developmental toxicants under Proposition 65. In Europe, use of cadmium and its compounds is prohibited for many uses, including stabilizing, plating, and coloring applications.

5. Implications for the TURA program

The TURA program has experience providing services to facilities and industry sectors that are likely to be using cadmium and its compounds. The 1,000 pound reporting threshold would make it possible to identify and extend program services to a wider range of cadmium users. In addition, designating cadmium and cadmium compounds as higher hazard substances would allow the program to determine

the extent to which cadmium is still being used in the Commonwealth. This information, in turn, could help to inform program activities to help users to identify alternatives and toxics use reduction opportunities.

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Higher Hazard Substance Designation Recommendation:
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The TURA Science Advisory Board (SAB) has recommended designating cadmium compounds as a higher hazard substance under TURA. The SAB also recommended that the Toxics Use Reduction Institute consider both cadmium and cadmium compounds in its policy analysis. Thus, the following analysis considers both cadmium and cadmium compounds.

If they are designated as higher hazard substances, the reporting threshold for cadmium and its compounds would be lowered to 1,000 lbs/year for companies in TURA-covered sectors with ten or more employees. New companies 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 cadmium in allocating program resources, ensuring that companies receive targeted assistance 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 both cadmium and cadmium compounds be designated as higher hazard substances.

1. State of the Science[1]

Acute Health Effects[2]

- Acute inhalation of cadmium may harm the lungs, causing bronchial and pulmonary irritation. Even one acute exposure at a high concentration can result in long-term impairment of lung function. Acute inhalation of cadmium can also cause nausea, vomiting, and diarrhea. At high concentrations, cadmium is immediately dangerous to life and health.

Chronic Health Effects[3]

- The International Agency for Research on Cancer (IARC) classifies cadmium and cadmium compounds in Group 1 (carcinogenic to humans).
- Cadmium is a potential reproductive and developmental toxicant. In animal studies chronic exposure to cadmium caused low fetal weight and skeletal malformations, and impaired neurological development.
- Inhalation and oral exposure may permanently damage the kidney.

Uncertainty

- The adverse effects of cadmium and its compounds are well understood. Thus, uncertainty does not play a significant role in our policy analysis for these substances.

2. Number of facilities affected

Cadmium is used in a range of industrial processes and consumer products.

- Historically, cadmium has been used in batteries, pigments, metal coatings, plastics, and some metal alloys.[4]
- Cadmium is used in low melting point and brazing alloys with bismuth, lead and tin. Cadmium-containing alloys are used as bearings, solders and copper hardeners in fire detection devices, high-speed machinery, automotive components and nuclear reactor control rods.
- In addition, silver containing cadmium oxide is used as an electrical contact in switches, relays and circuit breakers.[5]
- Historically, cadmium-based stabilizers were used extensively in flexible polyvinyl chloride.
- In plastics formulations, cadmium-based pigments provide brilliant colors in the yellow, orange, and red ranges and do not degrade from exposure to light.

Increasingly, manufacturers of pigments, coating and plating products, plastics, and metal alloys are turning to safer alternatives to reduce costs and comply with regulations.[6]

Historically, Cadmium Compounds have been reported to the TURA program by the following sectors:

3081	Unsupported plastics film and sheet
3087	Custom compound purchased resins
3341	Secondary nonferrous metals
3357	Nonferrous wire drawing and insulating
3714	Motor vehicle parts and accessories
3822	Environmental controls

Currently, only two companies file for cadmium compounds and one plating shop files for cadmium. The MassDEP Hazardous Air Pollutant list and TIER II show no additional users.

Based on input from OTA and industry, 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	7
3089	Plastics products, not elsewhere classified	15
3316	Cold-Rolled Steel Sheet, Strip, and Bars	1
3341	Secondary nonferrous metals	1
3357	Nonferrous wire drawing and insulating	1
3451 &	Screw machine products; Bolts, nuts,	1

3452	screws, rivets & washers	
3643	Current-Carrying Wiring Devices	2
3471	Plating and Polishing	2

In the resins, pigments and plastics sectors, we have estimated that a small percentage of the many Massachusetts companies in that industry use cadmium compounds in colorants over the 1000 pound threshold, resulting in approximately 21 new filers. An industry contact familiar with the plating industry states that some plating shops are using cadmium compounds, but most would be using them under 1,000 pounds. The Harris Selectory shows 77 platers with more than 10 employees in Massachusetts. However, it is likely only a few of these platers use cadmium compounds above 1,000 lbs/year. Other estimates in the table above are based on the use of cadmium in niche applications in those industries.

Thus, we estimate approximately 30 potential new cadmium compound filers, primarily in SIC 3089 (Plastic Products) and SIC 3087 (Custom Compounded & Plastic Resins). Other SIC codes are expected to be minimally affected.

