Polyurethane Amine Catalysts:
Safe Handling Guidelines

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American Chemistry Council | Center for the Polyurethanes Industry

Introduction

Use of Amine Catalysts in Polyurethanes Manufacture

Polyurethanes are generally made by reacting a diisocyanate, such as toluene diisocyanate (TDI) or methylene diphenyl diisocyanate (MDI), and a blended polyol. When a polyurethane foam is desired, the process uses additional chemicals, such as amine and/or metallic salt catalysts, auxiliary blowing agents, and silicone surfactants, to achieve the desired properties.

Amine catalysts are used to control and/or balance both the gelling reaction and the gas-forming or foaming reaction responsible for foam formation. Although several organometallic compounds or salts may be used as catalysts in the production of polyurethanes, many polyurethane manufacturers use either tertiary aliphatic amines or alkanolamines. Amine catalysts are typically 0.1 to 5.0 percent of a polyurethane formulation.

Chemical Composition

Amine catalysts are a class of organic compounds derived from ammonia (NH_3) by substituting one or more of the hydrogen atoms with alkyl groups (carbon and hydrogen containing molecular chains)—e.g., dimethylcyclohexylamine [$(CH_3)_2NC_6H_{11}$]. An amine is primary, secondary, or tertiary depending on whether one, two, or three of the hydrogen atoms of ammonia are replaced. Most amines are basic and can combine readily with acids to form salts, some of which are useful as delayed-action catalysts. Catalytic activity of tertiary amines depends on their structure and basicity. All tertiary amines have a very distinct and strong ammonia-like odor.

There are four potential routes of exposure to amine catalysts: INHALATION, SKIN CONTACT, EYE CONTACT, AND INGESTION

Because there are different types of amine catalysts, a detailed description of the physical and chemical properties of amine catalysts is beyond the scope of this document. Consult the manufacturer's Material Safety Data Sheet (MSDS) for specific information.

Flammability and Combustive Properties

Like many organic materials, amine-containing compounds will burn when exposed to sufficient heat, a source of ignition, and oxygen. This is especially true of vapors and mists, which are susceptible to sudden spontaneous combustion when mixed with air. Generally, liquid amine catalysts exhibit flash points in the range of 20°F to 115°F (-7°C to 46°C). The flash points of mixtures or blended components may be altered in the presence of water or other components.

The combustion of tertiary amine catalysts may yield a variety of toxic gases, including carbon monoxide, carbon dioxide, ammonia and nitrogen oxides.

Reactivity and Incompatibilities

Generally, liquid amine catalysts are corrosive and alkaline. Avoid using copper and copper copper containing alloys such as brass or bronze with anime catalysts.

Potential Health Effects of Amine Catalysts

This section provides a brief overview of information pertaining to potential health hazards associated with amine catalysts. This information is necessarily general in nature, since there are many amine catalysts used in polyurethane manufacture. A comprehensive discussion of health information pertaining to amine catalysts is beyond the scope of these Guidelines. For more information, you may want to contact your supplier, or consult the Material Safety Data Sheet (MSDS) specific to the amine catalyst of interest.

Typically, there are four potential routes of exposure to amine catalysts: inhalation, skin contact, eye contact, and ingestion, though ingestion is unlikely in the workplace. Consult the appropriate MSDS for specific details about potential acute and chronic effects of the particular amine catalyst used.

The adverse health effects listed below are applicable to aliphatic amines as a group and not necessarily to each specific catalyst. For more information, refer to the MSDS or contact your amine catalyst supplier and/or an experienced occupational physician.

Inhalation

Inhalation may result in moderate to severe irritation of nose, throat and lungs, manifesting as nasal discharge, difficulty breathing, and cough. Certain irritating amines can cause severe respiratory track injury in the airways such as laryngeal edema with bronchospasm, or severe bronchitis. Damage to the lung tissue may result in chemical pneumonitis and pulmonary edema, causing severe respiratory distress and delayed scarring of the lungs. Chronic exposure to short chain amines (<6 carbons) via inhalation may cause the systemic effects of headache, nausea, anxiety, and rise in blood pressure (Albrecht, 1988).

Medical conditions generally aggravated by inhalation exposure include asthma, bronchitis, and emphysema. Occupational asthma is not a commonly reported effect following exposure to amines. A few case reports document an asthmatic condition, however there is not a scientific consensus regarding the mechanism (Savonius, 1994, Piipari , 1998, Vallieres, 1977). Concurrent exposure to amines and diisocyanates have been reported to cause increased bronchial activity in one study, but this has not been confirmed in other studies (Belin,1983).

