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INITIAL SUBMISSION: LETTER FROM DOW CHEM TO ENVIRO CONTROL INC REGARDING TOLUENE DIISOCYANATE WITH ATTACHMENTS, DATED 03/27/81

Chemical Category
TOLUENE DIISOCYNATE

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THE DOW CHEMICAL COMPANY

MIDLAND, MICHIGAN 48640

March 27, 1981

Dr. George Parris, Project Chemist
Enviro Control, Inc.
One Central Plaza
11300 Rockville Pike
Rockville, MD 20852

Dear Dr. Parris:

This is in response to a request for information on toluene diisocyanate. The Dow Chemical Company is a member of the International Isocyanate Institute. This Institute has provided a detailed written response to the request published in the Federal Register of October 7, 1980 (p. 66506). Dow participated in the formulation of this response and our information has been incorporated into that document.

As additional information we are enclosing a technical bulletin published by Dow and a copy of our safety data sheet.

We believe that occupational exposure potential is very limited since the process is essentially totally enclosed. This process does produce several waste streams but these are properly destroyed by incineration.

The primary markets for TDI are as an intermediate in the manufacture of polyurethane foams, plastics and coatings. Detailed market information and annual production data are confidential.

We hope this information will be helpful to you. If you have need for additional information or have questions regarding this material, please feel free to contact me, in writing.

Sincerely,

Carlos M. Bowman
Regulatory and Legislative Issues
Health and Environmental Sciences
1803 Building

msg

Enclosures

cc: Martin Greif

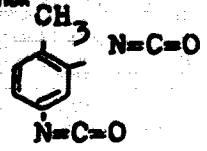
THE DOW CHEMICAL COMPANY
MIDLAND MICHIGAN

DATA SHEET OF PROPERTIES, HEALTH HAZARDS, AND PRECAUTIONS FOR SAFE HANDLING OF MATERIALS

K-22862

MOLECULAR FORMULA	CHEMICAL NAME
$C_9H_6N_2O_2$	TDI, Tolylene 2,4-diisocyanate
MOLECULAR WEIGHT 174.15	**INDUSTRIAL HYGIENE STANDARD** 0.02 ppm
SYNONYMS	

STRUCTURAL FORMULA - OR COMPOSITION



The commercial material contains about 20% of the 2,6-isomer.

PHYSICAL AND CHEMICAL PROPERTIES

BOILING POINT	EXPLOSIVE LIMITS (% BY VOL. IN AIR)	FLASH POINT	IGNITION TEMP.	MELTING POINT	VAPOR PRESSURE mm Hg 25°C
250 °c 760 mm Hg.		°F.	°C.	°C.	Approx. 0.015

CORROSIVENESS (To Common Metals)	PHYSICAL STATE	COLOR
May be corrosive (corrodes Sarallow)	liquid	Water-white, turns straw-colored on sta

CHEMICAL REACTIVITY Reacts with compounds containing active hydrogen, esp. with a basic catalyst present.

ODOR (Include Concentration in Air) Is irritati nose and throat at 0.5 p

STABILITY (To pH Change, Heat, Light)

TOXIC PROPERTIES

TYPE OF CONTACT	CLASSIFICATION OF TOXIC PROPERTIES	
EYE	☐ May cause no response or no more than very slight to slight transitory pain and/or slight transient corneal injury and/or irritation of the eyelids	☐ May cause some permanent loss of vision (this includes scar to cornea or internal injury which is incompletely healed in a week.)
	☒ May cause sufficient injury to the eye to result in loss of time from work. (This includes ~~damage to the cornea which heals or~~ nearly heals spontaneously with ~~some~~ considerable conjunctival irritation with ~~some~~ which might persist for a week.	☐ Vapor exposure may cause severe pain, lacrymation or severe injury to the eyes.
SKIN	☐ Single prolonged exposure (hours) causes no effect. Several repeated prolonged exposures may or may not cause the development of some slight irritation.	☒ Single short exposures (minutes) may cause considerable irrit and/or single prolonged or frequently repeated short exposu cause~~s~~ considerable swelling.
	☐ Single prolonged exposure may cause some reddening of the skin. Repeated prolonged contacts may cause appreciable irritation, possibly a mild burn and/or may cause appreciable systemic injury due to absorption.	☐ An exposure rapidly causes severe burns and/or serious sys injury, even death.
INHALATION — DUST OR MIST	☐ No systemic injury expected. No irritation to nose and throat in dusty or misty atmospheres.	☐ Dusty or misty atmosphere painful to nose and throat (intole to most people) and/or exposure may cause serious systemic injury.
	☐ Throat and nose irritation in a dusty or misty atmosphere is painful but not intolerable and/or prolonged or repeated exposures may cause systemic injury.	☐ Short exposure (minutes) may cause death or serious system injury.
INHALATION — VAPOR	☐ Exposures do not cause any effects other than some very slight irritation or pain to the eyes or respiratory passages at the most.	☐ Exposures may cause extreme drowsiness, and/or serious systemic injury, and/or may cause intolerable irritation to t respiratory passages.
	☐ Single exposures exceeding 1/2 hour, or frequently repeated exposures of shorter duration, may cause slight anesthesia and/or slight systemic injury, and/or cause appreciable, but not intolerable, irritation of respiratory passages.	☐ Short exposures may cause unconsciousness, and/or serious systemic injury, including death.
	☒ Even very short exposure will cause serious systemic injury or death.	
INGESTION	☒ Amounts which may be swallowed incidental to industrial handling will not cause injury. However, if substantial quantities should be swallowed, more or less serious effects may occur.	☐ Amounts which may be swallowed incidental to industrial handling and use may cause serious injury

COMMENTS This material can produce asthmatic sensitization upon either single inhalation exposure to a relatively high concentration, and/or upon repeated inhalation exposure to lower concentrations. Exposure to th vapors of TDI heated to 100°C. may produce death. The lethal effect may be delayed several days. Sensitization of the skin may occur as the result of skin contact.

0 0 0 4

TDI, Tolylene 2,4-diisocyanate

DEGREES OF EXPOSURE RELATED TO TYPES OF OPERATION		PRECAUTIONS (SEE CODE BELOW)				
		EYES	SKIN	INHALATION* DUST OR MIST	INHALATION* VAPOR	INGESTION
CT	Characterized by remote operation with equipment isolated from the work area. The persons entering isolated areas will require the personal protection outlined for IV below.	A	A		A	A
MINOR CONTACT	Characterized by closed systems with equipment vented outside the work area; instrument control; mechanical handling of materials in bulk. Examples are: continuous reactors, stills and filters; enclosed conveyors; ventilated packaging.	A	A		*C	A
OCCASIONAL DAILY CONTACTS	Characterized by manual handling of materials in packages such as bags, drums and fiberpaks. Ventilation may be provided for specific jobs. Many batch operations fall into this category.	**B	C		D	A
GROSS CONTACT LIKELY	Characterized by hand operation. Examples are: Emergency repairs, cleaning equipment, cleaning filters, taking care of spills, packaging volatile or dusty materials without ventilation, wheeling and tray drying.	**C,	D		D	A

EYE CONTACT

A No eye protection needed.
B Use safety glasses without side shields.
C Use safety glasses with side shields.
D Use chemical workers goggles.
E Use gas tight goggles or a full face gas mask.

SKIN CONTACT**

A A bath and clean clothes once per week along with the usual washing at mealtimes should be adequate precautions.
B Grossly contaminated clothing and shoes must be removed not later than the end of the work period and must be thoroughly cleaned before re-use.
C Require shower at the end of the work period and clean clothing from the skin out at the start of each work day.
D Clothing should be changed and skin washed promptly upon any detectable contact. Each use will require special consideration to determine suitable protective devices and standards of personal cleanliness.
E Impervious clothing such as rubber boots, rubber aprons, and rubber gloves will be required. Specific use will be directed as required by circumstance.

INHALATION*

DUST OR MIST

A No respiratory protection.
B No protection required for exposure of thirty min. duration or less to obviously dusty atmospheres. Exposures of longer duration will require the use of a dust respirator bearing the approval of the U. S. Bureau of Mines for the use with toxic dusts.
D Any exposure to obviously dusty atmospheres will require a dust respirator bearing the approval of the U. S. Bureau of Mines for use with toxic dusts.
E Any exposure to dusty atmospheres will require the use of an airline respirator, blower mask, or Chemox mask.

VAPOR

A No precautions necessary.
B No precautions necessary for single exposures of less than 1/2 hour. Longer single exposures, or frequently repeated exposures will require a gas mask or respirator equipped with appropriate canister.
C No precautions necessary for single exposures of no more than ten minutes. Longer exposures either single or repeated, will require gas mask or respirator equipped with appropriate canister.
D Gas mask with appropriate canister required at all times.
E Evacuate area at once and enter only with airline respirator, blower mask or Chemox mask.

INGESTION

A No unusual precautions required.
E Food and tobacco should not be present in the work area. Hands and face should be washed before smoking and eating.

COMMENTS

**GOOD PRACTICE REQUIRES THAT GROSS AMOUNTS OF ANY CHEMICAL BE REMOVED FROM THE SKIN AS SOON AS IS PRACTICAL

*SUITABLE GAS MASK CANISTER
Organic Vapor

Warning properties of this material (irritation of the eyes, nose and throat) are not adequate to prevent chronic overexposure from inhalation.

* If workmen are to occupy the same area with equipment which is handling TDI, they must wear suitable respiratory protection at all times unless assurance is given by air analysis that hazardous concentrations of TDI are not present in the atmosphere.

** If formulations containing TDI (or free isocyanate groups) are sprayed, persons within 150 feet downwind should wear better eye protection than side-shield spectacles, as particles of overspray are extremely painful in the eye. Side-shield safety spectacles are not adequate protection against overspray.

SIGNED Revised by J. E. Peterson CHECKED H.R.H.

DATE 5/22/61 DATE 5/22/61

0 0 0 5

Unloading Procedures . . . . Tank Cars

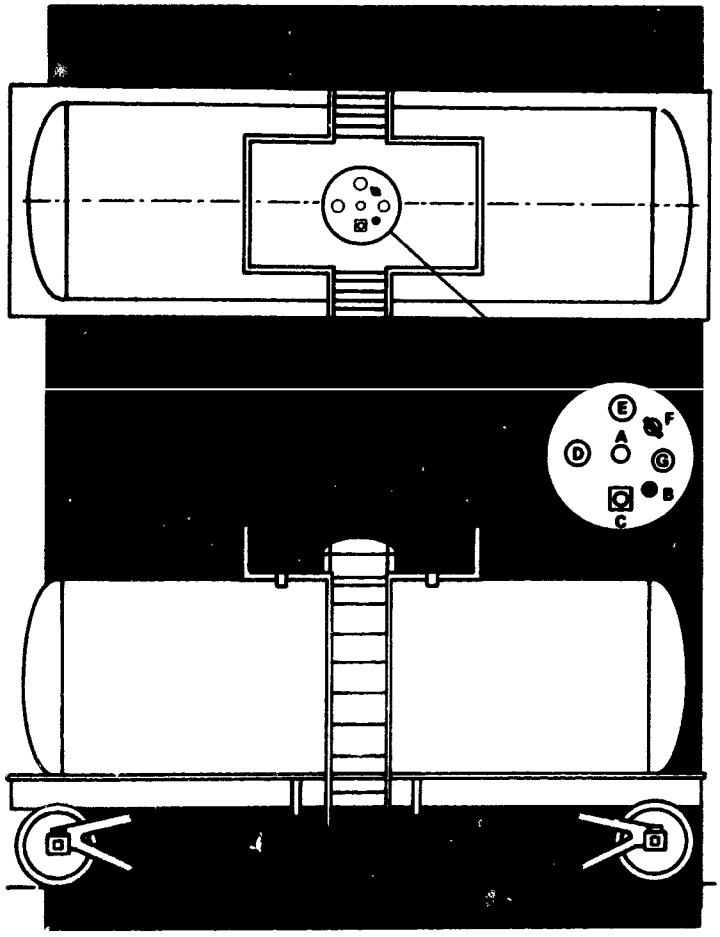
VORANATE T-80 isocyanate is shipped in insulated, baked-phenolic-lined tank cars, equipped with external heating coils and a safety valve set for 75 psi. (Note: Tank cars from The Dow Chemical Company may be unloaded only from the top. They are equipped with excess flow check valves set at approximately 130 gpm. Do *not* attempt to unload at higher rates.) The same general unloading procedures used for tank trucks may be used for tank cars. The following steps are exceptions to the tank truck unloading procedure.