3. Opportunities for New Filers

a. Trends among current filers

Cadmium use among TURA filers has decreased dramatically over the life of the program. In 1990, five companies reported use of a total of 560,292 pounds of cadmium. By 2004, only one company, New Method Plating, was reporting use of 25,058 pounds of cadmium. Firms reported on-site releases of 689 pounds of cadmium in 1990; this dropped to 3 pounds per year in 1994, and to zero in 2003 and 2004.

Table 1. Massachusetts Cadmium Data: Used and Released in 1990 and 2004

Data -- MA TURA	Year		Change in pounds	% Change
	1990	2004		
Cadmium used (pounds)	560,292	25,058	-535,234	-96%
Cadmium released (pounds)	689	0	-689	-100%

Use of **cadmium compounds** has also decreased. In 1990, a total of 4 firms reported use of cadmium compounds. In 2004, just two firms reported use of cadmium compounds. A number of other firms reported use of cadmium compounds in some of the intervening years. In 1990, TURA filers reported 298,589 pounds of cadmium compounds used. By 2004, this figure had dropped to 172,435 pounds, a 42% decrease.

Table 2. Massachusetts Cadmium Compounds Data: Used and Released in 1990 and 2004				
	Year		Change (lbs)	% Change
	1990	2004		
Cadmium Compounds used (lbs)	298,589	172,435	126,154	42%
Cadmium Compounds released (lbs)	551	10	541	98%

b. Availability of alternatives

The significant reduction in use of cadmium and cadmium compounds by current TURA filers indicates that toxics use reduction options are available for many applications, and that Massachusetts companies are taking advantage of those opportunities.

Substantial information is available on cadmium alternatives for soldering, plating, and stabilizers and pigments used in plastics. Of these, the principal application that continues to be relevant for potential filers within Massachusetts is pigments used in plastics.

In this section, we review information on cadmium alternatives for plating and pigments used in plastics. We do not discuss alternatives in soldering and in stabilizers for plastics, because cadmium has largely been replaced in these applications and is thus no longer a concern.

i. Plating

For metal plating applications, options include:

- Redesign the production process to eliminate the need for the coating.
- Use a metal deposition technology that does not require a plating bath (e.g. vapor-deposited aluminum).
- If these alternatives are not viable due to required surface characteristics or cost, zinc-based alloys (e.g. zinc-nickel or zinc-cobalt) in acid or alkaline baths offer alternatives in a variety of applications.

The ability to replace a cadmium coating with a zinc-based alloy depends on the specific characteristics required.

Metallic-ceramic coatings, using zinc, aluminum, or alloys of these metals, possess the corrosion resistance characteristic of cadmium without the same environmental issues, although often at a higher cost. Metallic-ceramic coatings have successfully replaced cadmium in more expensive military applications, including landing gear axles of modern aircraft, gas-turbine-engine compressor sections, and allied parts.[7] Replacing cadmium for plating of fasteners in military and aerospace applications may pose difficulties due to the unique requirements of those applications. Aluminum-molybdenum coatings have been investigated as a possible alternative to cadmium in applications with specialized requirements, such as aerospace applications.[8]

ii. Pigments in plastic products

A variety of alternatives are available for cadmium in pigments. Some alternatives also pose significant health and environmental hazards, while others are superior from a health and environmental perspective. Alternatives include inorganic pigments based on acid solutions of synthetic oxonitrides[9]; iron oxide pigments[10]; bismuth vanadate pigments[11]; organic/inorganic pigment blends using titanium dioxide, mixed metal oxide titanites, and/or iron oxide; rutile tin zinc compounds; and others.[12] As early as the beginning of the 1990s, many firms found that they were able to replace cadmium 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-free colorants. [13]

iii. Implementation: Opportunities and challenges

Historically, facilities have sometimes been confused about how to report metals and metal compounds. 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 cadmium and cadmium compounds for reporting purposes.

4. Regulatory context

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

EPCRA	• Reportable under TRI[14] • Subject to Tier II reporting requirements
CAA	• Hazardous air pollutant
RCRA	• Hazardous constituent; "Cadmium is a hazardous waste under the Resource Conservation and Recovery Act (RCRA) under several circumstances."[15]
Occupational exposures	• The OSHA permissible exposure limit (PEL) for airborne exposure to cadmium for an eight-hour work shift is 5 $\mu g/m^3$. For certain applications, the PEL is higher, reflecting the different challenges and costs of reducing cadmium exposures across manufacturing processes.[16] • OSHA includes cadmium on its list of known human carcinogens[15] • "The National Institute for Occupational Safety and Health recommends that exposure not exceed the lowest feasible level." [17]
SDWA	• MCL set at 0.005 mg/L
CWA	• Priority pollutant
FDA	• "The Food and Drug Administration (FDA) limits the amount of cadmium in food colors to 15 parts per million (15 ppm)." [18]

