THE MASSACHUSETTS TOXICS USE REDUCTION INSTITUTE

Massachusetts Chemical Fact Sheet

Cyanide and Cyanide Compounds

Cyanides[1] are severe acute toxins. Hydrogen, potassium, and sodium cyanide are three common commercial forms of cyanide used in Massachusetts. Running contrary to the national trend, cyanide consumption in Massachusetts is declining as the primary end-users, electroplaters, seek safer alternatives.

HYDROGEN CYANIDE FACTS

Other Names:	Hydrocyanic Acid
Chemical Formula:	HCN
CAS Number:	74-90-8
Water Solubility:	Miscible

POTASSIUM CYANIDE FACTS

CAS Number:	151-50-8
Chemical Formula:	KCN
Water Solubility:	Highly soluble

SODIUM CYANIDE FACTS

Other Names:	White Cyanide
CAS Number:	143-33-9
Chemical Formula:	NaCN

Hazards

Acute (Short-Term) Health Effects

- Cyanide is a severe acute toxin. At concentrations of 25 milligrams per cubic meter (mg/m^3) cyanide is lethal to human health and life. Exposure to 100 mg/m^3 of hydrogen cyanide can cause immediate death.
- When inhaled cyanide can cause coughing, wheezing, headache, weakness, dizziness, and nausea.
- Contact with cyanide can cause burns and possible eye damage.
- Hydrogen cyanide is highly flammable, highly reactive, and a fire and explosion hazard.

Chronic (Long-Term) Health Effects

- Sodium cyanide is a potential reproductive hazard (teratogen). Animal studies suggest that oral exposure to cyanide may cause malformations in the fetus and low fetal body weights.
- Chronic inhalation of cyanide effects 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 skin rashes.
- Cyanide has not been tested for carcinogenicity.

(For section references, see endnote #2.)

Exposure Routes

Worker Health

Facilities using cyanide must minimize worker exposure.

- Use cyanide in closed systems. If a closed production system is infeasible, facilities need to enclose operations and use local exhaust ventilation. Where the potential for exposures to hydrogen cyanide exceed 4.7 mg/m^3 or to sodium or potassium cyanide exceed 5 mg/m^3, use a Mine Safety and Health Administration/National Institute for Occupational Safety and Health-approved supplied-air respirator with a full facepiece.

- Take precautions to avoid cyanide contact with skin and eyes. If cyanide contacts skin, immediately wash the exposed area.

- Store hydrogen cyanide with a stabilizer to minimize opportunities for explosions.

Public Health

- Airborne sources of cyanide include automobile exhaust, chemical manufacturing facilities, municipal solid waste incinerators, and smoking.

- Waterborne sources of cyanide include organic chemical manufacturers, iron and steel facilities, electroplating facilities, and wastewater treatment plants.

(For section references, see endnote #2.)

Use Nationally and in Massachusetts

Nationally, hydrogen cyanide is an intermediary chemical in the manufacture of other chemical products including: adiponitrile, acetone cyanohydrin, sodium cyanide, methionine, chelating agents, cyanuric chloride, nitrilotriacetic acid and salts, and other chemical products such as potassium cyanide.[3]

- In 1994 U.S. manufacturers consumed 1,467 million pounds of hydrogen cyanide.

- Hydrogen cyanide demand is on the rise across the U.S., increasing in the 1990s at a rate of almost 2% per year.

- Production of sodium cyanide is the third largest end-use of hydrogen cyanide in the U.S., behind production of adiponitrile and acetone cyanohydrin, consuming 156 million pounds of hydrogen cyanide in 1994. Potassium cyanide production is a small end-use for hydrogen cyanide; it consumed 2 million pounds of hydrogen cyanide in 1994.

- The primary end-use for sodium cyanide in the U.S. is gold extraction; it accounted for 93% of total sodium cyanide consumption in 1994. Nationally, electroplating is a small end-use for sodium cyanide, accounting for only 5 million pounds of sodium cyanide use in 1994.

According to the Massachusetts Toxics Use Reduction Act (MA TURA) data, Massachusetts companies used 142,000 pounds of cyanide in 1996 (see Table 1). Electroplating is the primary end-use for sodium and potassium cyanide in Massachusetts.

- Metal finishing and plating accounted for 85% of all Massachusetts cyanide use in 1996 (see Table 2).

- The manufacture of a specialty chemical product, oxidized carbon fabric, accounted for the remaining 15% of Massachusetts' reported cyanide use.

