Toxics Use Reduction Institute
SUMMARY OF POLICY ANALYSIS
Aug 12, 2014
Higher Hazard Substance Designation Recommendation:

Cyanide Compounds (TURA #1016)

The following document analyzes the implications of designating Cyanide Compounds (TURA #1016) as Higher Hazard Substances (HHS). This chemical category is on the TURA Science Advisory Board (SAB) list of more hazardous substances and has been recommended for HHS designation by the SAB.

With this designation, the reporting threshold for this chemical category would be lowered from 10,000/25,000 lb/year to 1,000 lb/year for companies in TURA-covered industry 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.

This policy analysis summarizes key scientific information on this chemical category, estimates the number of facilities that are likely to enter the program as a result of the lower reporting threshold, notes opportunities and challenges that new filers are likely to face, and discusses the implications of this policy measure for the TURA program. Based on this analysis, the Toxics Use Reduction Institute supports the SAB's recommendation that cyanide compounds be designated as Higher Hazard Substances.

1. State of the Science

- Cyanide compounds pose significant acute and chronic toxicity concerns, particularly for the central nervous system (CNS). High levels of exposure result in convulsions, unconsciousness and death; lower levels may result in headache or dizziness.
- Cyanide is rapidly absorbed via inhalation and well absorbed via skin and the gastrointestinal tract. Once absorbed, cyanide is rapidly and ubiquitously distributed throughout the body, with the highest levels in the liver, lungs, blood, and brain.
- Chronic exposure to cyanide can result in CNS effects, including numbness and tremors, and cardiovascular, respiratory and thyroid effects. Cyanide is also a potential reproductive toxicant.

2. Number of facilities affected

To develop an estimate of the number and type of companies likely to be affected by a 1,000 lb reporting threshold, the Institute consulted sources including the TURA data; facilities reporting under EPCRA Tier II requirements; RCRA hazardous waste data; and past experience with other HHS designations.

Cyanide compounds reported under TURA are primarily used in electroplating, operations. A total of 14 facilities have reported cyanide compound use under TURA at some point. In 2012, the most recent year for which data are available, three companies reported the use of cyanide compounds in plating operations under TURA.

We estimate that approximately 25 new filers would be brought in by the HHS designation; most of these would be facilities that already file under TURA for other chemicals, and a few would be new to TURA.

2. Opportunities for New Filers

Cyanide compound use reported under TURA has decreased significantly since the program's inception. Use has declined from 168,090 lb in 1990 to 71,802 lb in 2012 (a 57% decrease), and releases have declined 100%, from 603 lb in 1990 to 0 lb in 2012 (figures not adjusted for changes in production levels).

Cyanide compounds are commonly used when plating zinc, copper, cadmium, brass, gold and silver. The most common cyanide compounds used in metal plating baths are sodium and potassium cyanide and the cyanide compounds of the metal being plated, such as copper cyanide or silver cyanide. Treating cyanide wastes before disposal requires the use of additional hazardous chemicals including sulfuric acid, sodium hydroxide and sodium hypochlorite.

Advantages of cyanide plating baths include the fact that they accommodate a wide range of electrical current and are good at removing tarnish or films from objects to be plated.

Practical alternatives to Cyanide Compounds are available for many applications, and there is a good body of knowledge about their performance, as most have been in use for many years.

- *Cyanide Zinc*: Alternatives include zinc acid chloride and zinc alkaline
- *Copper Cyanide:* Alkaline non-cyanide copper plating
- *Gold Cyanide:* Sulfate plating baths

4. Regulatory Context

- Due to its toxicity, cyanide compounds are subject to a number of regulations. At the federal level, cyanide compounds are reportable under TRI, many cyanide compounds are regulated as an Extremely Hazardous Substances (EHS) under EPCRA, and are regulated as a Hazardous Air Pollutant under the Clean Air Act, among other regulations. US EPA identified cyanide compounds on the Priority List of Hazardous Substances. Cyanide salts are regulated under California's Proposition 65 due to their reproductive toxicity in males.