Massachusetts: Occupational	• Subject to Right-to-Know requirements[19]

Massachusetts: Environmental & Public Health	• Ambient air guidelines for cadmium:[20] o Threshold Effects Exposure Limit (TEL) 0.003 $\mu g/m^3$ (24-hour average) o Allowable Ambient Limit (AAL) at 0.001 $\mu g/m^3$ (annual average) • Drinking water standard (acceptable daily intake over a lifetime exposure) is 0.005 mg/L (identical to the MCL at the federal level, under SDWA).[21] • Cadmium is also regulated under the Massachusetts Hazardous Waste regulations.[22]

Other state regulations of interest:

- Cadmium and cadmium compounds are regulated as carcinogens, and cadmium is regulated as a male developmental toxicant, under California's Safe Drinking Water and Toxics Enforcement Act of 1986 (Proposition 65).[23]

International

- Europe:
  - The Dangerous Substances Directive (76/769/EEC) restricts or prohibits many uses of cadmium. The Directive prohibits the use of cadmium and its compounds to give color to finished products made of polyvinyl chloride (PVC), polyurethane, and many other materials; in paints; as a stabilizer in PVC products including packaging materials, office or school supplies, furniture fittings, floor and wall coverings, insulation for electrical wiring, and others (except where required for safety reasons); and for plating metallic products or components in a variety of sectors. In addition, those cadmium compounds that are listed as carcinogens are restricted for use in "substances and preparations placed on the market for sale to the general public."[24]
  - Cadmium is one of the six chemicals regulated under the Restriction on Hazardous Substances (RoHS), which applies to electrical and electronic equipment.[25] Under RoHS, the maximum allowable concentration of cadmium by weight in a homogeneous material is 0.01%.
  - The European Union limits the amount of cadmium metal in a finished plastics product or component to 0.01% by mass of the polymer.[26]

- Sweden has more extensive regulations on cadmium than the current EU restrictions.
  - Sweden has a stated goal of a "Non-Toxic Environment," defined as an environment that is "free from man-made or extracted compounds and metals that represent a threat to human health or biological diversity."[27] One of the interim targets for achieving this goal states that "Newly manufactured finished products should as far as possible be free from: mercury by 2003, and cadmium and lead by 2010."[28]
  - The use of cadmium and its compounds for surface treatment, as a stabiliser, and as a coloring agent have been prohibited in Sweden since 1982. Sweden also prohibits "professional marketing and supply of goods which have been surface-treated with a cadmium substance or contain a cadmium substance as stabiliser or colouring agent, as well as import of such goods from countries outside of the European Union."[29]

- Sweden also restricts cadmium in fertilizers.

- Cadmium is also regulated under China's regulation of hazardous substances in electrical and electronic equipment, commonly known as China RoHS.[30]

5. Implications for the TURA program

Existing TURA filers have made significant progress in reducing or eliminating use of cadmium and its compounds. The TURA program has experience providing services to facilities working to reduce or eliminate use of cadmium and its compounds. Designating cadmium as a higher hazard substance would also help the program to determine the extent to which cadmium is still being used in the Commonwealth. This information, in turn, could help to inform program activities to help users identify alternatives and toxics use reduction opportunities.

There would be some additional cost to companies that would begin reporting cadmium and cadmium compounds based on a the lower reporting thresholds, including preparing annual toxics use reports and biennial toxics use reduction plans, and paying toxics use fees. The average base fee paid by TURA filers in 2006 was $3,425. However, many of the new filers for cadmium 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 begin to pay a per chemical fee of $1,100.

Assuming that the lower reporting threshold brings in 30 facilities that are not already reporting under TURA, the additional cost in fees to filers (and revenue to the program) could range from $88,500 (30 small companies reporting cadmium only) to $135,750 (30 average sized companies reporting cadmium only). If some of the facilities that begin filing for cadmium under the lower reporting threshold are already TURA filers, there would be less cost to these filers since they already pay a base fee.

6. Summary

Cadmium is recognized as a priority toxic chemical, and is subject to multiple regulations, at the national and international levels. Due in part to increasingly stringent regulations, many former cadmium users have shifted to safer alternatives. By lowering the reporting threshold for cadmium and cadmium compounds, the TURA program can help to ensure that Massachusetts facilities remain in the forefront of the effort to switch to safer substitutes, and minimize their use of cadmium and cadmim compounds in those uses for which substitutes are unavailable.

Appendix A: Data the SAB considered for Cadmium Compounds

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 reproductive toxicant*; Category 2 reproductive toxicant on EU list
Mutagenicity	EU Category 2
LD50	Oral rat 88 mg/kg
LC50	2.08 mg/m3
Reference Dose*	.00005 mg/kg/day water .3 mg/kg/day food
ACGIH Threshold Limit Value (time weighted average)*	.01 mg/m3
Bioconcentration factor*	366
ATSDR Minimum Risk Level*: Chronic oral	0.002 mg/kg/day

Unless otherwise noted, Cadmium chloride was the representative cadmium compound.