Read and follow carefully each of the safety recommendations and precautions listed below:

1. Tank cars to be unloaded should have the brakes set and the wheels chocked, and should be protected by a "derail" located at least 50 feet from the car. (Note: Be sure to attach a signal flag to the rail to indicate that the derail is in the derailing position.)
2. Verify that the proper car is being unloaded. (Note: Carefully check the car number against the bill of lading or other appropriate document. Also, sample the contents to be sure that the materials is indeed TDI.)
3. Check the temperature of the tank car by removing the cap from the thermowell (B) and inserting a thermometer approximately 24" for 15-20 minutes. (Note: The temperature of the contents must be above 59°F (15°C) when the car is unloaded.) Should heating be necessary, remove the cover from the magnetic gauge (A) and raise the gauge rod to engage the magnet on the float. Monitor the outage to assure that expansion does not fill the car "liquid full" and cause it to "pressure relieve" through the safety valve. (Note: The pressure on the tank car should be carefully monitored during heating. Do *not* allow pressure to go beyond 39 psig. Also dry nitrogen is recommended for padding.)
4. Connect the unloading line to the

Tank Car

- A — Gauging Device
- B — ¼" Thermowell
- C — 75 # Safety Valve
- D — 2" Top Unloading Valve
- E — 2" Vent Valve
- F — ¼" Sample Valve
- G — 2" Top Unloading Valve
- H — 2" Steam Coil Outlet
- I — 2" Steam Coil Inlet
- J — Safety Platform



Note: On some 17,000 gallon DOWX series cars there is a variation in the dome valving configuration. The diagram shows the normal configuration. However, in some cars the positions of A (the gauging device) and C (the 75# safety valve) are reversed.

unloading valve (G or D) and the pad gas line to the vent valve or pressure connection (E). (Note: All TDI tank cars are equipped with 2" removable plugs on the unloading valves and 1" removable plugs on the vent valves. Also, while the safety valve on the car is set at 75 psig, pad gas pressure should be regulated so as *not* to exceed 40 psig. In addition, each unloading line has an excess flow valve which will close at approximately 130 gpm.) CAUTION: Any throttling of flow should be in the plant unloading line. Valves on the tank car should be fully open so that the excess flow valves can check off in the event of a line rupture. Storage tank pressure should be carefully controlled and monitored during the unloading operation.

5. After the tank car is empty, unloading lines should be blown clear of liquid and blocked in before being disconnected. (Note: Adequate respiratory protective equipment should be worn when disconnecting lines.)
6. Before releasing, pad the tank car with 10-40 psig of nitrogen. Display DOT approved "EMPTY" placards and release the car for return to DOW.

*Note: Unloading must be *closely monitored,* particularly if there is no automatic "cut off" in the unloading line. For example, if gas flow is allowed to continue after unloading, the gas flowing into the storage tank could rapidly increase internal pressure. This could cause serious structural damage to the storage vessel.

DOW CHEMICAL U.S.A.
An Operating Unit of The Dow Chemical Company
ORGANIC CHEMICALS DEPARTMENT
MIDLAND, MICHIGAN 48640

DOW

Unloading Procedures . . . . Tank Trucks

VORANATE T-80 isocyanate is shipped in pressurized and insulated stainless steel tank trucks, equipped for bottom unloading only. (Note: Only properly trained and equipped personnel should be permitted to unload tank trucks. Operators should wear an appropriate respiratory protective device and impervious clothing, footwear, and gloves).

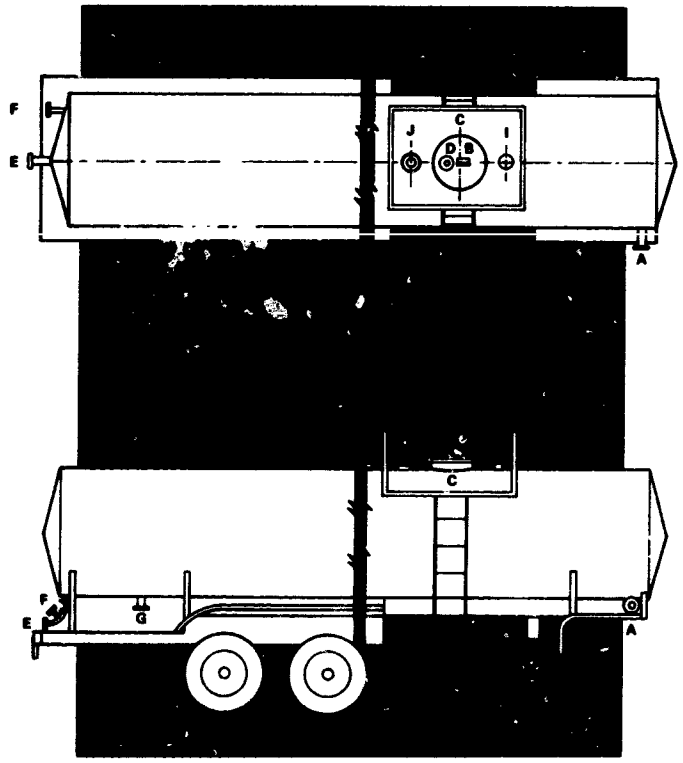
Read and follow carefully each of the safety recommendations and precautions listed below:

1. Position the trailer as level as possible and block the wheels.
2. Check the temperature of the contents. (Note: The temperature must be *above* 59°F (15°C) when the trailer is unloaded.)
3. If heating is required, attach a 25 psi steam supply to the heating coil inlet connection. Attach a steam trap, designed for the steam pressure available, to the heating coil outlet connection. (Note: For better control of the heating process, use a steam pressure of 15 psi.) Allow the contents to warm until the temperature is at least 68°F (20°C). When the temperature reaches 68°F (20°C), turn off the steam and disconnect the lines. (Note: To prevent the heating coils from freezing during cold weather, be sure to drain them or "blow them out.") CAUTION: Carefully watch the thermometer during heating. Do *not* allow the temperature to rise above 104°F (40°C).
4. Attach the unloading line. (Note: The line should be clean, dry, and preferably made of flexible metal or rubber hose which can safely withstand unloading pressures.)
5. Connect the dry purge gas (preferably nitrogen) line to the tank truck. Note: This line should have a pressure gauge, a safety valve set at 30 psig, and a pressure regulator set at 25 psig.)
6. Draw off a sample of the contents for analysis. (Note: A sample of the contents may be obtained by connecting stainless steel tubing to the sample connection. Flush the sample connection by drawing off at least one gallon of TDI into a clean, dry container. The sample to be analyzed may now be drawn off into another clean, dry container of whatever size is necessary for testing. CAUTION: Do *not* breathe vapors. Wear proper protective equipment whenever there is any possibility of contact with TDI liquid or vapors.)

7a. *If the contents are to be unloaded by purge gas pressure alone,* the storage tank should be

Tank Truck Trailer

- A — ¾" Steam Inlet
- B — 35 # Safety Valve and Pressure Gauge
- C — Manhole
- D — ¾" Dry air / Nitrogen Connection
- E — 3" Unloading Connection
- F — ¾" Sample Valve
- G — Steam Outlet
- H — Air Dryer
- I — 2" Loading Line
- J — 2" Vent Line



fitted with a vent scrubber. This will prevent TDI from being vented into the atmosphere during unloading. (CAUTION: Do *not* exceed 25 psig purge gas pressure to unload the tank truck.) When the tank truck is empty, the pressure gauge will show a drop in pressure. Close the valve at the storage tank connection *first*. Then close the truck unloading valve.

7b. *If the contents are to be unloaded by pump,* either a vapor line connecting the storage tank vent to the tank truck should be installed (closed loop) or a low-pressure, replenishable gas pad must be placed on the tank truck. (Note: If a gas pad is used, install a vent scrubber on the storage tank vent.) These precautions will not only prevent TDI vapors from being vented to the atmosphere, but will prevent a vacuum from being pulled on the tank truck during unloading. (CAUTION: Do *not* use a closed loop system unless the dead air space in the storage tank is free of moisture; i.e., −40°F (−40°C) dew point. Also, connection hoses should be purged with dry air or nitrogen before hookup.) When the trailer is empty, allow the unloading hose to vent down to the storage tank. Note. Be sure to close the valve at the storage tank connection *first*. Then close the tank truck unloading valve.

8. Shut off the purge gas to the tank truck. Close the tank truck purge gas valve and disconnect the purge gas line. (Note: If a closed loop system was used in conjunction with pump unloading, close the tank truck connection valve and the tank vent valve. Then disconnect the hose connecting the two.) All connection hoses should now be cleaned, dried, and capped for storage.

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ORGANIC CHEMICALS DEPARTMENT
MIDLAND, MICHIGAN 48640

VORANATE T-80 Isocyanate Safe Handling and Storage

Safe Handling and Storage of VORANATE T-80 Isocyanate

Contents

Introduction

VORANATE* T-80 Isocyanate —one of a growing number of quality isocyanate products manufactured and marketed by The Dow Chemical Company — is a unique mixture of the 2, 4 and 2, 6 isomers of toluene diisocyanate (TDI) in a ratio, by weight, of 80 to 20 percent. It is available in two acidity grades (i.e., Type I: low acidity; Type II: high acidity) and is produced in accordance with exacting standards of quality and product purity.

VORANATE T-80 Isocyanate is widely used in a variety of industrial applications, including the production of flexible urethane foams for furniture, bedding, and automotive applications. It is also widely used in the production of semi-flexible and rigid urethane foams, urethane sponge carpet backing, carpet underlayment, elastomers, coatings, and adhesives.

VORANATE T-80 Isocyanate is now available both in bulk quantities (via tank truck or tank car) and in 55-gallon, one-way, non-returnable drums. (Note: Since bulk systems and shipments are generally more economical and significantly reduce the possibility of product contamination, they are particularly recommended.) Regardless of the grade or quantity ordered, however, it must be emphasized that VORANATE T-80 Isocyanate is a potentially hazardous material which must be handled and stored only by knowledgeable and experienced personnel who are thoroughly familiar with the hazards associated with its use.

It is the purpose of this booklet, therefore, to inform the customer fully of the hazards associated with VORANATE T-80 Isocyanate and to outline in detail those practices and procedures which have been developed to assist in its safe storage and handling. In short: "Chemicals in any form can be safely stored, handled or used if the physical, chemical, and hazardous properties are fully understood and the necessary precautions, including the use of proper safeguards and personal protective equipment, are observed."†

Warning:

VORANATE T-80 Isocyanate is a potentially hazardous material which *must* be handled, used, and stored with extreme care and in strict compliance with the safety recommendations and precautions outlined on the product label and described in this booklet. Note: The recommendations contained in this booklet are based on the results of numerous tests and on actual experiences in the field, and are believed to be accurate and reliable. However, since the specific circumstances associated with a customer's use of VORANATE T-80 Isocyanate are unknown to The Dow Chemical Company and are beyond its control, it cannot guarantee that adherence to these recommendations will insure absolute safety. Inquiries about specific operations and procedures or about matters relating to the safe use, handling, and storage of VORANATE T-80 Isocyanate may be addressed to The Dow Chemical Company, Organic Chemicals Department, Midland, Michigan 48640.

*Trademark of The Dow Chemical Company

†Quoted from a publication of the Manufacturing Chemists Association.