Table 1 - Acute Oral and Dermal Toxicity Classification*		
Classification	**Acute Oral LD50**	**Acute Dermal LD50**
	(rat mg/kg)	**(rabbit, mg/kg)**
Practically Nontoxic	>5000	>5000
Slightly Toxic	2000-5000	2000-5000
Moderately Toxic	300-2000	1000-2000
Toxic	50-300	200-1000
Highly Toxic	<50	<200

*Regulatory requirements may vary between countries.

Skin Contact

Skin contact with amine catalysts can cause moderate to severe irritation and burns, from redness and swelling to painful blistering, ulceration, and chemical burns. Repeated or prolonged exposure may also result in severe contact dermatitis. In most instances, it will be irritant contact dermatitis, but dermal sensitization leading to allergic contact dermatitis has been associated with one amine catalyst (see Table 1) (Foti,2003, Hervella, 2006).

Systemic effects resulting from the absorption of selected amines through the skin may include headaches, nausea, faintness, anxiety, decrease in blood pressure, reddening of the skin, hives, and facial swelling. These symptoms are related to histamine release and they are generally transient in nature.

Eye Contact

Amine catalysts are alkaline in nature and their vapors can be irritating to the eyes, even at low air concentrations. Such concentrations may result in corneal swelling without pain, may be manifested by visual disturbances such as blurred or "foggy" vision with a blue tint ("blue haze") and sometimes may produce a halo phenomenon effect around lights (Mastromatteo, 1965). Another paper reported transient decrease in visual acuity due to reversible corneal opacities (E H Page, 2003). These symptoms are temporary and upon cessation of exposure, typically disappear within hours, or longer depending on the duration and extent of exposure.

Exposure to higher vapor concentrations or direct contact with the liquid amines may result in severe irritation and tissue injury, with symptoms like burning, discomfort, involuntary closing of the eyelids, redness, and tearing. Contact with droplets or mists of amine catalysts may result in mechanical irritation, pain, and permanent corneal injury.

Table 2 - Summary of Acute Toxicity Studies of Amines Commonly Used in Polyurethanes

Chemical Name	Trade Names, Common Names	Skin Effects[a]	Eye Effects	SkinSens[c]	Inhalation LC50(rat) ppm	Oral LD50 (rat) mg/kg	Dermal LD50 (rabbit) mg/kg LD50(rabbit) mg/kg LD50(rabbit) mg/kg LD50(rabbit) mg/k
Alkyl Amines							
bis(2-Dimethylamino-ethyl)ether	NIAX A-99; DABCO BL-19; TOYOCAT- ETS; JEFFCAT ZF-20	corrosive	corrosive halovision[b]	No	117 ppm (6 hr)	571-1236	122-750
N,N-Dimethylamino-propylamine	DMAPA	corrosive	corrosive halovision[b]	Yes	>1031 ppm (4 hr)	500-1870	490
N,N-Dimethylcyclo-hexylamine	POLYCAT 8; JEFFCAT DMCHA	corrosive	corrosive	No	476 ppm (females); 375ppm (males) (6 hr)	272-650	210-543
N,N,N',N'',N''-Penta-methyldiethylene-triamine	DESMORAPID-PV; POLYCAT 5; TO-YOCAT -DT; JEF-FCAT PMDETA	corrosive	corrosive	No	290 ppm (6 hr) male & female rats	1330-1630	232-280
Triethylenediamine	TEDA; DABCO Crystal; RC Catalyst 105; JEFFCAT TD-100	mild/ moderate irritant	moderate to severe irritant halovision[b]	No	>4402 ppm (1hr)	700-3300	>2000
Ethanol Amines							
Diethanolamine	DABCO DEOA-LF; DEOA LFG; DEA	moderate/ severe irritant	severe irritant halovision[b]	No	NA[d]	680-3460	1220-13000
2(2-Dimethylamino-ethoxy)ethanol	PAK-LOC V; JEFFCAT ZR-70; TOYOCAT –RX3	severe irritant/ corrosive	severe irritant halovision[b]	No	NA[d]	2337	1340
N-[2-(dimethylamino) ethyl]-N-methylethanolamine	DABCO T; TOYOCAT-RX5	severe irritant	severe irritant	No	1670 ppm (1hr)	1580-2520	>1800
Dimethylethano-lamine	DABCO DMEA; JEFFCAT DMEA	corrosive	corrosive	No	1461-1641 (4 hr)	1420-2340	1215
Other							
3-Dimethylamino-N,N-Dimethy-lpropionamide	DDPA; NIAX A4; NIAX C-191	corrosive	corrosive	No	>41.7 ppm	1474-2400	1162-1767
N-Ethylmorpholine	DABCO NEM; JEFFCAT NEM	corrosive	corrosive halovision[b]	No	>2000 ppm (4hr)	1640-1780	900-1980

[a] Corrosivity information based on U.S. DOT corrosivity testing per 49 CFR Ch. I 173.137.

