THE MASSACHUSETTS TOXICS USE REDUCTION INSTITUTE

Massachusetts Chemical Fact Sheet

Toluene Diisocyanates

Toluene-2,6-diisocyanate (2,6-TDI), toluene-2,4-diisocyanate (2,4-TDI), and toluene diisocyanate mixed isomers are the three forms of TDI commonly used in commerce. Acute exposure to TDIs can result in severe skin, eye, lung, and throat irritation. TDIs are possible carcinogens and may be teratogens (reproductive hazards). Workplaces are the primary source of exposure to TDIs, which are intermediary chemicals in the manufacture of polyurethanes. In Massachusetts, businesses used 7.4 million pounds of TDIs in 1998.

FACTS

TOLUENE-2,4-DIISOCYANATE

Chemical Formula:	$C_9H_6N_2O_2$
CAS Number:	584-84-9
Vapor Pressure:	0.04 mm Hg at 20°C
Water Solubility:	Reactive
Flash Point:	132°C (270°F)

TOLUENE-2,6-DIISOCYANATE

Chemical Formula:	$C_9H_6N_2O_2$
CAS Number:	91-08-7
Water Solubility:	Reactive
Flash Point:	>112°C (>235°F)

TOLUENE DIISOCYANATE (MIXED ISOMERS)

Chemical Formula:	$C_9H_6N_2O_2$
CAS Number:	26471-62-5
Vapor Pressure:	0.1 mm Hg at 20°C
Water Solubility:	Reactive
Flash Point:	121°C (250°F)

Hazards

Acute (Short-Term) Health Effects

- The inhalation of TDIs causes severe irritation of the skin and eyes, and affects the respiratory, gastrointestinal, and central nervous systems. Exposure to high levels of 2,4-TDI can cause pulmonary edema (fluid build-up in the lungs) and at 2.5 parts per million (ppm) 2,4-TDI is immediately dangerous to life and health.

- Contact with TDIs can cause severe skin and eye irritation and burns. Prolonged contact with 2,4-TDI can cause eye damage.

Chronic (Long-Term) Health Effects

- TDIs are possible carcinogens. The International Agency for Research on Cancer (IARC) classifies 2,4-TDI, 2,6-TDI, and TDI mixed isomers as Group 2B carcinogens, possible carcinogens. 2,4-TDI has been shown to cause pancreas, liver, and breast cancer and TDI mixed isomers have been shown to cause cancer of the pancreas, liver, and heart in animals.

- There is limited evidence that 2,4-TDI may be a reproductive hazard; it has caused temporary impotence in males. It is a mutagen, causing genetic changes.

- 2,4-TDI and 2,6-TDI may cause an asthma-like allergy, where future exposure to very low levels of TDI result in asthma attacks with shortness of breath, wheezing, coughing, or chest tightness.

- Chronic exposure to 2,4-TDI at high concentrations may cause memory and concentration problems.

Life-Cycle Hazards

Manufacturers produce TDI using the "phosgenation process," where phosgene is an intermediary in the manufacture of TDI. Phosgene is a lethal gas at very low concentrations and is considered a "more hazardous chemical" by the Massachusetts Toxics Use Reduction Science Advisory Board. To avert exposing workers to phosgene, manufacturers of TDI continuously monitor operating areas and employ a variety of alarm and shutdown systems.

(For section references, see endnote #1.)

Table 1. Toluene Diisocyanates: Massachusetts Use and Output Data for 1990 and 1998 (pounds)

Use Data -- MA TURA	1990	1998	Change	% Change
Manufactured or Processed	1,927,613	7,445,603	5,517,990	286%
Otherwise Used	3,315,664	0	-3,315,664	-100%
Total TURA Inputs	5,243,277	7,445,603	2,202,326	42%
Output Data -- MA TURA	**1990**	**1998**	**Change**	**% Change**
Generated as Byproduct	5,415	5,359	-56	-1%
Shipped In or As Product	183,140	114,147	-68,993	-38%
Total TURA Outputs	188,555	119,506	-69,049	-37%
Releases and Transfers Data -- US EPA, TRI	**1990**	**1998**	**Change**	**% Change**
Environmental Releases	4,843	1,317	-3,526	-73%
Off-site Transfers	117	3,914	3,797	3245%
Total TRI R&T	4,960	5,231	271	5%

Sources: MA TURA -- Massachusetts Toxics Use Reduction Act data, 2000; and US EPA, TRI -- US Environmental Protection Agency, Toxics Release Inventory data, 1999.

Exposure Routes

Worker Health

Facilities using TDIs must minimize worker exposure.