5. Implications for the TURA program

- *General.* Designating cyanide compounds as a Higher Hazard Substance would help to fulfill the intent of the 2006 amendments to TURA, providing important guidance and incentives to Massachusetts businesses to help them move away from the most hazardous chemicals and toward safer alternatives. A focus on cyanide compounds in Massachusetts would also be consistent with efforts to address this chemical in other states and nationally.
- *Costs to businesses of reporting, planning, and fees.* Assuming 25 new cyanide compound filers, with 7 small companies new to the program and 8 additional facilities that have already reached their maximum fee, the total additional cost in fees to filers (and revenue to the program) could be approximately $33,450.

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Policy Analysis

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3. State of the Science

Cyanide compounds pose significant acute and chronic toxicity concerns, particularly for the central nervous system (CNS). High levels of exposure result in convulsions, unconsciousness and death; lower levels may result in headache or dizziness.

Cyanide compounds dissociate in water, generating free cyanide (cyanide anions). Cyanide is rapidly absorbed via inhalation and well absorbed via skin and the gastrointestinal tract.[1] Once absorbed, cyanide is rapidly and ubiquitously distributed throughout the body, with the highest levels in the liver, lungs, blood, and brain.[2]

Acute toxicity

- Cyanide compounds are acutely toxic and can cause brain and heart damage.
- Inhalation of cyanide can cause coughing, headache, weakness, confusion, dizziness, nausea, coma and death.[3]
- Exposure irritates the eyes, nose and throat, and can cause burns and eye damage.
- Cyanide compounds prevent utilization of oxygen by body tissues.
- Cyanide compounds react with acids and other strong oxidizers to produce hydrogen cyanide gas. Hydrogen cyanide is highly toxic, highly flammable, highly reactive, and a fire and explosion hazard.[4]

Chronic toxicity

- Chronic exposures can cause chest pain, lung damage, blood changes, and headaches.
- Chronic inhalation of cyanide affects the central nervous system, causing dizziness, headaches, loss of appetite, numbness, and loss of visual acuity.
- Chronic exposure may also impair and enlarge the thyroid gland and cause cardiovascular and respiratory effects.[5]

- Cyanide is a potential reproductive hazard (teratogen). Animal studies suggest that oral exposure to potassium cyanide may cause malformations in the fetus.[6] Sodium Cyanide is also a potential reproductive toxicant.[7]

Nomenclature

TURA defines cyanide compounds as they are defined by the United States Environmental Protection Agency (US EPA) for purposes of reporting under the Toxics Release Inventory (TRI). Cyanide compounds include any chemical substance with the following chemical formula: $X^+ CN^-$ where $X = H^+$ or any other group where a formal dissociation can be made. Examples include potassium cyanide (KCN) or calcium cyanide ($Ca(CN)^2$).[8]

Hydrogen cyanide and ethyl cyanide are listed separately under TURA; neither are currently designated as Higher Hazard Substances, and so would remain with standard 10,000 lb/25,000 lb reporting thresholds.

Under Tier II, all the cyanide compounds are reported individually. The majority of the Tier II reports for Massachusetts companies in 2012 are for sodium cyanide and potassium cyanide. Copper, silver and zinc cyanide also appear in some reports.

Role of uncertainty

Uncertainty does not play a significant role in the development of our recommendations for these substances.

2. Number of facilities affected

To develop an estimate of the number and type of companies likely to be affected by a 1,000 lb reporting threshold, the Institute consulted sources including the TURA data; facilities reporting under EPCRA Tier II requirements; RCRA hazardous waste data; and past experience with other HHS designations.