Part I

Properties, Handling Precautions, and Industrial Hygiene

Properties

Table 1—Typical Physical Properties

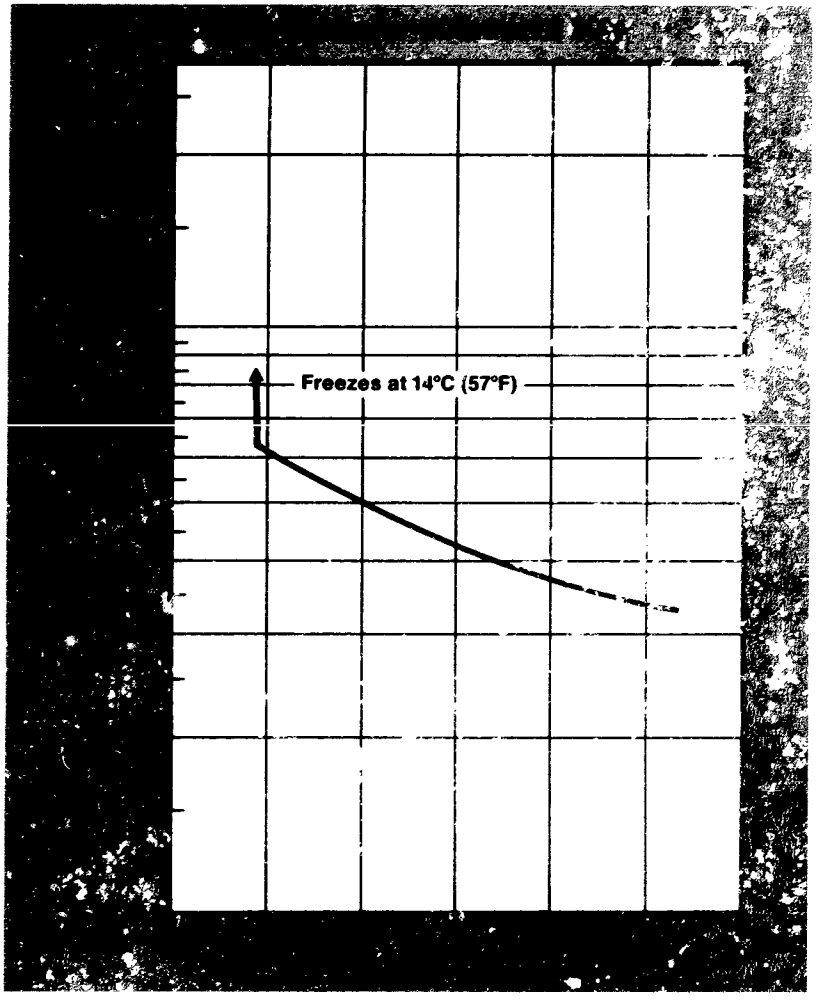
Properties[1]	Values
Molecular Weight	174.2
Physical Form	Colorless to Pale Yellow Liquid
Odor	Very Sharp and Pungent
Density (@ 20°C), lbs/gal	10.2
Specific Gravity (25°C/25°C)	1.22
Boiling Point at 10 mm Hg	248°F (120°C)
at 760 mm Hg	482°F (250°C)
Viscosity @ 77°F (25°C) cps	3
Freezing Point	57°F (14°C)
Flash Point	
Cleveland Open Cup	270°F (132°C)
Pensky-Martens Closed Cup	260°F (127°C)
Tag Open Cup	270°F (132°C)
Fire Point	
Cleveland Open Cup	295°F (146°C)[2]
Refractive Index @ 77°F (25°C)	1.5451
Specific Heat, Btu/lb. °F	0.35 @ 68°F
	0.41 @ 212°F
Specific Heat, cal/gram, °C	0.35 @ 20°C
	0.41 @ 100°C
	Btu/lb cal/g
Heat of Evaporation	
@ 250° (121°C)	131 73
@ 392°F (197°C)	121 67
Decomposition Temperature	530°F (267°C)
Vapor Density (Air = 1)	6.0
Vapor Pressure @ 77°F (25°C), mm Hg	0.01

[1] Typical properties, not to be construed as specifications.

[2] Results of small scale tests are not intended to reflect behavior of this or any other material under actual fire conditions.

Table 2—Specifications VORANATE T-80 Isocyanate

Properties	Type I Low Acidity Grade	Type II High Acidity Grade



Handling Precautions

Toluene Diisocyanate (TDI)

To insure product quality and to minimize the potential hazards associated with its use, VORANATE T-80 Isocyanate should be handled and stored only by knowledgeable and experienced personnel. Extreme care, for example, must be exercised to avoid exposing the product to water, heat, strong bases, and amines or other active hydrogen-containing compounds, all of which are among the most common sources of deterioration in the quality of TDI. Extreme care must also be exercised to minimize the hazards of fire and accidental spills. Be sure, therefore, before handling, using, or storing VORANATE T-80 Isocyanate, to read carefully the recommendations and precautions listed below.

Moisture Control

The most common contaminant encountered and one of the more hazardous, is water, which, at room temperature, reacts readily with TDI to form both a white, insoluble urea compound and carbon dioxide. This insoluble urea derivative will be deposited on the surfaces of the equipment in which it is formed. Should the lines and orifices become plugged, thus closing or restricting the vessel, the liberated carbon dioxide could present an extreme pressure hazard. In short, the presence of water or large amounts of moisture can produce sufficient carbon dioxide to rupture the container. (Note: Even small quantities of water can cause significant problems. For example, at standard temperature and pressure, as little as one pound (0.454 kg) of water can release as much as 21 cu ft (0.6 cu meter) of gas.)

Read and follow carefully each of the safety recommendations and precautions listed below:

- Do *not* tightly close containers of TDI if the product has been, or is suspected of having been, contaminated with water.
- To protect TDI from atmospheric moisture, use a dry, −40°F (−40°C) dew point, inert gas pad. (Note: Dry air having the same dew point may also be used. However, since TDI may be discolored by oxidation, nitrogen is preferred.)
- Carefully clean equipment or containers to be used for TDI; then purge with a dry gas before using. (Note: The purge gas, in addition to being moisture-free, must also be free of oil and rust. Filter traps in the gas lines are recommended for the removal of rust particles.)
- For small installations, manifolded cylinders of dry nitrogen arranged into banks may be adequate. Larger installations, however, may call for a nitrogen generator, a compressed air system, or a tie-in to existing plant gas systems. (Note: if a plant air system is used, purification equipment, such as oil traps, a bauxite absorber to keep oil out of the drying beds, and an air dryer, should be installed between the compressor and the TDI system. Also, a final filter should be fitted just in front of the TDI system. Stainless steel pipe or tubing should be used between the filter and the system.)
- Instrumentation for detecting the failure of the drying equipment for the purge gas is recommended when quantities of TDI are handled and stored. (Note: Moisture-detecting instruments may be obtained from many of the manufacturers and suppliers listed on page 29.)
- When lines leading to and from storage tanks are not in use, they should be tightly plugged or capped. This will prevent moisture from coming in contact with residual TDI left in the lines. Also, all flexible connection lines should be rinsed with methylene chloride, or other suitable solvent.* These fittings should be dried and stored in a dry place. (Note: a plastic bag containing a desiccant, such as silica gel, makes a convenient, portable dry place for storing such items.)

Temperature Control

Ideally, VORANATE T-80 Isocyanate should be stored at temperatures between 65°F (18°C) and 105°F (40°C). This may be accomplished by equipping the storage tank with either a heat exchanger installed in the storage tank recycle line or an external plate coil mounted on the outside of the tank. In addition, storage tanks should be insulated or otherwise protected from ambient weather conditions.

Read and follow carefully each of the safety recommendations and precautions itsied below:

- Before using VORANATE T-80 Isocyanate stored in storage tanks or drums, warm, thoroughly mix, and inspect the contents to be sure that no solids are present. (Warning: Avoid inhalation of vapors formed when VORANATE T-80 Isocyanate is heated.)
- If a storage tank is to be equipped with an external plate coil, be sure it is mounted on the outside of the tank. This will not only eliminate the possibility of contamination of the TDI by a water leak in the heating coils, but will also minimize the possibility of localized overheating.
- If TDI should freeze — the freeze point is approximately 57°F (14°C) — the 2,4 and 2,6 isomers may separate. If this occurs, the TDI should be warmed to a maximum temperature of 95°F (35°C) and thoroughly mixed. (Note: Do *not* heat TDI above 105°F (40°C) as discolorization and dimerization may occur. Also, at temperatures above 212-248°F (100-120°C), TDI will trimerize in an exothermic reaction to form isocyanurates. This reaction may furnish enough heat — more than 347°F (175°C) — to cause the formation of carbodiimides and the subsequent formation of carbon dioxide. This second reaction may create a pressure hazard in a closed or restricted vessel.)
- During the winter, drum deliveries may arrive in a solid state. If this occurs, the TDI can be readily liquefied by heating the product to a maximum temperature of 95°F (35°C). (Note: Be sure that the liquefied TDI is thoroughly remixed before use. Also, do *not* use partially melted material. Since the 2,4 isomer melts at a higher temperature then the 2,6 isomer, the supernatant liquid in contact with the crystals will have a higher 2,6 isomer content than the completely liquid product. Also, since the 2,6 isomer reacts more slowly with compounds having an active hydrogen than does the 2,4 isomer, the supernatant liquid will have a slower reaction rate than the material as a whole. This could cause serious processing difficulties.)

*Note: Most solvents are both toxic and flammable and should be used with care. Be sure to follow all label directions and precautions.

Strong Bases

The presence of strong bases — even in small amounts — can cause TDI to react with itself to form isocyanurates and carbodiimides. The carbodiimide formation is accompanied by the liberation of carbon dioxide, which may present a pressure hazard.

Read and follow carefully each of the safety recommendations and precautions listed below:

- Avoid any contact between strong bases, such as sodium and potassium hydroxide or alkoxides, and TDI. Such compounds catalyze the rapid formation of isocyanurates and carbodiimides. Normally, the trimerization reaction occurs first, furnishing heat to cause the carbodiimide reaction to occur. This second reaction liberates carbon dioxide — which could result in the rupture of a closed or restricted vessel — and a hard solid or foam which can only be removed from the vessel or line by mechanical means.
- A likely source of contamination by strong bases is from industrial cleaning. Do *not* use, or permit the use, of sodium or potassium hydroxide or other strong bases in the cleaning of lines or vessels.

Contamination from Amines and Other Active Hydrogen-Containing Compounds

The primary dangers from contamination by amines and other active hydrogen-containing compounds are product contamination and the liberation of heat.

Read and follow carefully each of the following safety recommendation and precautions:

- Avoid contamination of TDI by such compounds as alcohols, glycols, phenols, amines, amides, and acid anhydrides. Such compounds will react readily with TDI to form their corresponding addition products. (Note: Although reactions caused by contamination from amines or other active hydrogen-containing compounds do not release a gas, they do release considerable quantities of heat.)
- In the event of gross contamination, the exothermic reaction could raise the temperature of the mixture above 212-248 F (100-120 C). This could result in the secondary reaction of trimerization — an exothermic reaction which, in turn, could raise the temperature of the mixture above 347°F (175°C). At this temperature, another secondary reaction — the homopolymerization of the TDI to carbodiimides — can occur, with a concurrent release of carbon dioxide. Finally, the release of quantities of carbon dioxide especially in a closed or restricted vessel — could lead to an explosive rupture.

TDI Fire Hazards

Toluene diisocyanate has been classified as a Class III B combustible material by the National Fire Protection Association. (Depending on the method used, the flash point of TDI is between 260 and 270°F (126-132°C). The flammability limits are 0.9 to 9.5 percent.) In short, TDI will burn in the presence of an existing fire or high heat source and adequate oxygen. (Note: The low volatility of TDI minimizes the potential hazard of explosion. However, under fire conditions in which a large concentration of isocyanate vapor may be generated, explosive limits could be attained and an explosion could occur.)

Read and follow carefully each of the safety recommendations and precautions listed below:

- In the event of an isocyanate fire, use a carbon dioxide or dry chemical extinguisher. For fires covering large areas, use a water spray.
- Personnel engaged in fighting TDI fires must be protected against nitrogen dioxide vapors as well as TDI fumes. (Note: Fire fighters should wear a self-contained breathing apparatus and fire-resistant clothing, footwear, and gloves.)

Spills and Leaks (Containment and Clean-Up)

Spills or leaks of TDI should be contained and cleaned up only by properly trained and equipped personnel. All others should promptly leave the contaminated area. Protective equipment should include appropriate respiratory protective devices and impervious clothing, footwear and gloves. Also, work areas should be equipped with safety showers and eye baths in good working order. TDI or other chemicals accidentally spilled or leaked onto the skin should be quickly washed off. (Note: An approved* respiratory protective device *must* be worn whenever there is any possibility of exposure to

* The authority for approving or certifying respiratory protective devices has recently been transferred jointly to the National Institute for Occupational Safety and Health (NIOSH) and the Mining Enforcement and Safety Administration (MESA). For current information on the status of approvals for respiratory protective devices, contact any of the manufacturers or suppliers listed on page 31 or write to the National Institute for Occupational Safety and Health, Morgantown, West Virginia 26505.

toxic concentrations of vapors of TDI. An air-supplied or self-contained breathing apparatus, equipped with a full facepiece, hood, or helmet, is recommended. See "Respirator Selection Guide "on page 13.)

Method I: Using a Premixed TDI Neutralizer

All leaks and spills should be immediately "neutralized" to prevent further contamination of the surrounding area. This can best be accomplished by promptly covering the spill with an effective TDI neutralizer, such as the one described above.

Read and follow carefully each of the safety recommendations and precautions listed below:

- Always have a sufficient quantity of premixed TDI neutralizer in storage. (Note: premixed neutralizer may be stored in tightly closed heavy-duty polyethylene bags. Seal bags with wire twists.)

*Caution: alcohols are highly flammable. Keep neutralizer mixture away from heat or open flame.

**Conventional urethane amine catalysts may be substituted for triethanolamine.

- Ventilate the area. Open all doors and windows. (Note: To avoid inhalation of the vapors of either TDI or the decontaminants used, workers should wear appropriate respiratory protective devices; e.g., a self-contained breathing apparatus. See "Respirator Selection Guide" on page 13.
- Leaking drums should be immediately removed to the outdoors or to an isolated, well-ventilated area and the contents carefully transferred to other suitable, leak-free containers.
- Promptly cover the spilled or leaked material with the TDI neutralizer. (Note: For more effective coverage, and to ensure greater contact between the neutralizer and the TDI, use an industrial type heavy-duty broom to sweep the neutralizer into the spill.)
- After the neutralizer has been on the spill for at least two hours, shovel the material into a steel container and dispose of properly. (Note: The broom should be wrapped carefully in plastic to contain the contaminants and then burned in an incinerator. See "Disposal" on page 8.)
- Note: The use of neutralizing solvents and other chemicals may introduce additional hazards of toxicity and flammability. Such materials, therefore, *must* be used in strict compliance with the manufacturer's recommendations and precautions.