[b] Halovision is a phenomenon associated with many amines (See "Eye Contact," p. 7). The compounds listed as causing halovision are ones for which the effect has been documented.

[c] Skin sensitization studies are typically conducted at minimally irritating concentrations.

[d] NA= Not Available

Ingestion

The oral toxicity of amine catalysts varies from slightly toxic to toxic based on animal studies (see Table 2). Ingestion of amines can cause severe irritation, ulceration, or burns of the mouth, throat, esophagus, and gastrointestinal tract. Material aspirated (due to vomiting) can damage the bronchial tubes and the lungs. Affected persons also may experience pain in the chest or abdomen, nausea, bleeding of the throat and the gastrointestinal tract, diarrhea, dizziness, drowsiness, thirst, circulatory collapse, coma, and even death.

Exposure Guidelines

A number of organizations and entities establish limits for airborne contaminants in the workplace. Generally called Occupational Exposure Limits (OELs), some are enforceable regulatory limits and others are guidance. OELs are typically established for a specific chemical or family of chemicals, and are directed to the specific hazards presented. The U.S. Occupational Safety and Health Administration (OSHA) sets enforceable permissible exposure limits (PELs) to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air, and they are legally enforceable. In Canada, the Ontario Ministry of Labour also sets OELs, and these have the force of law.

Other OELs can be established by authoritative organizations such as the American Conference of Governmental Industrial Hygienists (ACGIH). ACGIH develops and publishes Threshold Limit Values (TLVs) as guidelines, which are not considered legal requirements (unless they have been adopted as regulatory standards by national, state, or local governments). OELs are reviewed periodically by occupational health professionals and updated as new information becomes available.

A number of organizations and entities establish limits for airborne contaminants in the workplace.

Table 3 - Permissible Exposure Levels and Threshold Limit Values of Some Polyurethane Amine Catalysts

Amine Catalyst	CAS #	Exposure Limit (Source)
Dimethylcyclohexylamine, N,N-	98-94-2	STEL: 5 PPM (Ontario, Canada)
N-ethylmorpholine	100-74-3	TWA: 5 ppm Skin[1] (ACGIH) PEL: 20 ppm Skin[2] (OSHA)
Triethanolamine	102-71-6	TWA: 5 mg/m3 (ACGIH)
Dimethylamino ethanol, 2-	108-01-0	TWA: 3 ppm (Ontario, Canada) STEL: 6 ppm (Ontario, Canada)
N,N-Dimethylaminopropylamine	109-55-7	TWA: 0.5 ppm (ACGIH)
Diethanolamine	111-42-2	TWA: 3 ppm (ACGIH) TLV: 1 mg/m3 (ACGIH)
Triethylamine	121-44-8	PEL: 25 ppm (OSHA) STEL: 3 ppm (ACGIH)
Triethylenediamine	280-57-9	TWA: 1 ppm Skin[1] (Ontario, Canada)
Bis (2-Dimethylaminoethyl) ether	3033-62-3	TWA: 0.05 ppm Skin[1] (ACGIH) STEL: 0.15 ppm Skin[1] (ACGIH)

[1] Potential for significant contribution to overall exposure by skin.
[2] Substance which may be absorbed through the skin.

Most exposure criteria, such as Ontario's OELs, OSHA PELs, and ACGIH TLVs, represent time-weighted average (TWA) concentrations where most members of a healthy, working population may be exposed repeatedly without adverse effects (8-hour day, 40-hour week). Furthermore, short-term exposures to elevated concentrations may be acceptable for many materials as long as the 8-hour TWA exposure is not exceeded. Short-term exposure limits (STELs) have been established for many materials which have an OEL, PEL or TLV. These STELs are 15 minute TWAs that should not be exceeded during a workday even if the 8-hour TWA is within the criteria. Some amine catalysts also have ceiling exposure limits which indicate concentrations that should not be exceeded during exposure.

Only a few of the polyurethane amine catalysts have been assigned OELs (see Table 3 for examples). Individuals who work with amine catalysts should stay informed of the most current standards governing exposure, understand the hazards associated with their use, and take precautions to avoid excessive exposure.

Methods for Exposure Control

Exposure to amine catalyst vapor or aerosols may present potential health risks. In those instances where the results of an industrial hygiene evaluation indicate the potential for amine catalyst exposure outside the applicable OEL, measures can be taken to protect workers from exposure. The National Institute for Occupational Safety and Health (NIOSH) suggests that the use of engineering controls be considered first, followed by administrative controls and then personal protective equipment.

Engineering Controls

Engineering controls are used to remove a hazard or place a barrier between the worker and the hazard. Consider the use of local exhaust ventilation, where feasible, to reduce airborne vapors. Local exhaust ventilation should be designed to draw vapors and/or aerosols away from the operator's breathing zone and designed to reduce airborne amine catalyst levels to acceptable concentrations at all work stations, including processing, fabricating, pouring, frothing, and spraying operations.