- Cyanide use in Massachusetts declined by 16% between 1990 and 1996, dropping from 168,000 to 142,000 pounds (see Table 1).

Table 1 includes two sources of "output" data: MA TURA and U.S. Environmental Protection Agency (EPA), Toxics Release Inventory (TRI) data. The MA TURA database

Table 1. Massachusetts Cyanide and Cyanide Compounds Data: Inputs and Outputs for 1990 and 1996

Input Data -- MA TURA	Inputs (pounds) 1990	1996	Change in Inputs (pounds)	% Change
Manufactured or Processed	7	23,245	23,238	N/A
Otherwise Used	168,083	118,356	-49,727	-30%
Total TURA Inputs	**168,090**	**141,601**	**-26,489**	**-16%**
Output Data – MA TURA	**Outputs (pounds) 1990**	**1996**	**Change in Outputs (pounds)**	**Change in Outputs**
Byproduct	128,203	95,741	-32,462	-25%
Shipped In/As Product	7	0	-7	-100%
Total TURA Outputs	**128,210**	**95,741**	**-32,469**	**-25%**
Releases and Transfers (R&T) Data -- EPA	**R&T (pounds) 1990**	**1996**	**Change in R&T (pounds)**	**% Change**
Environmental Releases	603	18,106	17,503	2903%
Off-site Transfers	4,210	9,991	5,781	137%
Total EPA R&T	**4,813**	**28,097**	**23,284**	**484%**

Sources: MA TURA – Massachusetts Toxics Use Reduction Act data, 1998; and EPA -- US Environmental Protection Agency, Toxics Release Inventory data, 1998.

includes all non-product material created by a process line prior to release, on-site treatment, or transfer ("byproduct") and the amount of toxic chemical incorporated into a product ("shipped in or as product"). The U.S. EPA, TRI database includes information on the waste materials generated by a facility after on-site treatment: including releases to air, land, and water ("environmental releases") and transfers off-site for treatment or disposal ("off-site transfers").

- MA TURA outputs mirrored the decline in total use, dropping from 128,000 to 96,000 pounds, between 1990 and 1996.

- Total EPA "releases and transfers" in Table 1 are significantly lower than MA TURA "byproduct" because cyanide is destroyed in the waste treatment process.

- Textron Systems first reported cyanide use in 1996 and was largely responsible for an almost six-fold increase in total EPA "releases and transfers" between 1990 and 1996.

Table 2. Massachusetts Cyanide and Cyanide Compounds Use by Use Categories for 1990 and 1996

Use Categories [1]	Facility Name	Use (pounds) 1990	1996	% Change
Metal Finishing and Plating	Chomerics Inc	32,547	0	-100%
	Coastal Metal Finishing	12,500	0	-100%
	Federal Metal Finishing Inc	19,400	0	-100%
	FM Callahan & Sons	0	19,008	n/a[2]
	General Metal Finishing	0	13,665	n/a
	National Metal Finishing Co	24,100	20,900	-13%
	New England Plating	17,863	10,396	-42%
	New Method Plating Co	25,800	20,690	-20%
	Texas Instruments	25,000	36,000	44%
	Westfield Electroplating Co	10,880	0	-100%
	Total	168,090	120,659	-28%
Oxidized Carbon Fabric	Textron Systems Corp [3]	0	20,942	n/a
	Total	0	20,942	n/a
Total Cyanide and Cyanide Compounds		**168,090**	**141,601**	**-16%**

[1] Production Unit Categories were assigned based on TURA production unit descriptions which were not specifically intended for this use. The final categories do not necessarily represent the manufacturers' descriptions of their use.
[2] n/a = not applicable
[3] Only user of Hydrogen Cyanide
Source: Massachusetts Toxics Use Reduction Act data, 1998.

Alternatives

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. Cyanide compounds are commonly used when plating zinc, copper, cadmium, gold, brass and silver. Cyanide plating baths have the advantage of accommodating a wide range of electrical current and are good at removing tarnish or films from objects to be plated. However, in addition to the health and environmental hazards associated with cyanide, treating cyanide wastes before disposal is a costly process and requires the use of other hazardous chemicals such as sulfuric acid, sodium hydroxide and sodium hypochlorite.

In past years much progress has been made in developing non-cyanide plating processes that produce the desired coating characteristics. The most progress has been made in substituting zinc acid chloride and zinc alkaline for the cyanide-zinc plating bath. Platers have realized better and brighter finishes using the zinc chloride or zinc alkaline baths. However, one drawback is that sometimes both zinc chloride and zinc alkaline baths must be added to replace a single cyanide-zinc plating bath.