Uses of cyanide compounds reported under TURA include primarily electroplating in metal working operations. One facility also reported precious metal refining.

a. Historical data on sectors using cyanide compounds in Massachusetts

A total of 14 facilities have reported cyanide compound use under TURA at some point. These facilities have been in the following sectors:

3053	Gaskets, packing, and sealing devices
3341	Secondary nonferrous metals, nec
3351	Copper rolling and drawing
3471	Plating and polishing

3484	Small arms
3674	Semiconductors and related devices
3822	Environmental controls

b. Current TURA data on cyanide compounds use in Massachusetts

In 2012, the most recent year for which data are available, three companies reported the use of cyanide compounds under TURA, all in plating processes.

SIC Code		**No. of 2012 Filers**	**Type of Use**
3351	Copper rolling and drawing	1	Processed
3471	Plating and polishing	2	Otherwise used

c. Storage & hazardous waste reporting data

Reports filed under EPCRA Tier II and under RCRA indicate current or recent cyanide compound use by additional facilities. The EPCRA Tier II data show 48 facilities reporting cyanide compounds in 2012 and the RCRA data show 250 hazardous waste shipments. 14 facilities have reported under TURA at some point.

Storage of at least 1000 lb onsite was used as a basis for estimating the number of facilities that may be using at least 1,000 lb/year of cyanide compounds. Based on the maximum amounts reported under Tier II for 2012, 23 facilities have reported at least 1000 lb of cyanide compounds stored onsite and have at least 10 FTEs. Sectors represented in this data set are primarily plating and metal finishing operations. Seventeen of these are current or past TURA filers.

Two additional facilities that appear to be in a TURA sector report shipments of cyanides above 1000 lb in their hazardous waste data reported under RCRA.

d. Past experience with HHS designations

Experience since 2006 indicates that in general, an HHS designation brings in a number of new filers in the first couple of years of the designation, and this number falls in subsequent years as filers move to safer substitutes. Each sector is different, but this pattern may be indicative of future trends as well. For the six HHS for which data are currently available, the number of new filers in the first year the designation was effective ranged from 5 to 19.

e. Estimated number of companies that would be affected by a lower reporting threshold

We estimate that approximately 25 new filers would be brought in by the HHS designation; most of these would be facilities that already file under TURA for other chemicals, and a few would be new to TURA.

3. Opportunities for New Filers

In this section, we briefly review trends in cyanide compound use among existing TURA filers, and summarize basic information on cyanide compound alternatives in selected applications.

a. Trends in cyanide compound use

Cyanide compound use reported under TURA has decreased significantly since the program's inception. Use has declined from 168,090 lb in 1990 to 71,802 lb in 2012 (a 57% decrease), and releases have declined 100%, from 603 lb in 1990 to 0 lb in 2012 (figures not adjusted for changes in production levels).

Massachusetts TURA Cyanide Compound Use and Release Data: 1990 and 2012 (figures not adjusted for production)

	Year		Change In lbs	% Change
	1990	2012		
Cyanide Compounds used (lbs)	168,090	71,802	-96,288	-57%
Cyanide Compounds released (lbs)	603	0	-603	-100%

b. Opportunities to reduce use of cyanide compounds

Cyanide compounds are commonly used when plating zinc, copper, cadmium, brass, gold and silver. The most common cyanide compounds used in metal plating baths are sodium and potassium cyanide and the cyanide compounds of the metal being plated, such as copper cyanide or silver cyanide.[9] Treating cyanide wastes before disposal requires the use of additional hazardous chemicals including sulfuric acid, sodium hydroxide and sodium hypochlorite.

Advantages of cyanide plating baths include the fact that they accommodate a wide range of electrical current and are good at removing tarnish or films from objects to be plated.