Method II. Using an Absorbent Material

The following is an effective alternate method for handling leaks or spills in the event a premixed neutralizer is not available.

Read and follow carefully each of the safety recommendations and precautions listed below:

- Ventilate the contaminated area. Open all doors and windows. (Note: To avoid inhalation of the vapors of either TDI or the decontaminants used, workers should wear appropriate respiratory protective devices; e.g., a self-contained breathing apparatus.)
- Completely cover the leak or spill with an absorbent material, such as sawdust, vermiculite, an all-purpose commercial oil absorbent, or sand. Use an amount greater than is estimated to be necessary to absorb the TDI.
- Carefully shovel the absorbent-TDI mixture into an open top steel container; cover, but do *not* make pressure tight. Remove to a safe disposal site away from the operating area.
- Soak the mixture in the container with a solution of 5 percent ammonia in water and allow it to stand undisturbed for at least 24 hours. (WARNING: Considerable heat, which could cause ignition, will be

generated when the aqueous ammonia solution is first applied. After standing for 24 hours, however, the drum may be closed (though *not* pressure tight) and properly disposed of. (See "Disposal" on page 8.)

- Immediately after shoveling the absorbent-TDI mixture from the floor, complete the decontamination by mopping the floor with a solution of 5 percent aqueous ammonia and 10 percent isopropyl alcohol (rubbing alcohol). Be sure the area is well ventilated both during and after cleanup.

Cold Weather Spills

During cold weather, spilled or leaked TDI may freeze. Under these conditions, the use of ammonia and water will merely coat the frozen material with an insoluble urea, stopping further reaction. It is essential, therefore, to use a solution that will not only dissolve the frozen TDI, but will also form a liquid product during decontamination.

Read and follow carefully each of the safety recommendations and precautions listed below:

- Estimate the quantity spilled, and make up a mixture of approximately 50% isopropyl alcohol* and 50% perchloroethylene by volume, using the same volume of each solvent as the estimated volume of spilled TDI. (Note: To avoid inhalation of the vapors of either TDI or the decontaminants used, workers should wear appropriate respiratory protective devices; e.g., a self-contained breathing apparatus. See "Respirator Selection Guide" on page 13.)
- Completely cover the spilled material with the alcohol-perchloroethylene solution.
- Allow the solution to remain in place for at least one hour.
- If practical, carefully wash down the contaminated area with copious amounts of water. If this is not practical (e.g., if the temperature is below freezing), cover the area with enough absorbent material to soak up all the liquid. Shovel this material into open top steel containers, treat, and dispose of properly. (Note: Thoroughly air or ventilate the decontaminated area to remove all traces of vapor.)
- Note: The use of decontaminating solvents and other chemicals may introduce additional hazards of toxicity and flammability. These materials, therefore, *must* be used with care and in strict compliance with the manufacturer's recommendations and precautions.

*Caution: Alcohols are highly flammable. Keep neutralizer mixture away from heat or open flame.

Major Spills

In the event of a major spill, a *State of Emergency* should be assumed to exist in the affected area.

Read and follow carefully each of the safety recommendations and precautions listed below:

- All persons not properly equipped with protective clothing and appropriate respiratory devices should immediately leave the site of the spill and should remain upwind.
- Only experienced and properly equipped personnel should attempt to isolate or contain the spill. Note: Do *not* wash spilled TDI down a drain or into a river or creek.
- Keep all improperly equipped and unauthorized personnel away from the spill area.
- *Immediately contact Dow Chemical U.S.A. Call Freeport, Texas: 713-238-2112.*

Disposal

Read and follow carefully each of the safety recommendations and precautions listed below:

- Fully neutralized TDI may be disposed of either by burial in an approved landfill or by burning in an approved incinerator.
- Only thoroughly trained and properly equipped persons should be permitted to participate in disposal operations.
- Note: Keep waste diisocyanate and waste polyol widely separated. Also, be certain that all disposal procedures are conducted in strict compliance with all applicable federal, state, and local regulations and ordinances.

Drum Decontamination

Read and follow carefully each of the safety recommendations and precautions listed below:

Residual TDI remaining after the emptying of drums may be decontaminated by the following procedures:

- Remove emptied drums from the work area to a well ventilated location or to the out-of-doors.
- Remove all bungs and fill drums with water. (Note: Wear protective equipment and keep face away from bungholes while filling. Also, do not reinstall bungs.)
- Allow drums to stand undisturbed for 48 hours or until

the residual TDI has been completely converted to solid urea. (Note: A dilute solution of aqueous ammonia or isopropyl alcohol may be added to the water to speed up the reaction.)

- All drums should be scrapped. They should be drained and crushed to render them totally unreusable.

Other Urethane Chemicals

Polyols

Most polyols are very low in acute oral toxicity and are considered only mildly irritating to eyes and skin. However, despite their relatively innocuous characteristics (compared with those of isocyanates), they should be handled with appropriate caution. *Skin and eye contact should be avoided.* (Note: Eye protection, such as safety glasses or their equivalent, should be worn whenever polyols are handled or used. Also, and because they are frequently used with chemicals that are an inhalation hazard, appropriate caution dictates thorough ventilation of all storage, handling, and manufacturing facilities.)

Catalysts

Catalysts are used in urethane chemistry to control both the polymer reaction and the gas-formation reaction. They are generally metal salts (i.e., stannous octoate) or tertiary amines (i.e., triethylenediamine). Both types of catalysts can be toxic, burn intact skin, and can induce sensitization. Eye contact can cause severe irritation or burn. *With either type of catalyst, therefore, skin and eye contact must be avoided.*

Many liquid amine catalysts have Tag Open Cup flash points in the range of 20° to 115° F (−6° to 46° C) and are classified, depending on the flash point, as flammable or combustible liquids. Because of their volatility and flammability, therefore, tertiary amines should be considered fire hazards.

Note: Users are cautioned to secure specific handling and disposal information from their catalyst suppliers.

Blowing Agents

Halocarbon blowing agents are commonly used in urethane foam manufacture and represent a significant health hazard.

Commonly used halocarbons are:

Trichlorofluoromethane (R-11) ..... 75° F (23° C) boiling point

Dichloromethane 104° F (40° C) boiling point

Trichlorotrifluoroethane (R-113) .....114° F (45° C) boiling point

Although they have a low order of toxicity, inhalation of high concentrations of the vapors of these products can be dangerous and may cause anaesthesia and unconsciousness. Cases have been cited showing that severe acute exposures to some fluorocarbons have caused cardiac arrhythmias, including ventricular fibrillation.

Although fluorocarbon blowing agents are generally considered nonflammable, they can, when heated to decomposition (as when drawn through a lit cigarette) generate quantities of highly toxic carbonyl chloride (phosgene) and carbonyl fluoride. In addition, when confined and subjected to high temperatures, fluorocarbon blowing agents may also present a serious pressure hazard.

Like the fluorocarbons, dichloromethane has neither a flash nor fire point as reported by any of the standard test methods: Tag Open Cup, Tag Closed Cup, Cleveland Open Cup. However, the National Fire Protection Association reports flammable limits in pure oxygen between 15.5% and 66% by volume of $MeCl_2$, and Dow laboratory data indicate flammable limits in air of 12%-19% by volume at 30°C, both of which are impractical under normal circumstances. However, when heated to decomposition, it too will produce a variety of hazardous and toxic materials, such as hydrochloric acid, chlorine, carbon dioxide, and carbon monoxide.

Note: Users are urged to contact their suppliers for detailed information and instructions on the handling and disposal of these blowing agents.

Miscellaneous Products

Many other additives, such as surfactants, fillers, fire retardants, pigments, and dyes, are used in various urethane applications. Each has its own profile of hazards and recommended safety precautions. It is essential, therefore, that users contact their suppliers for specific instructions on the safe handling, use, storage, and disposal of each of these products.

Application Hazards (Urethane Foam)

Urethane chemicals and foams, like many other industrial materials, can be hazardous if misused or improperly handled. However, when potential hazards are recognized and procedures for safe handling and storage are understood and practiced, urethane chemicals can be used safely.

Dust

Urethane foam dust produced during cutting, sawing, and other operations can cause mechanical irritation to the eyes and mucous lining of the nose and throat. In

addition, laboratory studies with rats indicate that long-term respiratory difficulties may be caused by exposure to large quantities of finely ground urethane dust.

It is imperative, therefore, that the generation and accumulation of dusts be carefully controlled during fabrication. If it is not feasible to install control devices, such as ventilators, then suitable equipment for respiratory and eye protection should be worn by all persons exposed to such dusts.

In addition, finely divided airborne urethane dust can, under the proper conditions, produce a "dust explosion." (Note: Even settled dust can be made potentially explosive by relatively low order concussions which can raise the dust into airborne "clouds.") To ensure safe working conditions, therefore, it is essential that workers exercise extreme care and practice good housekeeping in all urethane foam fabrication areas.

Combustibility

While product composition may vary, virtually all urethane foams are combustible and will burn readily, often generating a variety of toxic gases and dense clouds of black smoke. Even when fire retardant chemicals have been added to the formulation, the end product — under the right conditions of heat and oxygen supply — will burn. It is essential, therefore, that urethane foam producers, fabricators, and end users know and understand the combustibility hazards and burning characteristics of the final foam product.

Products of Combustion

When urethane burns, many products of combustion are released. What and how much are released varies with product composition, fire conditions, oxygen level, and other factors. As in all organic fires, however, large quantities of carbon monoxide, as well as other products, can be anticipated. In addition, large quantities of dense, dark smoke will be quickly generated which may make it difficult to escape from the fire area. Sprinkler systems, however, have proven effective in reducing smoke levels and in increasing visibility.

(Note: While many different tests are used to define the burning characteristics of urethane foam — some are small scale tests useful only in comparing different products — none are comprehensive enough to define the hazards in all potential fire situations. In short, no two fires are the same. Fire conditions vary with room size, ventilation, available oxygen, fuel load, ignition sources, types of materials present, and other factors. Also, how a given urethane material will react to such varying conditions depends on the type of foam, the type of covering or flame barrier, the source of ignition, the proximity to ignition or heat, etc. It is unlikely, therefore, that all potential hazards can be defined or eliminated from a potential fire condition. However, when used and stored within their known limitations, urethane foams can be handled with minimal hazard.)

Slabstock Foam Fires

The producer of urethane foam slabstock must consider the exothermic (heat generating) hazard of the urethane foam reaction. Because of the insulating effect of the foam, temperatures can be generated in the center of a bun which can cause decomposition and autoignition of the foam. This can occur several hours after bun manufacture when the material is largely unattended. Extremely reactive systems and those containing an improper ratio (i.e., off-index) of polyol and isocyanate are particularly susceptible. (Note: Similar conditions may exist in other urethane applications, particularly in spraying operations, where large masses of urethane polymer may be formed. Safety precautions similar to those for slabstock should be carefully followed.)

Read and follow carefully each of the safety recommendations and precautions listed below:

- Allow buns to cure and cool completely before stacking or storing. (Note: High air flow along the sides of fresh or hot buns may draw off reaction products and cause an influx of oxygen. This can cause rapid depletion of the antioxidant and could result in autoignition.
- Monitor bun temperatures at the center of the mass on a routine basis. This is particularly important with new formulations or new bun sizes.
- Design and construct slabstock pouring equipment to ensure "on-ratio" metering. Be sure equipment is kept carefully calibrated and in good working order.
- Cure bunstock in isolated areas equipped with effective fire detection equipment and sprinkler systems. (Note: Leave at least a three-foot clearance between the stacked buns and the sprinkler heads.)
- Do *not* smoke in storage areas.

Note: Large quantities of stored urethane foams or foam products can be a tremendous fuel source should a small fire start. In laying out manufacturing and storage areas, therefore, designers should consider maximum storage area, possible sources of ignition, and the location and effectiveness of fire and smoke detection equipment and sprinkler systems.

Construction Foam Fires

Urethane foam used for insulation can be a combustion hazard if it is left exposed or unprotected. For example, fires involving rigid urethane foam insulation have occurred in buildings under construction when exposed or unprotected foam was ignited by welding, cutting, or burning operations.