- Use TDIs in a closed system. If a closed production system is infeasible, enclose operations and use local exhaust ventilation. If 2,4-TDI exposure may exceed 0.005 ppm, 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 contact with TDIs. If TDIs contact skin or eyes, immediately wash and transport the victim to a hospital for treatment.

Public Health

Products are the primary source of public exposure to TDIs.

- Residual amounts of unreacted TDI are often found in polyurethane products. The unreacted TDI seeps out of products ("off-gases"), exposing people to small concentrations of TDI. Indoor products that may release TDI monomer include polyurethane coatings, cushions, pads, cement sealers, and mastic sealants.

- The public may also be exposed to TDIs through the use of household products, including polyurethane foam kits.

(For section references, see endnote #1.)

Use Nationally and in Massachusetts

TDIs are part of a family of isocyanate-based chemicals called "diisocyanates and polyisocyanates." TDIs and 4,4'-methylene diphenyl isocyanate (MDI) are the primary isocyanates, accounting for 94% of U.S. isocyanate production capacity in 1998. ARCO Chemical (247,000 metric tons of global capacity), BASF Corporation (616,000 metric tons), Bayer Corp. (929,000 metric tons), Dow Chemical (525,500 metric tons), and ICI (425,000 metric tons) are the principal global producers of MDI and TDI. They account for 80% of worldwide capacity and are the only producers of MDI and TDI in the U.S. TDIs and MDI are primarily intermediaries in the manufacture of urethane-based materials, especially polyurethane foams.

In 1996, U.S. manufacturers consumed 616 million pounds of TDIs in the production of polyurethane flexible foams (92%), rigid foam (2%), surface coatings (3%), cast elastomers (2%), adhesives and sealants (2%), and other materials (<1%).

- The primary end-uses for TDI-based polyurethane flexible foams are (in order of highest to lowest levels of demand) transportation, furniture, bedding, carpet underlay, packaging, textile, and other.

- TDI use in rigid polyurethane foam is being replaced with MDI.
- End-uses for TDI-based polyurethane surface coatings include floor and wood finishes and paints.
- Cast elastomer products made with isocyanates include gaskets, shoe soles, mechanical parts, and wheels.
- The primary end-uses for TDI-based polyurethane adhesives and sealants are construction applications, automobile production, wood binders, and shoe production.

In 1998, Massachusetts' facilities used 7.4 million pounds of TDIs. The major end-uses are for TDI in Massachusetts are polyurethane foam (79%), surface coatings (5%), spandex (11%), and adhesives and sealants (4%) (see Table 2).

The use of TDIs increased by 42% between 1990 and 1998.

- This increase is due primarily to Crest Foam Company, which reported 3.3 million pounds in 1990 and 5.9 million pounds in 1998. Crest Foam reports TDI (mixed isomers) in the manufacture of polyurethane flexible foam. Partially offsetting this increase within foam products were two facilities which reported 0.5 million lbs. of TDI in 1990, and no longer reported in 1998.
- Other uses, exclusive of polyurethane foam, increased 14% from 1990 to 1998 .

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 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"). Outputs of TDIs, as measured by MA TURA program, decreased by 37% between 1990 and 1998.

- Byproduct generation remained relatively constant from 1990 to1998.

Table 2. Toluene Diisocyanates: Massachusetts Consumption by Use Categories (1990 and 1998)

Use Category [1]	Facility Name	Use (pounds) 1990	1998	% Change
Adhesives and Sealants	Bostik Inc	97,525	37,065	-62%
	CL Hauthaway & Sons	66,900	41,276	-38%
	Mace Adhesives & Coatings Co	108,171	214,259	98%
	subtotal	272,596	292,600	7%
Photographic Equipment and Supplies	Polaroid Corporation	17,470	0 [2]	-100%
	subtotal	17,470	0	-100%
Polyurethane Fiber (Spandex)	Globe Manufacturing	706,600	787,300	11%
	subtotal	706,600	787,300	11%
Polyurethane Foam	Crest Foam Company Inc	3,315,664	5,860,000	77%
	Hasbro Inc	430,941	0	-100%
	Boston Whaler Inc	105,685	0	-100%
	subtotal	3,852,290	5,860,000	52%
Surface Coatings	Surface Coatings Inc	101,401	101,984	1%
	Zeneca Resins	149,919	229,586	53%
	Stahl USA	143,001	59,525	-58%
	subtotal	394,321	391,095	-1%
Chemical Distributor	Truesdale Co.	0	114,608	n/a
	subtotal	0	114,608	n/a
	Totals	5,243,277	7,445,603	42%

[1] Use Categories were assigned based on the Institute's examination of TURA data and in some cases may not represent the actual use; [2] "0" indicates that the facility is either not using the chemical or has dropped below the reportable threshold. Source: Massachusetts Toxics Use Reduction Act data, 2000.