Non-cyanide plating processes[10]

Substitutes for plating zinc. Metal platers have achieved good technical performance by substituting zinc acid chloride and zinc alkaline in place of a cyanide zinc plating bath. These alternative processes have been found to produce superior finishes. One drawback is that sometimes both the zinc chloride and the zinc alkaline bath must be added to replace a single cyanide zinc plating bath.[11]

The Substitution Support Portal (Subsport) provides access to a sample case study of an electroplating company that switched from zinc cyanide to zinc chloride for galvanizing. The case study notes that the acid zinc method requires more process steps, but the total time required is the same, because “the cleaning step in the acid zinc method is more efficient.” The case study notes further that the quality using the acid zinc method is identical or superior to the zinc cyanide method, and costs have remained the same. In addition, the company was able to keep the same chemical supplier. According to the Subsport evaluation, the new process was equivalent to the previous process in environmental impact, but was safer for workers.[12]

Substitutes for plating or stripping copper. The most common substitute for copper cyanide plating is the alkaline non-cyanide copper plating solution, with less common substitutes being copper acid sulfate and copper pyrophosphate. Each of these substitutes has been shown to give good appearance and product quality on most substrates.[13]

Cyanide is also used for stripping copper (removing it, for example from circuit boards). Ammonia-based products can be used as alternatives for cyanide in stripping applications. According to one company offering this option, the ammonia-based systems offer improved efficiency and lower costs in addition to reduced hazard.[14]

Substitutes for plating cadmium. Since cadmium and cadmium compounds are designated as Higher Hazard Substances, the best options for reducing or eliminating the use of cadmium cyanide baths is to switch to an alternative metal. Depending on the final properties required, alkaline and zinc alloys can be used as alternatives to cadmium cyanide plating baths. (The zinc alloys may include the zinc nickel or zinc cobalt, which can also pose health concerns.) These alternatives present both advantages and disadvantages from a technical feasibility standpoint. [15] For example, acid zinc-nickel plating processes provide good corrosion protection, even without a post treatment conversion coating.[16]

The Strategic Environmental Research and Development Program (SERDP) of the Department of Defense has an on-going project to demonstrate and validate zinc-nickel as a replacement for cadmium/cyanide plating for air force landing gears. Technical advantages of this process include “excellent throwing power” and “excellent sacrificial corrosion protection for steels.” The project, which is anticipated to be completed in 2015, will install a prototype plating line at an air force base for demonstration and validation of the process. Costs are expected to be similar to those of the cyanide-based process. The new process promises to eliminate occupational exposures to cadmium and cyanide at depot facilities as well as cadmium and cyanide pollution associated with DoD field activities worldwide.[17]

Substitutes for plating gold. For plating gold, a sulfate plating bath can be used in place of a cyanide bath, producing an acceptable coating for use in the circuit board industry.

Wang et al. (2004) describe a cyanide-free, sulfite-based gold electroplating process with improved stability. Technical advantages of the process include “good pull and shear strengths” and a “simple and convenient” process for analyzing and maintaining the plating bath.[18]

Selected TURA program projects

The Woburn-based company Union Etchants worked with the TURI laboratory to demonstrate the feasibility of using iodine-based compounds as alternatives to cyanide compounds for etching and gold extraction.[19]

Texas Instruments reduced its use of cyanide compounds from 35,000 pounds in 1996 to 5,000 in 2000, for which TI received the Massachusetts Governor's Award for Excellence in TUR.[20]

4. Regulatory context and exposure limits

Due to their toxicity, cyanide compounds are subject to a number of regulations. Selected federal and state regulations, as well as related non-regulatory initiatives, are noted below.