Administrative Controls/Work Practices

Administrative controls are generally described as written procedures and policies that help minimize the potential for exposures. For example, workers using any chemical, as well as amine catalysts, should follow proper handling procedures and utilize good work practices. Since it is important to avoid inadvertent contact with amine catalysts, including the possibility of ingestion, a good work practice is to prohibit consumption of food or beverages, use of tobacco or chewing gum, and application of cosmetics or other personal care products in the work area.

Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is often used after appropriate and feasible engineering and administrative controls have been implemented. Selection of PPE begins with a review of statutory and regulatory requirements, such as those outlined by OSHA. It also takes into consideration applicable standards, such as ANSI standards, other relevant requirements and guidance, and site-specific circumstances. This discussion is necessarily general in nature; the manufacturer's MSDS should be consulted for specific PPE recommendations for the amine catalyst of interest.

Chemical Protective Clothing

The purpose of chemical protective clothing (CPC) is to prevent contact with materials that can injure or be absorbed through the skin or eyes. Compatability of the chemical with the CPC material is a critical criterion in the selection process. Where there is a possibility of direct contact with liquid amines, skin and eye protection may include, but is not limited to:

- Chemical goggles and face shield
- Neoprene, nitrile, or butyl rubber gloves (DO NOT USE latex; latex is chemically incompatible with amines)
- Rubber apron
- Long-sleeve coveralls
- Rubber-soled safety shoes or rubber boots

Respiratory Protection

For routine manufacturing operations, air-purifying respirators equipped with cartridges designed to protect against organic vapors or amines may be recommended by the manufacturer. Consult the manufacturer's MSDS for specific information regarding respirator use and selection.

For firefighting, cleaning up large spills, and other emergency operations, wear a self-contained breathing apparatus with full face-piece, operated in a pressure-demand mode. OSHA requires that these self-contained respirators be used in conjunction with a site-specific, written respiratory protection program, which would include training, suitable fit testing, and medical evaluation of the user. Air purifying respirators are not appropriate for use during firefighting or other emergency or upset conditions.

PPE in Emergency Incidents

Protective equipment should be used during emergency situations whenever there is a likelihood of exposure to liquid amines or to excessive concentrations of amine vapor. Examples of "emergency situations" include equipment failure, rupture of containers, or failure of control equipment that results in an uncontrolled release of amine liquid or vapor.

Emergency protective equipment may consist of:

- Self-contained breathing apparatus, with full facepiece, operated in positive pressure or pressure-demand mode
- Neoprene, nitrile, or butyl rubber gloves (DO NOT USE latex; latex is chemically incompatible with amines)
- Long-sleeve coveralls or impervious full body suit
- Rubber apron
- Rubber-soled safety shoes or rubber boots

Medical Surveillance

Based on the risk assessments of potential exposure to amines, employers may require pre-placement and periodic medical examinations of their employees. These examinations can establish whether individuals may perform their duties without compromising their health. In addition, periodic medical evaluations can have significant value in the early detection of disease and in providing an opportunity for health counseling.

The following medical surveillance guidance focuses on respiratory and skin effects that might be amine-related. These screens do not establish a definitive diagnosis. Follow-up by a physician experienced in occupational respiratory disease is advisable in order to properly establish a diagnosis.

If you have any questions or would like further guidance in establishing medical surveillance in your workplace, contact your employer or amine catalyst supplier.

Medical Surveillance Components and Frequency Pre-Placement and Baseline Testing

- History – with special emphasis on skin and respiratory tract
- Spirometry (Pulmonary Function Studies)
- Physical examination depending on the presence of other health risks
- Respirator medical evaluation per 29 CFR 1910.134 (when respirator use is required)

Periodic Surveillance

- Medical History – with special emphasis on skin and respiratory tract
- Spirometry (Pulmonary Function Studies)
- Physical examination – by physician if there are positive findings in the Medical History or Spirometry
- Medical surveillance frequency to be determined by whether there are concurrent exposures to diisocyanates and use of respirators
- In addition, employers may want to offer exams in the following instances:
    - Following an emergency situation involving amines
    - If an employee complains of amine-associated signs or symptoms

The components for these examinations will be determined by the health care professional, who should have been supplied with information about the health effects of the amine catalysts.

Exposure Monitoring

Table 4 below illustrates physical properties and industrial hygiene sampling/analytical procedures for common polyurethane and polyisocyanurate amine catalysts.