Read and follow carefully each of the safety recommendations and precautions listed below:

- Foam scrap should not be allowed to accumulate and should be properly disposed of daily.
- Open flames, cutting and welding torches, heaters, smoking, and other possible sources of ignition should be prohibited in foam storage and insulation areas. When hot work must be done near exposed urethane foam, shield the foam with a thermal barrier, and establish a fire watch. (Note: Do *not* do hot work on metal which is in contact with urethane foam.)
- Rigid foam boardstock should be stored in limited quantities and in an area free of sources of ignition. Be sure to provide adequate aisle space between stacks. (Note: Do *not* stack materials over 8 feet high. Also, sprinkler protection is strongly recommended.)
- Have fire extinguishing equipment available in both storage and insulation areas.
- Regardless of intended use or location, and as soon after installation as possible, cover the foam insulation with a thermal or flame barrier. (Note: For interior applications, a cover of one-half-inch cement plaster or fire-rated gypsum wallboard is considered adequate.)

Note: A bulletin, "Fire Safety Guidelines for Use of Rigid Urethane Foam Insulation in Building Construction," is available from the Society of the Plastics Industry, 250 Park Avenue, New York, N.Y. 10017.

Cushion Foam Fires

Many of the fire deaths in the U.S. are attributed to the misuse of smoking materials. Such fires frequently start in upholstered furniture and bedding. As a consequence, regulations have been passed or proposed requiring mattresses and other upholstered furniture to meet specified combustibility tests. Also, the proper combination of foam and covering material can now be selected to meet the standards established by these tests. It is essential, therefore, that manufacturers of urethane foam and foam products keep themselves informed of both the increasing knowledge of the combustibility hazards associated with the use of urethane foams and of changing regulations at the federal, state, and local levels.

Extinguishing Fires

Read and follow carefully each of the safety recommendations and precautions listed below:

- Know where all fire extinguishers are located and how to use them.
- For small urethane foam fires, use water, foam, dry chemicals, or carbon dioxide. Large fires of burning foam, however, should be drenched with large quantities of water from sprinklers or fire hoses.
- Because urethane foam is a good insulator, it is necessary to disperse and carefully inspect the foam after drenching to be certain that the fire has been completely extinguished.
- Note: Hazards of rapid heat buildup, rapid flashover, and oxygen depletion exist when fighting fires in enclosed areas. Fire fighters, therefore, should be equipped with self-contained breathing apparatus when extinguishing urethane fires of *any* magnitude.

Fire Safety and Prevention

Read and follow carefully each of the safety recommendations and precautions listed below:

- All workers should be thoroughly familar with the plant's fire emergency procedures.
- Workers should know where all exits are located. Also, access to exits should be kept clear and unobstructed.
- Smoking in areas where foams are made or stored should be strictly prohibited. No smoking areas should be clearly posted with large "NO SMOKING" signs.
- Welding torches, open flames, or other sources of high heat or ignition should be prohibited in areas where foams are made or stored.
- Keep work areas clean. Foam scraps, dust, and other waste materials should be promptly and properly disposed of.

Handling Precautions Summary

To minimize the hazards associated with the handling, use, and storage of urethane chemicals and polymers...

Read and follow carefully each of the safety recommendations and precautions listed below:

- Never work alone when using or handling reactive chemicals.
- Do *not* inhale vapors or mists. (Note: Be sure work areas are adequately ventilated to control vapors below workmen exposure limits established by

the Occupational Safety and Health Administration (OSHA)* or have workers wear suitable respiratory protective devices, particularly when handling isocyanates, amines, or solvated adhesives. See "Respirator Selection Guide" on page 13.)

- Avoid skin and eye contact with all formulation chemicals. (Note: Be sure all workers are properly equipped with protective clothing and eye protection.)
- Do *not* allow persons with a history of asthma, other respiratory problems, or allergic responses, to work with polyurethane chemicals.
- Handle freshly polymerized parts with care. Be aware of the potential hazards of toxic vapors and of the heat of cure.
- Do *not* stack fresh polyurethane buns. Insulation of the heat can cause spontaneous combustion.
- Equip polyurethane foam storage areas with sprinkler systems.
- Keep adequate quantities of isocyanate neutralizer on hand for quick decontamination of work areas in the event of spills or leaks.
- Never expose isocyanate in containers to water, amines, or other reactive chemicals.
- Never expose polyurethane chemicals in closed containers to elevated temperatures.
- Never expose a polyurethane foam to an open flame or high heat source.
- Always use proper dust handling equipment and dust filter masks when sawing or fabricating polyurethane foams or parts.

*See "OSHA Safety and Health Standards (29 CFR 1910)." Copies are available from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402.

Industrial Hygiene

Toxicity

The potential hazard of a given material is based both on the degree of toxicity and on the likelihood and level of exposure. Responsible users of chemical and industrial materials, therefore, must be concerned not only with the "toxicity" of such materials, but with the actual hazards which may be encountered under specific use conditions. In short, the greater the toxicity, the greater must be the control over the level of exposure. Remember: Toxic effects can occur not only from a single exposure *(acute toxicity)* but also from frequent, repeated exposures over a period of several hours or days *(subacute toxicity)*, or even from continuous or intermittent exposure over long periods of time *(chronic toxicity)*.

While significant hazards are associated with such materials as catalysts and blowing agents, the primary hazard in urethane chemical applications is associated with the isocyanate component, and particularly with the inhalation of its vapors. For example, even short exposures to relatively low concentrations of isocyanate vapor may cause progressively disabling effects to the respiratory function. As such, limits have been established regarding allowable isocyanate vapor concentrations in the work environment.

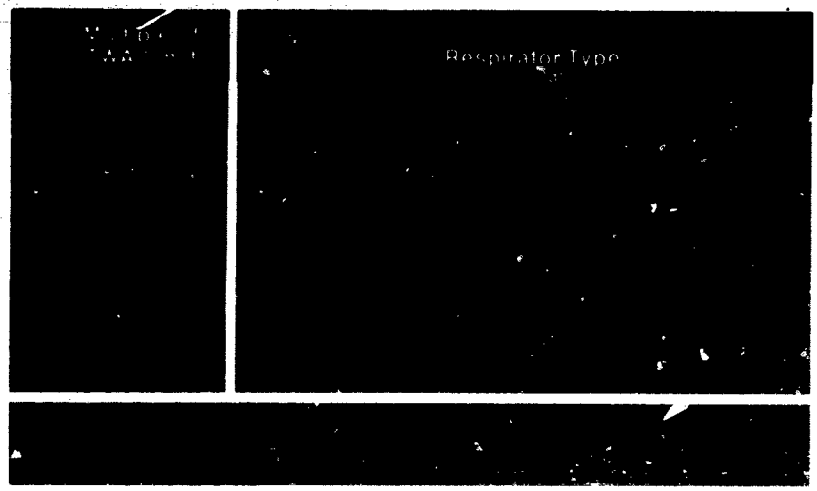
Presently, two values are used to describe those limits: the "acceptable ceiling concentration" which is the absolute maximum concentration not to be exceeded, and the "time-weighted average" (TWA) exposure limit, which is the concentration under which it is believed that nearly all workers may be repeatedly exposed for 8 hours a day, 40 hours a week, without adverse effect. (Note: It is important to remember that while these values represent the best current thinking of toxicologists and industrial hygienists, they offer no guarantee of absolute safety. It is imperative, therefore, that personnel working with urethane chemicals understand fully the hazards associated with their use and are familiar with those procedures which have been designed to minimize the hazards involved.)

As of August 1977, a ceiling limit for workman exposure to toluene diisocyanate was set at 0.02 ppm. Initially, this was a voluntary standard set by both the American Conference of Governmental Industrial Hygienists and the American Standards Association. However, with the enactment of the Occupational Safety and Health Act, The Department of Labor, through the Occupational Safety and Health Administration (OSHA), accepted this value as an industry regulation. (Note: Recently, the National Institute of Occupational Safety and Health (NIOSH) has proposed an 8-hour TWA for toluene diisocyanate of 0.005 ppm (0.036 mg/cu m) with a ceiling value of 0.02 ppm (0.14 mg/cu m) for a maximum twenty minute period in the 1973 Criteria Document, "Toluene Diisocyanate." Recently the American Conference of Governmental Industrial Hygienists has proposed that the Threshold Limit Value (TLV) be changed to 0.002 ppm (0.014 mg/m³.) OSHA may or may not accept this recommendation and may or may not promulgate new regulations. It is essential, therefore, that each user of urethane chemicals keep himself fully informed on the most current regulations.)

Read and follow carefully each of the safety recommendations and precautions listed below:

- All employees should be instructed and periodically re-

Table 3— Respirator Selection Guide For Protection Against TDI*



trained in the use of all protective and emergency equipment, as well as in preventive procedures. (Note: Important to any safety program is thorough worker education. In short, the best planned procedures do no good if they are not understood and followed. Similarly, the best of safety equipment is useless if it is not properly used and maintained.)

- Proper respiratory protective equipment should be readily available and in good working order. (Note: For nonroutine operations, or where vapor levels cannot be controlled by ventilation alone, all personnel should use appropriate respiratory protective devices. Also, only those devices approved by the National Institute for Occupational Safety and Health (NIOSH) and the Mining Enforcement and Safety Administration (MESA) should be used.
- Use air-supplied masks or hoods when spraying urethane foam. (Note: Because spraying operations often result in relatively high levels of vapors and aerosol mists, which can injure the eyes and respiratory tract, workers should use air-supplied or self-contained breathing apparatus. Caution: Paint or dust respirators are *not* adequate. Also, canister-equipped gas masks are *not* recommended for this type of operation.)
- Regularly inspect and repair exhaust and ventilating equipment. Also, work area atmospheres should be checked periodically to be sure that established TDI vapor levels are not being exceeded. (Note: Isocyanate and other toxic vapor levels in the work environment are best controlled by properly designed equipment and adequate ventilation and exhaust. Combined with safe work procedures, properly designed equipment in good working order can maintain vapor levels within acceptable limits. Warning: Tests have shown that the least detectable odor level of toluene diisocyanate is approximately 0.2-0.4 ppm. Because this odor threshold occurs at levels significantly higher than allowable concentrations, vapor levels *must* be monitored continuously using equipment specifically designed for that purpose. Such equipment is available from MDA Scientific Inc., 808 Busse Highway, Park Ridge, Ill. 60686.)
- Prevent all contact with urethane chemicals. (Note: Skin and eye contact with isocyanates and other urethane chemicals may result in injury and, in some cases, in skin sensitization. It is essential, therefore, that operating and ventilating equipment be properly designed and maintained, and that all procedures for the safe handling, use, and storage of urethane chemicals be fully understood and followed. Also, the use of protective clothing, gloves, boots, chemical goggles or face shields, and approved respiratory protective devices must be considered whenever there is any possibility of exposure.)
- Eyewash fountains and safety showers should be installed in all areas where urethane chemicals are handled. (Note: It is important that the number and location of such units be designed to serve both individual and multiple employee exposures.)

Health Hazards

Inhalation

Isocyanate vapors are exceedingly irritating to the mucous membranes of the upper and lower respiratory tracts. Even very brief exposures to TDI vapors may cause both irritation and difficult or labored breathing, including a "burning" throat, deep coughing, and choking.

In addition, inhalation of TDI vapor may cause nausea, vomiting, and abdominal pain. Furthermore, exposure to isocyanate vapors may cause sensitization or hypersensitivity, which on subsequent exposure, even to very low concentrations, may result in severe asthma-like attacks. (Note: Inhalation of vapors of heated TDI can be extremely hazardous. An appropriate respiratory protective device *must* be worn, therefore, whenever there is any possibility of exposure to unknown concentrations of vapors. See "Toxicity," page 12. Also, see page 31 for a list of manufacturers and suppliers of approved respiratory protective equipment.)

Skin Contact

Repeated or prolonged contact with TDI may cause redness, swelling, blistering, and burns. Also, direct contact may produce skin sensitization (e.g., contact dermatitis). Therefore, any contact with the spray, vapor, or liquid should carefully be avoided. (Note: Protective clothing, including impervious rubber or plastic aprons, rubber gloves and footwear, chemical goggles or faceshields, etc., should be worn whenever there is any possibility of direct contact with TDI. Also, safety showers should be installed in and near all TDI work areas.)

Eye Contact

While brief eye contact with low concentrations of TDI vapor may cause only mild tearing or a slight burning sensation, contact with high concentrations of vapors or mists may cause painful irritation. Furthermore, direct contact with TDI liquid or dust may be extremely painful and, if not immediately removed, may cause both severe irritation and possible permanent injury. (Note: Chemical worker's goggles or monogoggles should be worn whenever there is any possibility of direct contact with TDI liquid, dust, or mist. Also, eye baths should be installed in all TDI work areas.)

Ingestion

Although TDI has a low level of acute oral toxicity (e.g., LD_{50} Rats 5800 mg/kg), it will irritate the mucous membranes of the mouth, esophagus, and stomach. (Note: While accidental ingestion of TDI in a normal industrial environment is highly improbable, it *is* possible. Foodstuffs, therefore, should not be prepared or consumed where TDI is used, handled, or stored. Also, in the event of accidental ingestion, workers should be prepared to administer emergency first aid.)