* Data for Cadmium was used

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
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

[1] Unless otherwise noted, for this discussion of health effects, "cadmium" encompasses both cadmium and its compounds.
[2] Toxics Use Reduction Institute, "Massachusetts Chemical Fact Sheet: Cadmium and Cadmium Compounds."
[3] Toxics Use Reduction Institute, "Massachusetts Chemical Fact Sheet: Cadmium and Cadmium Compounds."
[4] Agency for Toxic Substances and Disease Registry, "Public Health Statement for Cadmium," July 1999. Available at http://www.atsdr.cdc.gov/toxprofiles/phs5.html, viewed July 2007.
[5] Toxics Use Reduction Institute, "Massachusetts Chemical Fact Sheet: Cadmium and Cadmium Compounds."
[6] Toxics Use Reduction Institute, "Massachusetts Chemical Fact Sheet: Cadmium and Cadmium Compounds."
[7] Davis, et al, 1994, p. 119.
[8] M. Bielawski, "Development of Unbalanced Magnetron Sputtered Al-Mo Coatings for Cadmium Replacement," *Surface Coatings and Technology* 179 (2004), pp. 10-17.
[9] Andrew Wood, "Cadmium-free Inorganic Pigments," *Chemical Week* 162: 18, p. 39 (2000); Jansen, M. & Letschert, H. P. Inorganic yellow-red pigments without toxic metals. *Nature* 404, pp. 980 - 982 (2000).
[10] Colorants," in *Encyclopedia of Polymer Science and Technology.*
[11] H. Endriss and M. Haid, "Bismuth Vanadate Pigments," *Kunststoffe Plast Europe* 86:4 (April 1996), pp. 538-540.
[12] Helen Hatcher et al., "Providing Unique Solutions with a New Pigment Chemistry," *Paint and Coatings Industry* 20:1 (January 2004), pp. 60-62.
[13] See, for example, "Chromatics to discontinue production of heavy metal-based colorants," *The Wire Association International* 39:10 (October 2006), p. 14; "Bruce M. Mulholland (Hoechst Celanese Corporation), "Cadmium Free Colored Engineering Plastics for the Automotive Industry," *ANTEC 1994* (Annual Technical Conference, Society of Plastics Engineers), pp. 2529-2532.
[14] List of TRI Chemicals available at http://www.epa.gov/tri/chemical/index.htm.
[15] ATSDR, Toxicological Profile for Cadmium (July 1999), available at http://www.atsdr.cdc.gov/toxprofiles/tp5-c7.pdf (Chapter 7: Regulations and Advisories).
[16] OSHA, 1910, subpart Z, 1910.1027, available at http://www.osha.gov/SLTC/carcinogens/standards.html.
[17] ATSDR, Toxicological Profile for Cadmium (July 1999), available at http://www.atsdr.cdc.gov/toxprofiles/tp5-c7.pdf (Chapter 7: Regulations and Advisories).
[18] ATSDR ToxFAQs for Cadmium, June 1999, available at http://www.atsdr.cdc.gov/tfacts5.html.

[19] 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
[20] Massachusetts Department of Environmental Protection, Revised Air Guidelines, www.mass.gov/dep/air/aallist.pdf
[21] 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
[22] Massachusetts Hazardous Waste regulations, 310 CMR 30.125, Maximum Concentration of Contaminants for Toxicity Characteristic, http://www.mass.gov/dep/service/regulations/310cmr30.pdf.
[23] California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65), www.oehha.ca.gov/prop65/prop65_list/files/060107LST.pdf
[24] 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/chemicals/legislation/markrestr/01976L0769_2006_1230_consolidated.pdf.
[25] Restriction on Hazardous Substances, legislation available at http://europa.eu/eur-lex/pri/en/oj/dat/2003/l_037/l_03720030213en00190023.pdf.
[26] Information available at http://ec.europa.eu/environment/index_en.htm. See EU Directive 91/338/EC regarding cadmium in consumer goods and packaging materials containing plastics, resins, or paints.
[27] Swedish Chemicals Inspectorate, http://www.kemi.se/templates/Page____2872.aspx.
[28] Asa Thors, Swedish Chemicals Inspectorate, personal communication, October 2007 (asa.thors@kemi.se).
[29] Asa Thors, Swedish Chemicals Inspectorate. Section 3 of the Ordinance (1998:944) on Prohibitions Etc. in Connection with Handling, Importing and Exporting Chemical Products (Certain Cases).
[30] For detailed information, see http://www.chinarohs.com/.