Table 4 - Physical Properties and Industrial Hygiene Sampling/Analytical Procedures for Common Polyurethane and Polyisocyanurate Amine Catalysts

Chemical Name	Trade Names, Common Names	Vapor Pressure,* mm Hg @20°C	Industrial Hygiene Sampling/ Analytical Procedures
bis(2-Dimethyamino-ethyl)ether	POLYCAT 8 NIAX A-99; DABCO BL-19; TOYOCAT ETS; JEFFCAT ZF-20;	0.28	Crompton MethodXAD-2 Resin (100 mg/50 mg) Bayer Method 2.10.3 XAD-2Resin (400 mg/200 mg)
N,N-Dimethylcyclohexylamine	POLYCAT 5; JEFFCAT DMCHA	2.2	Huntsman Method – Chromosorb-102 Resin Air Products Method - XAD-2 Resin BTR Method – Porasil B Resin +5% KOHNIOSH XAD-2 Resin
N,N,N',N',N"-Pentamethyldiethylenetriamine	TOYOCAT – DT; JEFFCAT PMDETA	0.42	Bayer Method 2.10.3 XAD-2 Resin (400 mg/200 mg) Air Products Method - XAD-2 Resin
Triethylenediamine	TEDA; DABCO Crystal; RC Catalyst 105; JEFFCAT TD-100	0.45	Bayer Method 2.10.3 XAD-2 Resin (400 mg/200 mg) Huntsman Method – Chromosorb-102 Resin
Diethanolamine	DABCO DEOA-LF; DEOA LFG	<0.01	Crompton Method 38c-17g2-R2 NIOSH Method 3509Impinger (hexanesulfonic acid) Swenden PublicationNaphthylisothiocyanate-impregnatedglass fiber filters
2(2-Dimethylaminoethoxy)ethanol	PAK-LOC V; JEFFCAT ZR-70; TOYOCAT-RX5	0.05	Crompton Method 38C-6L15-R2 XAD-2 Resin (400 mg/200 mg)
Dimethylethanolamine	DABCO DMEA; JEFFCAT DMEA	4	Crompton Method 38C-17G1-R2XAD-8 Resin (250 mg/110 mg) Huntsman Method – Chromosorb-102 Resin
N-Ethylmorpholine	JEFFCAT NEM	6.1	BTR Method – Porasil B Resin +5% KOH NIOSH Method #S146 – Silica Gel Tube

*Note: The maximum achievable vapor concentration at room ("saturated atmosphere") in parts per million corresponds to [vapor pressure (mm Hg)]/760 mm Hg x 106. For example, a saturated atmosphere of triethylenediamine, which has a vapor pressure of 0.45 mm Hg, would be 592 ppm.

First Aid

Employee training can enhance the administration of appropriate first aid procedures after an exposure to an amine catalyst. Suitable emergency personnel may also need to be called depending on the severity of the accident. This guidance is general in nature; for specific first aid information, consult the MSDS for the specific amine being used. Always follow the first aid instructions in the MSDS.

Inhalation

Promptly move the affected person away from the contaminated area to an area of fresh air. Keep the affected person calm and warm, but not hot. If breathing is difficult, oxygen may be administered by a qualified person. If breathing stops, qualified persons should give artificial respiration. Call a physician at once.

Skin Contact

In the event of an amine catalyst spill or splash that results in skin exposure, promptly remove any contaminated clothing including rings, watches, and shoes, preferably under a safety shower. Wash skin for 15 to 30 minutes with plenty of flowing water. Call a physician immediately. Remove and dry-clean or launder clothing soaked or soiled with this material before reuse. Dry cleaning of contaminated clothing may be more effective than normal laundering. Inform individuals responsible for cleaning to avoid direct skin contact with those areas of clothing contaminated. Discard contaminated leather articles such as shoes, belts, and watchbands. Skin burns can be treated as thermal burns. The onset of dermal symptoms may be delayed, depending on the amine product. After decontamination, consider the use of cold packs and topical antibiotics.

Eye Contact

If liquid amines come in contact with the eyes, irrigate immediately and continuously with low pressure flowing water, preferably from an eye wash fountain, for 15 to 30 minutes. For more effective flushing of the eyes, use the fingers to spread apart and hold open the eyelids. The eyes should then be "rolled" or moved in all directions. Seek immediate medical attention, preferably from an ophthalmologist. In the event of vapor contact leading to irritation, consider irrigation with low pressure flowing water, preferably from an eye wash fountain, for 15 minutes.

Ingestion

If amine catalysts are ingested, consult the MSDS for specific first aid advice. It may be helpful to have the affected person drink several glasses of water or milk. Do not induce vomiting. Immediately transport to a medical facility and inform medical personnel about the nature of the exposure. If lavage is performed, endotracheal and/or esophagoscopic control is suggested. If the patient has ingested other chemicals, physicians should review the appropriate MSDSs to ensure treatments do not conflict.