Note: A Material Safety Data Sheet, similar to OSHA Form 20, is available from The Dow Chemical Company, Organic Chemicals Department, Midland, Michigan 48640. Also, similar information should be requested from suppliers of other products prior to handling or formulating with them.

Emergency First Aid

All employees working in areas where contact with isocyanate is possible should be thoroughly trained in the administration of appropriate emergency first aid. Experience has demonstrated that prompt administration of such aid can be important in minimizing the possible adverse effects of accidental exposure. (Caution: First aid is "emergency treatment" only, and medical attention from a qualified physician should be provided as soon as possible.)

Inhalation

Promptly move the affected person away from the contaminated area and to an area of fresh air. Quickly remove all contaminated clothing. Keep the affected person calm and warm, but not hot. If breathing stops, administer artificial respiration. *Call a physician at once.* (Note: The severity of respiratory distress will determine the need for oxygen and bronchodilators; however, these should be administered only by properly qualified personnel or a physician. Warning: Never attempt to give anything by mouth to an unconscious person.)

Skin Contact

In the event of direct contact with the skin, immediately get under a safety shower. Remove all clothing and shoes while under the shower. Thoroughly wash the affected skin, using plenty of water and a mild soap. Get medical attention. (Note: Contaminated clothing should not be worn again until laundered. Also, shoes should be completely decontaminated before being reused.)

Eye Contact

If TDI contacts the eyes, first aid must be administered at once. The eyes should be held open and flushed with a continuous low-pressure stream or spray of water for at least 15 minutes. Seek medical attention at once. (Note: For more effective flushing of the eyes use the fingers to spread apart and hold open the eyelids. The eyes should then be frequently "rolled" or moved in all directions.)

Ingestion

In the event TDI is ingested, have the affected person drink large amounts of water. Do *not*, however, encourage or induce vomiting. Call a physician at once. (Note to Physician: TDI attacks the mucous membranes of the mouth, esophagus, and stomach. Gastric lavage, therefore, is hazardous. If used, it should be done under esophagoscopic control.)

Part II

Bulk Storage and Handling Systems

Shipment and Handling

General Specifications (Tank Trucks and Tank Cars)

Toluene diisocyanate is classified as a poisonous Class B liquid and is therefore shipped in specially designed tank trucks and tank cars. The following table (Table 4) and figures (Figures 2 and 3) contain general specifications for vehicles used by The Dow Chemical Company for the bulk shipment of VORANATE T-80 Isocyanate.

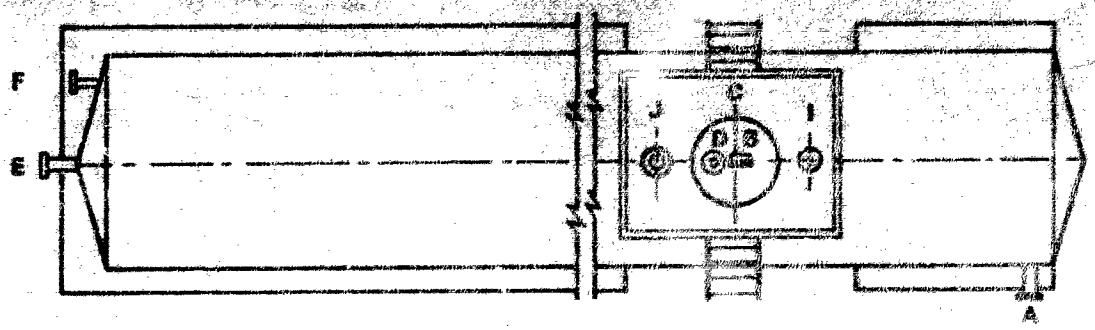
Table 4—General Specifications (Tank Trucks and Tank Cars)

	Tank Trucks	Tank Cars
Capacity, Gallons	4,500	10,000 17,300
Capacity, Approximate Weight, lbs	46,000	160,000 178,000
Construction Material	Stainless Steel	Baked Phenolic Lined
Temperature Gauge	Yes	Thermowell
Pressure Gauge	Yes	No
Nitrogen Pad during Shipping	Yes	Yes
Nitrogen Pad Connection Size, Type	¾", QC†	2", Flange
Top Unloading	No	Yes
Top Unloading Connection Size, Type	None	2", Flange
Bottom Unloading	Yes	No
Bottom Unloading Connection Size, Type	3", MPT††	None
Unloading Pressure, psig	25 max	25 max
Steam Plates	Yes	Yes
Steam Plate Connection Size, Type	¾", MPT	2", Screw
Steam Pressure, psig	15	25

†Quick Connect

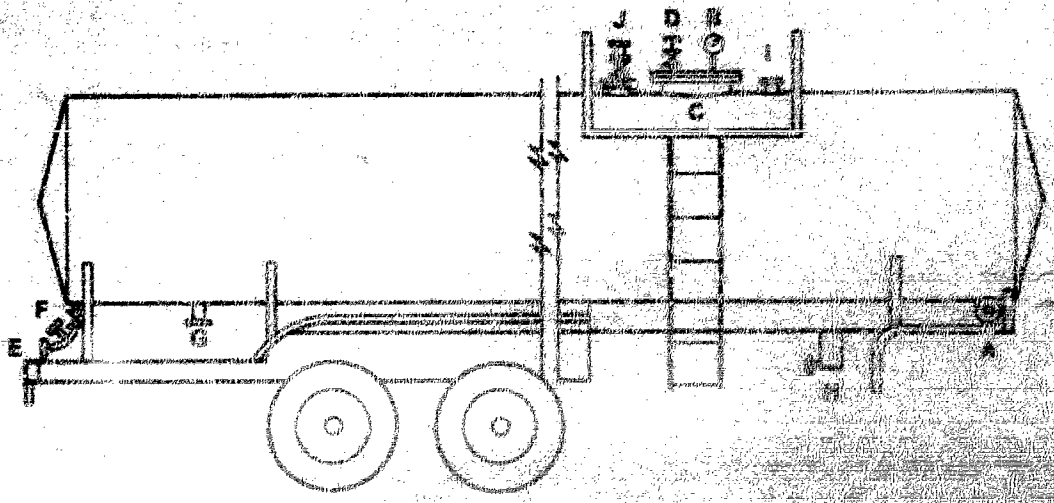
††Male pipe thread. Can be reduced to 2" with adapters.

Figure 2—Tank Truck



TOP VIEW

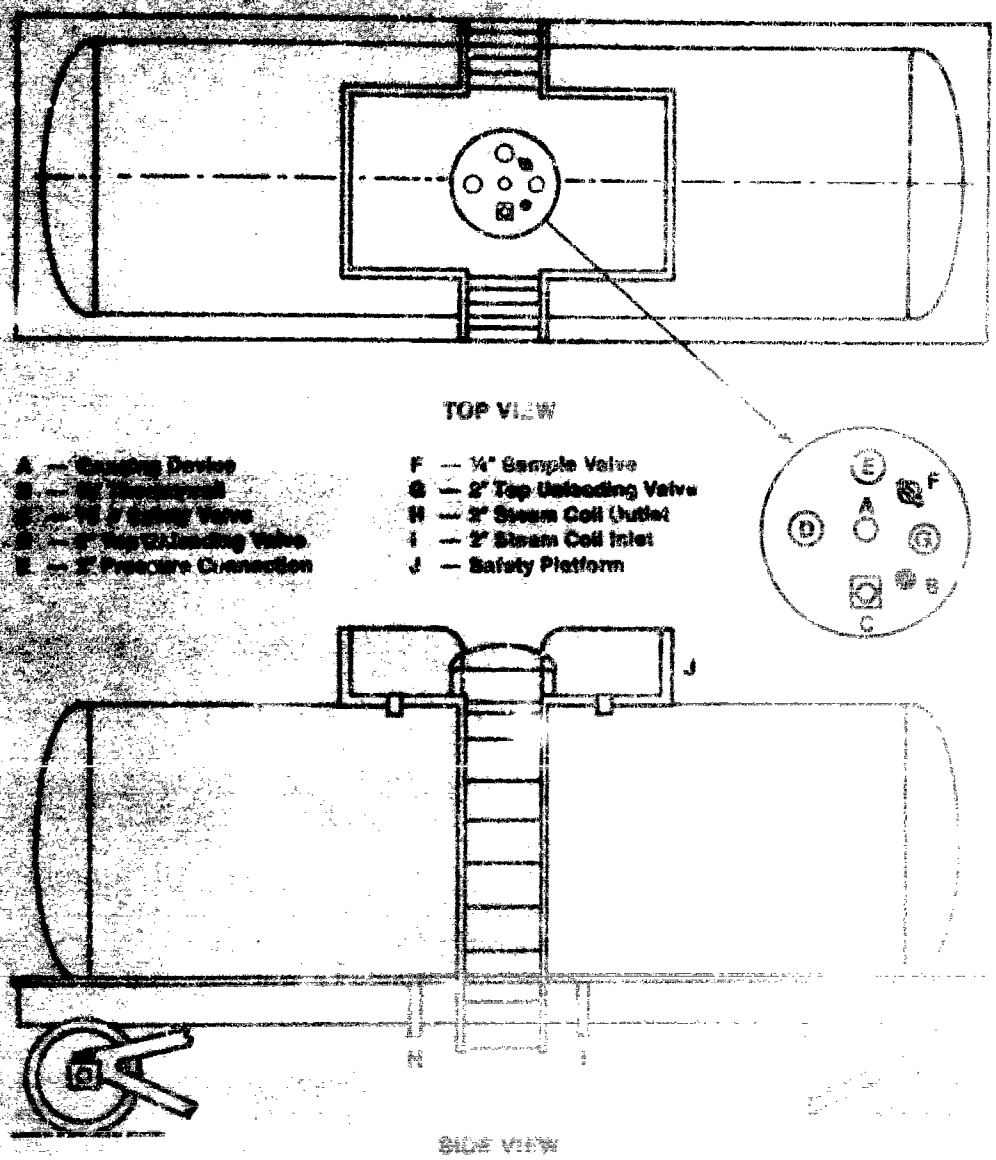
A — 4" Steam Inlet
B — 35 # Safety Valve and Pressure Gauge
C — Manhole
D — ¼" DRY AIR / NITROGEN CONNECTION
E — 3" Unloading Connection
F — ¾" Sample Valve
G — Steam Outlet
H — Air Dryer
I — 2" Loading Line
J — 2" Vent Line



SIDE VIEW

Note: On some 17,000 gallon DOWX series cars there is a variation in the dome valve configuration. The diagram below shows the normal configuration. However, on these cars the positions of A (the gauging device) and C (the 75# safety valve) are reversed.

Figure 3 — Tank Car



Unloading Procedures

Tank Trucks

VORANATE T-80 Isocyanate is shipped in pressurized and insulated stainless steel tank trucks, equipped for bottom unloading only. (Note: Only properly trained and equipped personnel should be permitted to unload tank trucks. Operators should wear an appropriate respiratory protective device and impervious clothing, footwear, and gloves).

Read and follow carefully each of the safety recommendations and precautions listed below:

1. Position the trailer as level as possible and block the wheels.
2. Check the temperature of the contents. (Note: The temperature must be *above* 59°F (15°C) when the trailer is unloaded.)
3. If heating is required, attach a 25 psi steam supply to the heating coil inlet connection. Attach a steam trap, designed for the steam pressure available, to the heating coil outlet connection. (Note: For better control of the heating process, use a steam pressure of 15 psi.) Allow the contents to warm until the temperature is at least 68°F (20°C). When the temperature reaches 68°F (20°C), turn off the steam and disconnect the lines. (Note: To prevent the heating coils from freezing during cold weather, be sure to drain them or "blow them out.") CAUTION: Carefully watch the thermometer during heating. Do *not* allow the temperature to rise above 104°F (40°C). See "Temperature Control," page 5.
4. Attach the unloading line. (Note: The line should be clean, dry, and preferably made of flexible metal or rubber hose which can safely withstand unloading pressures.)
5. Connect the dry purge gas (preferably nitrogen) line to the tank truck. Note: This line should have a pressure gauge, a safety valve set at 30 psig, and a pressure regulator set at 25 psig.)
6. Draw off a sample of the contents for analysis. (Note: A sample of the contents may be obtained by connecting stainless steel tubing to the sample connection. Flush the sample connection by drawing off at least one gallon of TDI into a clean, dry container. The sample to be analyzed may now be drawn off into another clean, dry container of whatever size is necessary for testing. CAUTION: Do *not* breathe vapors. Wear proper protective equipment whenever there is any possibility of contact with TDI liquid or vapors.)

7a. *If the contents are to be unloaded by purge gas pressure alone,* the storage tank should be fitted with a vent scrubber. This will prevent TDI from being vented into the atmosphere during unloading. (CAUTION: Do *not* exceed 25 psig purge gas pressure to unload the tank truck.) When the tank truck is empty, the pressure gauge will show a drop in pressure. Close the valve at the storage tank connection *first.* Then close the truck unloading valve.