- Adhesives manufacturers reported 183,000 lbs. of TDIs shipped in or as product in 1990, and 0 lbs in 1998. Partially offsetting that decrease was the new reporting of 114,000 lbs. shipped by a chemical distributor in 1998.

Environmental releases and transfers of TDIs, as measured by the TRI program, dropped by 5% between 1990 and 1998. Environmental releases dropped by 73%.

- The decrease in environmental releases was led by Boston Whaler (2500 lb. in 1990, ceased operations in mid-90's) and CL Hauthaway & Sons (1400 lb in 1990, 0 lb. In 1998).

- One facility, Zeneca Resins, accounted for 67% of the off-site transfers in 1998.

(For section references, see endnote #2.)

Regulatory Context

The U.S. Occupational Safety and Health Administration (OSHA) and U.S. EPA regulate TDIs.

OSHA has set a permissible exposure limit (PEL) for 2,4-TDI and the National Institute for Occupational Safety and Health (NIOSH) has set recommend exposure levels for 2,6-TDI and TDI, mixed isomers (see Table 3).

The U.S. EPA regulates TDIs under the authority of the following three environmental statutes:

- Clean Air Act: 2,4-TDI and 2,6-TDI are "regulated toxic, explosive, or flammable substances."

- Comprehensive Environmental Responsibility, Compensation and Liability Act (popularly known as "Superfund"): 2,4-TDI and 2,6-TDI are regulated as both an "extremely hazardous substance" and a "hazardous substance," whereas TDI (mixed isomers) is only regulated as a "hazardous substance."

- Emergency Planning and Community Right-to-Know Act, TRI program: all large quantity users of 2,4-TDI, 2,6-TDI, and TDI (mixed isomers) must submit data on environmental releases and off-site transfers.

(For section references, see endnote #3.)

Endnotes

1 The data for this section were collected from the following sources: Environmental Defense Fund (EDF), 1999, "Chemical Profile: Toluene-2,6-Diisocyanate", "Chemical Profile: Toluene-2,4-Diisocyanate", and "Chemical Profile: Toluene Diisocyanate (Mixed Isomers)" (New York: EDF; see webpage: http:/www.scorecard.org/chemical-profiles/); Richard J. Lewis, Sr. (ed.), 1993, *Hazardous Chemicals Desk Reference* (New York: Van Nostrand Reinhold); National Institute for Environment, Health, and Safety (NIEHS), National Toxicology Program (NTP), "NTP Chemical Repository (Radian Corporation, August 29, 1991), Toluene Diisocyanate," (see webpage: http://ntp-db.niehs.nih.gov/NTP_Reports/NTP_Chem_H&S/NTP_Chem2/Radian26471-62-5.txt) and "NTP Chemical Repository (Radian Corporation, August 29, 1991), Toluene-2,6-Diisocyanate," (see webpage: http://ntp-db.niehs.nih.gov/NTP_Reports/NTP_Chem_H&S/NTP_Chem9/Radian91-08-7.txt) and New Jersey Department of Health and Senior Services, 1996, "Hazardous Substance Fact Sheet: Toluene-2,6-Diisocyanate" and "Hazardous Substance Fact Sheet: Toluene-2,4-Diisocyanate" (Trenton, New Jersey; see webpage: http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm); and U.S. EPA, Office of Air Quality Planning and Standards, 1998, "Toluene-2,4-Diisocyanate" (Washington, D.C.: U.S. EPA; see webpage: http://www.epa.gov/ttn/uatw/hlthef/toluene2.html); Stanford Research Institute (SRI) International, *Chemical Economics Handbook,* "Diisocyanates and Polyisocyanates" (1998) and "Phosgene" (1997) (Palo Alto, California: SRI).

2 The national chemical use data are from Stanford Research Institute (SRI) International, 1996, *Chemical Economics Handbook,* "Diisocyanates and Polyisocyanates" (Palo Alto, California: SRI). The Massachusetts chemical use data are from the Massachusetts Department of Environmental Protection (MA DEP), 1998, "Massachusetts Toxics Use Reduction Act Chemical Reporting Data" (Boston: MA DEP).

3 The data in this section are from the following sources: EDF, 1999; and New Jersey Department of Health and Senior Services, 1996 (see endnote #1 for full citations).