Chemical Incompatibilities

Violent reaction and fire can result when amine catalysts are exposed to, or mixed with, oxidizing agents such as perchlorates, nitrates, permanganates, chromates, nitric and other strong acids, halogens, and some cleaning solutions containing acids. The large amount of heat generated by the reaction of the catalyst with the oxidizing agent may be sufficient to cause vigorous boiling, which can cause the hot material to splash or splatter. Latex (e.g., gloves) is not compatible with amine catalysts and should not be used in PPE.

Spills and Emergency Response

Minor Spills

Small spills can be contained by diking. The amine catalyst may then be neutralized as recommended in the manufacturer's MSDS. Absorb the neutralized product with an inert absorbant such as clay, sawdust, or vermiculite, and shovel into containers. Store the containers appropriately outdoors. Dispose of the material according to all federal, state, and local laws and regulations governing the disposal of chemical wastes. It is the user's responsibility to properly characterize the waste materials and dispose of them in accordance with legal requirements. Waste materials from an amine catalyst spill may be characterized as hazardous wastes that are subject to special requirements under the federal Resource Conservation and Recovery Act (RCRA).

Major Spills

Consider diking the spill for spill containment, with consideration to entryways into municipal water systems, waterways, or other sensitive points. Contact the supplier's emergency response center for advice and/or assistance. If the spill involves a tank car or tank truck, call CHEMTREC® (1-800-424-9300). A useful technique for addressing larger spills is to pump spilled material into drums during the response.

Clean-up and Decontamination

Brooms and mops, along with any remaining absorbent, should be disposed of in accordance with all applicable federal, state, and local regulations and requirements. Decontamination of floors and other hard surfaces after the spilled material has been removed may be accomplished by using a 5% solution of acetic acid, followed by very hot water.

Fire

In the event of a large fire, consider alcohol foam or all-purpose foam application; for small fires, carbon dioxide or dry chemical media. Also, water fog or water spray may be used to protect firefighters from the heat, to cool fire-exposed containers, or to disperse vapors; however, water will likely have little or no effect on extinguishing the fire itself. Contain spent liquids used to fight or extinguish fires to facilitate proper waste disposal.

Disposal

All relevant local, state, and federal regulations and requirements governing the disposal of amine-containing wastes must be adhered to strictly. Among the various federal enactments that may govern the disposal of these materials are: The Resource Conservation and Recovery Act (RCRA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (also known as "Superfund") and the Hazardous Materials Transportation Act (HMTA), as well as its 1990 Amendment, the Hazardous Materials Transportation Uniform Safety Act (HMTUSA).

Additional Information

For further information on handling other polyurethane chemicals, consult these Center for the Polyurethanes Industry (CPI) publications:

MDI-Based Polyurethane Foam Systems: Guidelines for Safe Handling and Disposal, AX119
Working with MDI and Polymeric MDI: What You Should Know (AX-205)
TDI-Based Polyurethane Foam Systems: Guidelines for Safe Handling and Disposal, AX142
Working with TDI: What You Should Know (AX-202)
Industrial Hygiene Air Monitoring for MDI and TDI (AX-248)
Hyperreactivity and Other Health Effects of Diisocyanates: Guidelines for Medical Personnel, AX150
Guidelines for the Responsible Disposal of Containers and Wastes from Polyurethane Raw Materials Processing AX151
Polyurethane Products: Overview of U.S. Model Building Code Fire Performance Requirements (AX-265)
Fire Safety Guidelines for Use of Rigid Polyurethane and Polyisocyanurate Foam Insulation in Building Construction (AX-230)
Polyurethane and Thermal Degradation(AX-396)
Polyurethane and Polyisocyanurate Foams: Energy Efficient, Versatile, High Performance (AX-106)
Polyurethane Recycling (AX-394)
Polyurethane and Polyisocyanurate Foam: Six Steps for Fire Safety During Construction (AX-236)
Polyurethane Recycling - Advanced Topics

For additional information on toxicological properties, health effects, protective clothing, and safe handling, consult the following sources:

Akesson, Beng, et al. 1986. Visual Disturbances After Industrial Triethylamine Exposure. Int. Arch. Occup. Environ. Health, 57:297-302.
Albrecht, William N., and Richard L. Stephenson. 1988. Health Hazards of Tertiary Amine Catalysts. Scand. J. Work Environ. Health, 14:209-219.
American Conference of Governmental Industrial Hygienists. 1987. Guidelines for the Selection of Chemical Protective Clothing, 3rd Edition. Cincinnati, OH..
American Conference of Industrial Hygienists. Annual Publication. TVLs, Threshold Limit Values for Chemical Substances and Physical Agents. Cincinnati, OH.
Belin, L., et al. 1983. Amines: Possible Causative Agents in the Development of Bronchial Hyperreactivity in Workers Manufacturing Polyurethanes from Isocyanates. British Journal of Industrial Medicine, 40:251-257.
Clayton, George D., and Florence E. Clayton (eds.). 1994. Aliphatic and Alicyclic Amines. Patty's Industrial Hygiene and Toxicology, Vol. IIB, Fourth Revised Edition. New York: John Wiley & Sons.
E H Page, C K Cook, M A Hater, C A Mueller, A A Grote, V D. Mortimer Visual and ocular changes associated with exposure to two tertiary amines. Occup Environ Med. 2003 Jan;60(1):69-75.
Foti C et al. Contact Dermatitis. 2003 Apr;48(4):194-8.
Hervella M, Yanguas JI, Inglesias ME, Larrea M,, Ros C, Gallego M. [Contact allergy to 3-dimethylaminopropylamine and cocamidopropyl betaine[Article in Spanish] Actas Dermosifiliogr. 2006 Apr;97(3):189-95.
Holsapple, Michael P., et al. 2000. Characterization of the Irritation and Sensitization Potential of Amine Catalysts Used in Polyurethanes. (Unpublished API Report)
Hurd, R. 1991. Some Actions Taken by Flexible Foam Producers in Europe to Meet the Requirements of Legislation on Health and the Environment. Polyurethanes World Congress 1991.
Mastromatteo E. J Occup Med 7 (1965) 502 -512
Oertel, Günter (ed.). 1994. Polyurethane Handbook, 2nd Edition. Munich: Hanser Publishers.Potts, Albert M., et al. 1986. An Unusual type of Keratopathy Observed in Polyurethane Workers and its Reproduction in Experimental Animals. American Journal of Medicine, 9:203-213.
Piipari R, Tuppurainen M, Tuomi T, Mäntylä L, Henriks-Eckerman ML, Keskinen H, Nordman H.Diethanolamine-induced occupational asthma, a case report. Clin Exp Allergy. 1998 Mar;28(3):358-62.
Savonius B, Keskinen H, Tuppurainen M, Kanerva L. Occupational asthma caused by ethanolamines.Allergy. 1994 Dec;49(10):877-81.
Schutte N. P. Amines (Aliphatic and Aromatic) pp. 706-709. Occupational medicine / editor-in-chief, Carl Zenz ; editors, O. Bruce Dickerson, Edward P. Horvath, Jr. 43rd ed. St. Louis : Mosby, c1994.3rd ed. St. Louis
Technical Data Sheets (TDS)) and Material Safety Data Sheets (MSDS).). (Copies of these documents are available from the chemical suppliers.)
Tyl, Rochelle W., et al. 1986. Evaluation of the Teratogenicity of Bis(2-Dimethylaminoethyl) Ether After Dermal Application in New Zealand White Rabbits. J. Toxicol. Cutaneous Ocul. Toxicol., 5(4):2634-284.
Vallieres M, Cockcroft DW, Taylor DM, Dolovich J, Hargreave FE. Dimethyl ethanolamine-induced asthma. Am Rev Respir Dis. 1977 May;115(5):867-71.
Warren, Donald W., Jr., and Dale F. Selchan. 1988. An Industrial Hygiene Appraisal of Triethylamine and Dimethyethylamine Exposure Limits in the Foundry Industry. American Industrial Hygiene Association Journal, 49(12):630-634.
Woods, George. 1990. The ICI Polyurethanes Book, 2nd Edition. New York: ICI Polyurethanes and John Wiley & Sons.

Appendix A: Partial list of amine catalysts that may be used in polyurethanes manufacture