7b. *If the contents are to be unloaded by pump,* either a vapor line connecting the storage tank vent to the tank truck should be installed (closed loop) or a low-pressure, replenishable gas pad must be placed on the tank truck. (Note: If a gas pad is used, install a vent scrubber on the storage tank vent.) These precautions will not only prevent TDI vapors from being vented to the atmosphere, but will prevent a vacuum from being pulled on the tank truck during unloading. (CAUTION: Do *not* use a closed loop system unless the dead air space in the storage tank is free of moisture; i.e., −40°F (−40°C) dew point. Also, connection hoses should be purged with dry air or nitrogen before hookup.) When the trailer is empty, allow the unloading hose to vent down to the storage tank. Note: Be sure to close the valve at the storage tank connection *first.* Then close the tank truck unloading valve.

8. Shut off the purge gas to the tank truck. Close the tank truck purge gas valve and disconnect the purge gas line. (Note: If a closed loop system was used in conjunction with pump unloading, close the tank truck connection valve and the tank vent valve. Then disconnect the hose connecting the two.) All connection hoses should now be cleaned, dried, and capped for storage.

Tank Cars

VORANATE T-80 Isocyanate is shipped in insulated, baked-phenolic-lined tank cars, equipped with external heating coils and a safety valve set for 75 psi. (Note: Tank cars from The Dow Chemical Company may be unloaded only from the top.

They are equipped with excess flow check valves set at approximately 130 gpm and should *not* be unloaded at higher rates. Also, only properly trained and equipped personnel should be permitted to unload tank cars. Operators should wear an appropriate respiratory protective device, eye protection, and impervious clothing, footwear, and gloves.)

Read and follow carefully the safety recommendations and precautions listed below:

1. Before attempting to use the following procedure, operators should be thoroughly familiar with the hazards associated with the handling and storage of VORANATE T-80 Isocyanate. Also, see p. 17 for a diagrammatic drawing of a typical tank car. (Note: All letter references refer to this drawing.)

2. Verify that the proper car is being unloaded. (Note: Carefully check the car number and commodity stenciling against the bill of lading or other appropriate document. Also, sample the contents to be sure that the material is indeed TDI.)

3. Position the car on the selected siding; then set the brakes and block the wheels.

4. Position caution signs on the track or car in such a way as to give adequate warning to persons approaching the car from the open end(s) of the siding.

   (Note: The signs should *not* be removed until the car has been unloaded and disconnected from the discharge connection. In addition, R.M. Graziano's Tariff No. 31, "Hazardous Materials Regulations of the Department of Transportation," Section 174.67, "Tank Car Unloading," states, in part, that:

   The signs must be of metal or other comparable material, at least 12 inches high by 15 inches wide in size, and bear the words, "STOP—Tank Car Connected," or "STOP—Men at Work," the word "STOP" being in letters at least 4 inches high and the other words in letters at least 2 inches high. The letters must be white on a blue background.)

   NOTE: In addition to these mandatory regulations, The Dow Chemical Company recommends that the switch(es) on the open end(s) of the siding be provided with locks or that derails be placed on the track at least 50 feet from the end(s) of the car. This should effectively prevent the entry of other cars into the siding where the TDI car is being unloaded. Caution: In the event derails are used, be sure to attach a signal flag to the track to indicate that the derail is in the derailing position.

5. Climb the ladder to the platform area on top of the car. (Note: All of the unloading apparatus on Dow tank cars is located in the manway bonnet in the center of the platform.) Remove the seal from the latch pin and open the bonnet dome. When the cover is open, check to see that all valves are in the closed position.

6. Check the temperature of the tank car by removing the ¾" cap from the thermowell (B) and inserting a thermometer approximately 24" for 15-20 minutes. (Note: The temperature of the contents must be above 59°F (15°C) when the car is unloaded.)

7. Should heating be necessary, remove the cover from the magnetic gauge (A) and raise the gauge rod to where the magnet in the end of the rod engages the magnet on the float. (Note: The rod is calibrated in ¼-inch increments and should read between 4 and 7 inches.) Next, attach a steam hose to the steam inlet connection located on the bottom of the car. Attach a steam trap, designed for the steam pressure available, to the heating coil outlet connection. (Note: For greater control of the heating process—that is, to avoid hot spots and product deterioration—use a steam pressure of 25 lbs or less. Also, carefully monitor the outage to be sure that expansion does not fill the car "liquid full" and cause it to "pressure relieve" through the safety valve. Finally, be sure to monitor the pressure on the tank car during heating. Do *not* allow pressure to go beyond 30 psig. Also, dry nitrogen is recommended for padding.)

8. Allow the contents to warm until the temperature is at 68°F (20°C). When the temperature reaches 68°F (20°C), turn off the steam, disconnect the lines, and allow the heater coils to drain. (Caution: Carefully watch the thermometer during heating. Do *not* allow the temperature to rise above 104°F (40°C).)

9. Connect the pad gas line to the vapor or vent valve (E). (Note: Both the vent and

load / unload valves are equipped with 2" ASA Series 15 flanges with four bolts in a 4¾" bolt circle. Although these are combination flanges to which a screw-type hookup may be made (e.g., by removing the 2" solid plug instead of the flange), it is strongly recommended that a flanged connection be used:

a. Use the proper wrenches to remove the bolts; e.g., an open-end wrench of proper size to hold the nut on the bottom of the flange and a box-end or socket wrench to turn the bolt on the top side of the flange. Pipe or crescent wrenches are *not* recommended. Note: The bolts away from the operator should be removed *first.*

b. Carefully connect the purge line to the valve by reinstalling the gasket and bolts.

c. Tighten opposite bolts with equal pressure until all bolts are uniformly tight.

d. Equip the purge line connection with a pressure gauge regulated to a maximum pressure of 40 psig.

10. If desired, a sample of the contents may be drawn off through the sample valve (F), which is a ¼" needle valve equipped with standard pipe threads. (Note: If a sample is desired from an unpressurized car, use 3 to 4 lbs of purge gas pressure.) The sample valve is attached to a sample line, which is equipped with an excess flow valve. (Note: Should the excess flow valve close, turn off the sample valve. Wait approximately one minute; then reopen the sample valve. If the excess flow valve does not reopen, it may be necessary to rap with a ball peen hammer against the manway cover plate near the sample valve to cause the ball in the excess flow valve to drop into the open position. A good preventive practice against excess flow valve closure is to draw the sample very slowly.) CAUTION: Do *not* breathe vapors. Wear proper protective equipment whenever there is any possibility of contact with TDI liquid or vapors.

11. Attach the unloading line(s) to the unloading valve(s) (D and G). (Note: Follow the procedure outlined under step no. 9.) After proper attachment of the unloading line(s), slowly open the unloading valve(s) until discharge line(s) are liquid full. (Note: If the valve(s) are opened too quickly, the sudden flow of the product into the empty line(s) may cause the excess flow valve(s) to close.)

12. Vapor pressure on the car may now be increased to effect discharge of the product. Be sure, however, that the amount of pressure is appropriate to the unloading method used; i.e., by purge gas pressure or pump. (Note: Each eduction line is equipped with an excess flow valve set for 130 gpm. These valves are of the vertical slug type and may be closed by the combined action of a float and the flow of the product. When this happens there will be a sharp hammering noise. The operator should then close the unloading valve and wait until the excess flow valve reopens. (There will be an audible "klunk" when the float falls back into the open position.) The operator may now reopen the unloading valve, but should throttle the flow to a rate below that which will close the excess flow valve. CAUTION: It is strongly recommended that throttling be done at the pump or storage tank rather than on the tank car unloading valves. Valves on the tank car should be fully open so that the excess flow valves can close in the event of a line rupture. Also, storage tank pressure should be carefully controlled and monitored during the unloading operation.)

13. When the tank car is empty, the unloading lines should be blown clear of liquid and blocked in before being disconnected. See step 14d. (Note: There are a number of ways to determine when the tank car is empty. For example, a rapid drop in vapor pressure on the car would indicate that the liquid is gone and that the gas is blowing out through the unloading line. The amount of product received into the storage tank should also indicate whether or not the tank car is empty. CAUTION: Do *not* use the Magnetic Gauging Device to determine if the car is empty. This device only extends 60" into the car; the car itself is 102" in diameter. Also, do *not* breathe vapors. Wear proper protective equipment whenever there is any possibility of contact with TDI liquid or vapors.)

14. Once the tank car is empty, return all valves and connections to their original condition:

a. Remove the thermometer from the thermowell and replace the dust cap.

b. Completely lower the Magnetic Gauging Device and replace the dust cap.

c. Close the sample valve and replace the ¼" plug.

d. Liquid unloading lines should be blown dry and disconnected in accordance with the following sequence: First, blow the line to the storage tank; then close off the valve to the storage tank. Second, open the unloading valve on the tank car and blow any material left in the line back into the car. Next, determine the amount of pressure remaining in the car. If it is below 10 lbs psig, continue flow of purge gas until pressure in the car reaches a minimum of 10 lbs psig. (Note: Do *not* allow pressure to exceed 40 lbs psig.) Now close the tank car valve, bleed off any pressure left in the unloading line, and remove the bolts. (Note: To prevent residual material or pressure from blowing toward the operator, be sure to remove the bolts away from the operator *first*.) Finally, replace the gasket and flange on the unloading valve. (Note: Alternately tighten opposite bolts until all bolts are uniformly tight and a leakproof seal has been made.)

e. Remove the purge gas line and replace the gasket and flange. (See "Note" immediately above.)

f. Close dome cover and replace latch pin.

15. R.M. Graziano's Tariff No. 31, "Hazardous Materials Regulations of the Department of Transportation," Section 174.69, "Removal of Placards and Car Certification After Unloading," states, in part, that:

> *When lading requiring placards or car certificates is removed from rail cars other than tank cars, placards and car certificates must be removed by the party unloading the car. For empty tank cars, the placards must be removed, replaced or reversed in accordance with the provisions 172.510(c) of this subchapter.*

Section 172.510(c), "Removal of placards and car certificates after unloading," states, in part, that:

> *Each empty tank car must be placarded with an EMPTY placard as required and described in 172.525 for paragraph (a) of this section, as appropriate, that corresponds to the placard that was required for the material the tank car last contained unless the tank car last contained a combustible liquid or has been —*
>
> *(1) Reloaded with a material not subject to this subchapter, or*
>
> *(2) Sufficiently cleaned of residue and purged of vapor to remove any potential hazard.*

Section 172.525, "Standard requirements for the EMPTY placard," states, in part, that:

> *(a) Each EMPTY placard must be as follows:*
>
> *(1) The triangle at the top of the placard must be black. The word "EMPTY" must be white.*
>
> *(2) The midsection and lower triangle on the EMPTY placard must be as specified in 172.519 and Appendix B to this part, and... as appropriate for the residue of the commodity being transported and required by this subchapter to be placarded.*
>
> *(b) The top part of each EMPTY placard must be as specified in Appendix B to this part and as illustrated on the FLAMMABLE — EMPTY placard which, except for size and color, must be as follows:*

> *(c) The EMPTY placard must be as shown in paragraph (b) of this section and may be —*
>
> *(1) A separate placard,*
>
> *(2) On the reverse side of a placard, or*
>
> *(3) A composite made by covering the top triangle of the appropriate placard with a black triangle bearing the word "EMPTY" in white letters.*

16. Remove warning, open derails, unlock switches, etc. Release hand brakes and remove chocks from wheels. If an unloading rack was used for en-

trance to the dome platform, be sure that all parts of the rack are removed and relocated far enough away from the car to conform to AAR specified clearance for entry of the rail crew for switching operations.

17. Complete all final paperwork; e.g., "Empty Return Instructions." (Note: After all forms have been completed and the proper carrier endorsements obtained, send the various copies to the locations designated in the instructions.)

Drums

VORANATE T-80 Isocyanate is shipped in phenolic-lined steel drums, equipped with two bungs on the top. (Note: These drums meet DOT 17C specifications.)

Read and follow carefully each of the safety recommendations and precautions listed below:

1. Closely examine each shipment for damaged drums. (Note: Drums should be handled and unloaded carefully to prevent damage. If damaged drums are found, they should be closely inspected for leaks. Leaking drums should be removed to a well ventilated area and the contents transferred to other suitable containers. The empty drums should be decontaminated (see page 8) and then pierced to render them unreuseable.
2. Drums may be unloaded with conventional stainless steel drum pumps. To prevent collapse of the drum during unloading, equip the drum vent with a dry air or dry nitrogen breather. This attachment will also prevent moisture contamination of the contents. (Note: When not in use, pump lines should be protected from moisture by fitting a plug or cap into the open end. Portable pumps, lines, and fittings should be carefully rinsed, dried, and stored in a dry location. See "Moisture Control," page 4.) CAUTION: Operators engaged in handling, opening, unloading, and closing drums should be completely familiar with the hazards associated with TDI and should be properly equipped with protective clothing and an appropriate respiratory protective device.