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 product quality on most substrates but the substitutes may be more costly.

In addition to cyanide, cadmium is also on the Toxics Use Reduction Science Advisory Board's More Hazardous Chemicals List. Depending on the final properties required, alkaline and zinc alloys (most commonly zinc-nickel or zinc-cobalt) can be used as alternatives to cadmium-cyanide plating baths. The alkaline and acid zinc baths have a long history in the electroplating industry but have more recently been used as substitutes for cadmium-cyanide. Zinc alloys have as good or better corrosion resistance but cannot match cadmium-cyanide's lubricity properties.

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. Current alternatives to silver-cyanide require customization for each application but the technology is constantly developing.

(For section references, see endnote #4.)

Regulatory Context

A well-known hazard to human and environmental health, both the U.S. Occupational Safety and Health Administration (OSHA) and EPA regulate cyanide.

Table 3. OSHA Permissible Exposure Limits (PEL) for Cyanides[6]

Air Contaminant	PEL
Hydrogen Cyanide	11 mg/m^3
Sodium Cyanide	5 mg/m^3
Potassium Cyanide	5 mg/m^3

mg/m^3 = milligrams per cubic meter.
The PEL for hydrogen cyanide is not to be exceeded during any 15-minute work period.
The PELs are averaged over an 8-hour workshift.

- The OSHA permissible exposure limit (PEL) for an eight-hour workshift for cyanide ranges from 5 to 11 mg/m^3, depending on the specific cyanide compound (see Table 3).

The EPA regulates cyanide under authority of the Safe Drinking Water Act and Emergency Planning and Community Right-to-Know Act (EPCRA).

- The "maximum contaminant level" (MCL) for cyanide in drinking water is 0.2 parts per million. The MCL is the maximum permissible level of a contaminant in drinking water from a public water system.[5]

- Emergency Planning and Community Right-to Know Act, Toxics Release Inventory (TRI) program, all large quantity users of cyanide compounds must submit data on releases, transfers and waste.

Endnotes

1 Unless otherwise noted, "cyanide" includes hydrogen, potassium, and sodium cyanide.

2 The data for this section were collected from the following sources: Richard J. Lewis, Sr. (ed.), 1993, *Hazardous Chemicals Desk Reference* (third edition) (New York: Van Nostrand Reinhold); three New Jersey Department of Health and Senior Service (Trenton, New Jersey) chemical factsheets: "Hazardous Substance Fact Sheet: Hydrogen Cyanide" (1998), "Hazardous Substance Fact Sheet: Potassium Cyanide" (1998), and "Hazardous Substance Fact Sheet: Sodium Cyanide" (1998) (see the Department's webpage: http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm); and U.S. EPA, Office of Air Quality Planning and Standards, 1998, "Cyanide" [specifically, hydrogen cyanide — CAS #: 74-90-8] (Washington, D.C.: U.S. EPA — see webpage: http://www.epa.gov/ttn/uatw/hlthef/cyanide.html).

3 The national chemical use data are from Stanford Research Institute (SRI) International, 1996, *Chemical Economics Handbook,* see sections on "Hydrogen Cyanide" and "Sodium Cyanide" (Palo Alto, California: SRI).

4 The data for this section were collected from the following sources: Environmental Protection Agency. September 1994. "Guide to Cleaner Technologies: Alternative Metal Finishes." (EPA/625/R-94/007). Washington, D.C; Environmental Protection Agency. September 1994. "The Product Side of Pollution Prevention: Evaluating the Potential for Safe Substitutes." (EPA/600/R-94/178). Washington, D.C.; Environmental Protection Agency. August 1996. "International Waste Minimization Approaches & Policies to Metal Plating." (EPA/530-R-96-008). Washington, D.C.; Toxics Use Reduction Institute. 1994. 'Non-Cyanide Plating Processes.' Lowell, Massachusetts; Worobey, Walter, et. al. 1992. 'Gold Sulfite Replacements of Cyanide Solutions.' Environmentally Conscious Manufacturing: Recent Advances. Albuquerque, NM. ECM Press.

5 Source: U.S. EPA, Office of Water, 1998, "Drinking Water and Health: National Primary Drinking Water Regulations — Consumer Factsheet on: Cyanide" (Washington, D.C.: U.S. EPA — see webpage: http://www.epa.gov/OGWDW/dwh/c-ioc/cyanide.html).

6 The data sources for Table 3 are the New Jersey Department of Health and Senior Services chemical factsheets — see endnote #2.

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