Chemical Name	CAS Number	Trade Names, Common Names
2,4,6-Tris(Dimethylaminomethyl)phenol	90-72-2	DABCO TMR-30; JEFFCAT TR30; RC Catalyst 6330
N,N,N',N'-Tetramethyl-1,3-butanediamine	97-84-7	TMBDA
N,N-Dimethylcyclohexylamine	98-94-2	POLYCAT 8; JEFFCAT DMCHA
N,N-Diethylethanolamine	100-37-8	DEEA
N-Ethylmorpholine	100-74-3	JEFFCAT NEM; TOYOCAT NEM; RC Catalyst 6072
1-azabicyclo[2.2.2]octane	100-76-5	QUINICLIDINE
Triethanolamine	102-71-6	TEA
N,N,4-Trimethyl-1-piperazineethanamine	104-19-8	TOYOCAT -NP
N,N'-Dimethylpiperazine	106-58-1	JEFFCAT DMP; RC Catalyst 6117
Dimethylethanolamine	108-01-0	DABCO DMEA; JEFFCAT DMEA
N-Methylmorpholine	109-02-4	JEFFCAT NNM; RC Catalyst 101
N,N-Dimethylaminopropylamine	109-55-7	DMAPA; TOYOCAT RH2
N,N,N',N'-Tetramethylethylenediamine	110-18-9	TMEDA; TOYOCAT-TE; JEFFCAT TMEDA
1,3-bis(Dimethylamino)propane	110-95-2	
N,N,N',N'-Tetramethyl-hexamethylenediamine	111-18-2	TMHDA; TOYOCAT-MR
Diethanolamine	111-42-2	DABCO DEOA-LF; DEOA LFG; DEA
Dimethyldodecylamine	112-18-5	DM-12D
N,N-dimethylhexadecylamine	112-69-6	DM-16D; DABCO B-16
Triethylamine	121-44-8	ACCURE C (Allied)
N,N-Diisopropylethanolamine	121-93-7	DIEA
Ethanolamine (Monoethanolamine)	141-43-5	EA (MEA)
Triethylenediamine	280-57-9	TEDA; DABCO Crystal; RC Catalyst 105; JEFFCAT TD-100;TOYOCAT TEDA; RC Catalyst 104
4-butyl-morpholine	1005-67-0	NBM
2(2-Dimethylaminoethoxy)ethanol	1704-62-7	PAK-LOC V; JEFFCAT ZR-70
1,2-Dimethylimidazole	1739-84-0	DIME 12
N-[2-(dimethylamino)ethyl]-N-methylethanolamine	2212-32-0	DABCO T; TOYOCAT RX55
N,N,N',N',N"-Pentamethyldiethylenetriamine	3030-47-5	POLYCAT 5; TOYOCAT DT; JEFFCAT PMDETA
bis(2-Dimethylaminoethyl)ether	3033-62-3	NIAX A-99; DABCO BL-19; TOYOCAT ETS; JEFFCAT ZF-20;RC Catalyst 6433
N,N'-bis(1,4-dimethylpentyl)1,4-benzenediamine	3081-14-9	TENAMENE 4

N-[3-(dimethylamino)propyl]-N,N',N'-trimethyl-1,3-propanediamine	3855-32-1	POLYCAT 77; JEFFCAT ZR40;
4-[2-(dimethylamino)ethyl]-morpholine	4385-05-1	DABCO XDM
N-cyclohexyldiethanolamine	4500-29-2	DECA
N-Hydroxyethyl-N'-methylpiperazine	5464-12-0	TOYOCAT-HP
N-(3-Dimethylaminopropyl)formamide	5922-69-0	
1,3-bis(Dimethylamino)-2-propanol	5966-51-8	UC-2 (Sipene)
2,2'-dimorpholinodiethylether	6425-39-4	JEFFCAT DMDEE
1,8-diazabicyclo[5.4.0]undec-7-ene	6674-22-2	POLYCAT DBU; RC Catalyst 6180
Tetramethylimino-bis(propylamine)	6711-48-4	POLYCAT 15; JEFFCAT ZR-50B
N-Methyldicyclohexylamine	7560-83-0	POLYCAT 12
4-(2-methoxyethyl)-morpholine	10220-23-2	JEFFCAT MM
2-propanol,1,1'-[[2-[(2-hydroxypropyl) amino]ethyl]imino]bis-	10507-78-5	JEFFCAT DPA
1,3,5-tris[3-(dimethylamino)propyl] hexahydro-s-triazine	15875-13-5	POLYCAT 41; JEFFCAT TR41; TOYOCAT TRC; RC Catalyst 6099
3-Dimethylamino-N,N-Dimethylpropionamide	17268-47-2	DDPA; NIAX A4; NIAX C-191
N,N-dimethyl-(4-methyl-1-piperazinyl)-ethanamine	29589-40-0	JEFFCAT TAP; RC Catalyst 6076
Tris(3-Dimethylamino)propylamine	33329-35-0	POLYCAT 9; JEFFCAT Z80
ethanamine, 2,2'-[methylene bis(oxy)] bis[N,N-dimethyl-	36996-87-9	Cl-710
4-(2-aminopropyl)morpholine	50998-05-5	MAEM
1-[bis(3-dimethylaminopropyl)amino]-2-propanol	67151-63-7	JEFFCAT ZR-50
N,N,N',N'-2-pentamethyl-1,2-propanediamine	68367-53-3	PMT
N-Cocomorpholine	72906-09-3	DABCO NCM; JEFFCAT NCM
N-Methyl,N-(N',N'-2-Dimethylaminopropyl)ethanolamine	82136-26-3	POLYCAT 17
2-(2-(2-dimethylamino ethoxy)-ethylmethylamino)-amino	83016-70-0	JEFFCAT ZF-10

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American® Chemistry Council | Center for the Polyurethanes Industry

700 2nd Street, NE
Washington, DC 20002
(202) 249-7000
www.americanchemistry.com