EPCRA/SARA	• Reportable under TRI[21] • Subject to US EPA Tier II reporting requirements[22] • Section 110 – Priority List of Hazardous Substances [143-33-9][23] • A number of cyanide compounds (including cyanide compounds of potassium, sodium, copper, nickel, silver, zinc, calcium and others) are regulated as Extremely Hazardous Substances (EHS) under EPCRA Section 302.[24] • Potassium cyanide (151-50-8) and Sodium cyanide (143-33-9) have an EPCRA Section 304 EHS reportable quantity of 10 lbs.[25]
CAA	• Regulated as a Hazardous Air Pollutant (HAP) (143-33-9)[26] • Section 111 – Standards of Performance for New Stationary Sources of Air Pollutants
CWA	• Section 311 – List of Hazardous Substances[27] • Cyanides are listed in Section 307A – Toxic Pollutants[28]
RCRA	• Must be managed as hazardous waste.[29]
SDWA	• 0.2 mg/L Maximum Contaminant Level[30]
CERCLA	• No reportable quantity assigned to this class.[31] • Reportable quantities are listed for the following[32]: o Silver cyanide, Copper cyanide, Sodium cyanide, and Potassium cyanide = 10 lbs o Zinc cyanide = 1lb
OSHA PEL	• OSHA PEL: 5 mg/m^3, skin designation for cyanide salts [33] Silver cyanide = 0.01 mg/m^3, Silver, metal and soluble compounds as Ag[34]** Copper cyanide = 1 mg/m^3, Copper dusts and mists as Cu[35]**
NIOSH	• NIOSH REL: Ceiling, 5 mg/m^3 (4.7 ppm) [10-minute][36] • Immediately Dangerous to Life and Health: 25 mg/m^3 (as CN)[37]
ACGIH* TLV (TWA)	• 1993-1994 ACGIH TLV: 5 mg/m^3 TWA [skin][38] Silver cyanide = 0.01 mg/m^3, Silver soluble compounds as Ag[39]** Copper cyanide = 1 mg/m^3, Copper dusts and mists as Cu[40]**
ACGIH* TLV-STEL	• Ceiling limit; 5 mg/m^3, skin designation for cyanide salts [143-33-9; 151-50-8; 592-01-8][41]
* The ACGIH recommended TLV values noted above are based on upper respiratory tract	

irritation; headache; nausea; thyroid effects. ** Occupational exposure limits based on metal exposures.

Other states

- Cyanide salts are regulated under California's Proposition 65 due to male reproductive toxicity.[42]
- The following States have legislation listing selected cyanide compounds: California, Hawaii, Illinois, Michigan, Minnesota, New Jersey, Pennsylvania, Rhode Island, Vermont, and Washington.

International

- Canada has set a maximum acceptable concentration of 0.2 mg/L for free cyanide in drinking water.[43] Several cyanide compounds are included on Canada's Hazardous Products Act (HPA) – Ingredient Disclosure List (IDL).[44]

5. Implications for the TURA program

Designating cyanide compounds as a Higher Hazard Substance would help to fulfill the intent of the 2006 amendments to TURA, providing important guidance and incentives to Massachusetts businesses to help them move away from the most hazardous chemicals and toward safer alternatives.

There would be some additional cost to companies that would begin reporting cyanide compounds based on a lower reporting threshold, including preparing annual toxics use reports and biennial toxics use reduction plans, and paying toxics use fees.

Based on the Tier II and RCRA data, we estimate new reporting by 25 facilities. Current Tier II and TURA filers are primarily 10-100 employees with a few companies sized over 500 employees. Predicted new filers appear to be mostly under 50 employees.

Most of these 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. In addition, some facilities are already paying the maximum fee corresponding to their size; these facilities would not pay any additional fee.

After two years of reporting toxics use, companies are required to engage in TUR planning. Companies that want to have their own in-house TUR planner can qualify either by relying on past work experience in toxics use reduction or by having a staff member take the TUR Planners' training course. Those companies with experienced staff can become certified for as little as $100. For those that want staff to take a course the cost is $650. Companies with in-house toxics use reduction planners are likely to reap ancillary benefits from having an employee who is knowledgeable about methods for reducing the costs and liabilities of toxics use. Additionally, through the process of planning and reducing or eliminating cyanide compound use, companies may be able to expand markets, improve compliance with other regulations, and achieve financial savings through process improvements.

Assuming 25 new cyanide compound filers, with 7 small companies new to the program and 8 additional facilities that have already reached their maximum fee, the total additional cost in fees to filers (and revenue to the program) could be approximately $33,450.

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