Drum Storage

Whenever possible, drums containing VORANATE T-80 Isocyanate should be stored indoors. During cold weather, the temperature in storage areas should be kept above 68°F (20°C). If drums are received frozen, be sure the contents are completely thawed and mixed before using. Thawing may be accomplished by allowing the frozen drums to sit in a warm storage area or by using a drum heater. (Note: During warm weather, drums may be stored outdoors. However, drums should be stored in such a manner as to prevent water from collecting on the drum tops. This may be accomplished by storing the drums under a cover or by stacking them on their sides.)

CAUTION: Do *not* heat the contents above 104°F (40°C) or the drum wall above 175°F (79.5°C). Overheating may cause expansion of the contents, homopolymerization, and the subsequent formation of carbon dioxide, which can seriously weaken or completely rupture the drum. (See "Temperature Control," page 5.)

Bulk Storage

A properly designed bulk storage system for VORANATE T-80 Isocyanate must:

- permit safe handling of the material,
- provide both moisture and temperature control,
- prevent contamination of the product, and
- minimize the hazards of combustibility.

In attempting to construct such a system, therefore, it is essential that designers familiarize themselves with the hazards, safety recommendations, and precautions associated with the handling and storage of VORANATE T-80 Isocyanate. A genuinely practical design, therefore, must not only include a physical layout of the facilities and equipment, but must also include a plan for personnel safety in all areas of the operation. In short, the establishment of safe work procedures must be an integral part of *any* bulk storage system. In addition, designers must also consider all applicable insurance requirements, as well as governmental codes and regulations, and should consult with all appropriate local agencies during each stage of planning and construction.

Note: The equipment described below is suitable for use in bulk storage systems for VORANATE T-80 Isocyanate. Such items, however, are merely components of typical systems and must not be considered a finished design. Also, other equipment similar to the

items listed can be tested for performance and may give equally good results. See the lists of "Equipment Manufacturers and Suppliers" on pages 27-32.

Tanks

Tanks should be sized to meet plant and customer needs. (Note: Minimal capacity equivalent to 150% of normal monthly bulk receipt is suggested.) Each storage vessel should be a welded, vertical or horizontal, cylindrical, carbon steel tank (A283C steel) built to API 650 Code and designed to hold the specified product safely when filled to capacity.

Both vertical and horizontal tanks should be equipped with the following openings:

- 1 — 20″ roof manway.
- 1 — 20″ shell manway 12″ off floor.
- 1 — 3″ or 4″ roof nozzle for vent.
- 3 — 1½″ roof nozzles for gauge.
- 1 — 2″ shell nozzle near floor leading to a dished sump for drain.
- 2 — 2″ to 3″ shell nozzle 12″ above floor for inlet and outlet. Inlet and outlet are to be 90° apart.
- 1 — 1″ 3,000 lb coupling in shell 36″ above floor for thermometer well.

In the design of tanks to be lined, minimal radii recommended by the lining manufacturer must be observed. Full fillet interior welds should be utilized, and all splatter must be ground smooth. Welds must be continuous and smooth and should have no undercuts or porosity. (Note: The tank manufacturer should be responsible for providing the proper radii and welds and for removing all splatter. The lining contractor should be responsible for other surface preparation.)

Tanks should be water tested to design pressure, and then dried, brush sandblasted inside, and cleaned. (Note: A silica gel charge should be placed inside the tank prior to sealing it for shipment. Also, moisture content should be 125 ppm maximum.) Exterior scale should be removed and the exterior primed with one coat of red inorganic zinc primer. (Note: Silica gel charges in tanks must be removed and the system must be thoroughly cleaned, dried, and purged with a dry pad gas prior to use.)

Linings

Linings are desirable to prevent the pickup of rust or iron which can cause product discoloration. If a lining is to be used, surface preparation and lining application are of prime importance and should be conducted in strict accordance with the lining manufacturer's recommendations. Also, only experienced lining applicators who are licensed or approved by the lining manufacturer should be considered for application work.

Surfaces should be prepared and coated within eight hours, during which time proper temperature and humidity controls should be maintained. In no case, however, should a lining application be attempted on a surface once evidence of rust has been detected. Also, if linings are applied in the shop, extra care must be exercised to prevent lining damage during transportation and erection of the tank. If any damage does occur, it should be thoroughly repaired prior to placing the tank in service. (Note: Provided proper application and curing methods are employed, a high-temperature baked-phenolic lining of either Heresite† P403-L66, Bisonite†† 957 or Plasite††† 3055 brands, or an equivalent material is satisfactory for VORANATE T-80 Isocyanate.

Insulation

Storage tanks which are located out-of-doors and which may be exposed to extremes of temperature should be insulated with either a 1″ to 1½″ thickness of urethane foam or STYROFOAM* brand plastic foam or a 2″ thickness of fibrous glass. (Note: If tanks are located indoors, where normal room temperatures are maintained, insulation may not be necessary.) In addition, an effective weather cover of corrugated aluminum or asbestos-cement sheeting should be used to protect the tank from rain, snow, ice, etc. (Note: Interior storage tanks which have been insulated with plastic foam should be covered with an effective flame barrier to minimize the hazard of combustibility. Also, to prevent lining damage, insulation and any necessary welding should be completed before the lining is installed.)

Pumps

Steel or stainless steel canned-type pumps with nitrogen filled stator cavities are preferred. However, standard centrifugal or positive displacement pumps equipped with mechanical seals may also be used. (Note: Do *not* use silicone with canned-type pumps. Also, mechan-

*Trademark of The Dow Chemical Company

†Trademark of Heresite and Chemical Company.

††Trademark of Bisonite Company, Inc.

†††Trademark of Wisconsin Protective Coating Corporation.

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ical seals should be purged with dry gas to prevent moisture from contacting the seal face and causing urea formation and seal failure.)

Depending upon preferred flow rates, two pumps for each system may be desirable. (Note: Truck unloading pumps should have a capacity of 100-150 gpm. Lower rates, however, may be preferred for process pumps. If so, two suitably sized pumps should be used.)

Relief Valves

Three types of valves are required:

1. Pressure-vacuum (P-V) vents for tanks,
2. Relief valves for positive displacement pumps, and
3. Line relief valves.

Each storage tank must be provided with a pressure-vacuum (P-V) vent valve which, to prevent accumulation of vapors, should relieve or terminate out-of-doors.

Also, and provided that all parts and equipment are rated for a working pressure of 150 psig, each positive displacement pump should be equipped with a relief system set at a maximum of 125 psig. If parts and equipment are not rated at 150 psig, the relief should be set at 75 to 95% of the system's lowest working pressure.

Finally, each line section which can be closed off by valves while full of liquid should have a relief valve which relieves back toward the tank, with the final section relieving into the tank itself. Settings for these reliefs should be the same as those for pumps.

Pressure Gauges

Gauges should be provided at the pump, before and after filters, and near the process. They should be protected by a sealed diaphragm filled with nonhydrocarbon fluid. Gauges are also advisable on steam and air lines and on equipment where gases or liquids are handled, such as chillers and heat exchangers.

Sample Valves

To facilitate product sampling, ½"-¾" sample valves, which terminate in a stainless steel nipple, should be provided in each system.

Piping

Both schedule 40 seamless carbon steel pipe (A53) and welded pipe joints with flanges and flanged valves work well. Threaded couplings and valves may also be used, provided that tape made of Teflon† brand fluorocarbon fiber is used on all threaded fittings. (Note: Tape must be applied carefully. Also, *no* pipe dopes may be used.)

Selection of line sizes will be determined by product flow rate, system design, and pump specifications. Normally, a 3" diameter line is satisfactory; however, for short, simple systems, 2" may be more suitable, while for longer and more complex systems, 4" may be required. In any event, sizes should be established in conjunction with the pump supplier, keeping the diameter to the practical and economical minimum.

Note: Pipeline insulation and heating or cooling may be required if lines are either outdoors or in an area in which normal room temperatures are not maintained.

Heating

VORANATE T-80 Isocyanate should be maintained at slightly above room temperature; i.e., 70-80°F (21-27°C). For heating uninsulated indoor storage tanks, an industrial heater may prove adequate. However, for outdoor insulated tanks, external plate coils using steam to 25 psig are recommended. (Note: To maintain suitable product temperatures, pipelines may also require insulation, tracing, or both.)

Heat Exchangers

Heat exchangers should have an area of 2 to 3 square feet per gallon / minute.

Pad Gas

Dry nitrogen is preferred; however, dry, oil-free air supplied by an air compressor and dryer may also be used. Either gas should have a maximum dew point of −40°F (−40°C).

Pressure Control Valve (PCV)

Use a low-pressure regulator to control the pressure in the isocyanate storage tank.

Temperature Indicators (TI)

The temperature of the product may be accurately monitored with a dial-type thermometer inserted in a suitable thermowell. (Note: To achieve greater heat transfer for a more accurate reflection of the temperature of the contents, be sure the thermometer is in direct contact with the thermowell.)

Level Indicators (LI)

A level indicator should be used to measure product level in the tank and to determine inventory.

Strainers

Steel-cased, dual-line strainers having 100-mesh stainless steel reinforced wire screen baskets are recommended. Units should also be equipped with control valves which

†Trademark and product of E.I. duPont de Nemours Co., Inc.

permit one side to continue in operation while the other is being serviced. (Note: It is strongly recommended that all unloading and process lines be equipped with either strainers or filters; e.g., use strainers on the unloading lines close to the tank and filters on the process lines close to the process.)

Filters

Filters should be equipped with elements which are suitable to the product and the desired flow rate. (Note: Ten-micron, cotton-wound elements with voile-covered steel mesh cores are recommended.)

Meters

Use suitably sized meters. (Note: Meters should contain no aluminum or aluminum alloys nor any synthetics other than Teflon† fluorocarbon and Viton† fluoroelastomer.)

Valves

Cast steel, malleable iron, or 316 stainless steel 150 psig valves are suitable for tank nozzles. Steel, malleable iron or iron 125 psig valves may be used on lines. Also, gate, ball, or plug valves may be used provided no internal lubrication is required. (Note: Valve packing, if required, should be nongraphited asbestos, asbestos impregnated with Teflon fluorocarbon fiber, or braided Teflon fluorocarbon fiber. Also, ball valves should have seats of Teflon.)

Gaskets

Gaskets of nongraphited asbestos, asbestos impregnated with Teflon fluorocarbon, or braided Teflon fluorocarbon fiber may be used. (Note: Envelope-type gaskets made of Teflon fluorocarbon are also suitable.)

†Trademarks of E.I. DuPont de Nemours Co., Inc.

Hoses

Hose made of Viton fluoroelastomer is preferred. (Note: Hoses for permanent and continuous service should be made of flexible seamless metal, steel, or stainless steel.)

Electrical

Explosion-proof wiring and equipment should be used in all areas where flammable vapors or dusts are likely to be present. Also, all electrical equipment should be grounded. (Note: Electrical work must conform to all applicable codes and ordinances. Also, when ordering electrically operated equipment, be sure to specify the type of electrical service available.)

Foundation

Depending upon load and soil conditions, reinforced concrete pads, concrete rings, reinforced concrete piers, or crushed stone rings may be used. (Note: Vertical tank bottoms should be coated and, if out-of-doors, sealed to the foundation with asphalt. Also, if ring foundations are used, the centers should be filled with compacted oiled sand.)

Paint

All steel equipment used out-of-doors should be carefully cleaned and coated with a suitable primer.

Dual-Service Equipment

Equipment to be used for two or more products must be so designed that it can be drained and blown dry between products. (Note: Manifolds should *not* be used. Instead, switch-hose and quick-coupler connections should be made between dual service equipment and individual product lines.)

Drains

All equipment should be provided with drains and should be designed to drain completely. (Note: Piping should slope toward low points equipped with drains.)

Ventilation

Indoors storage systems should be housed in a separate room, equipped with exhaust fans and intakes. This will minimize vapor accumulation in the event of a leak or spill. (Note: Tank areas should be diked; however, there should be no open drains within the diked area.)

Miscellaneous

- Waste control, disposal, and air pollution control measures should be carefully considered. Proper systems and operational controls should be instituted and carefully maintained.
- All equipment and facilities, as well as their installation, should conform to the specifications and requirements of appropriate federal, state, and local codes and ordinances.
- All equipment and materials should be compatible with the product to be handled and should be installed in strict compliance with the manufacturer's recommendations.
- All systems should be bonded and grounded. (Note: Bonding and grounding cables should be available at all loading stations.)
- All electrical equipment, such as motors, switches, etc., as well as their installation and use, must fully conform to the Underwriter's code.
- All tanks should be equipped with a stripping connection so that the tank may be com-

pletely emptied for cleaning, inspection, or repair.

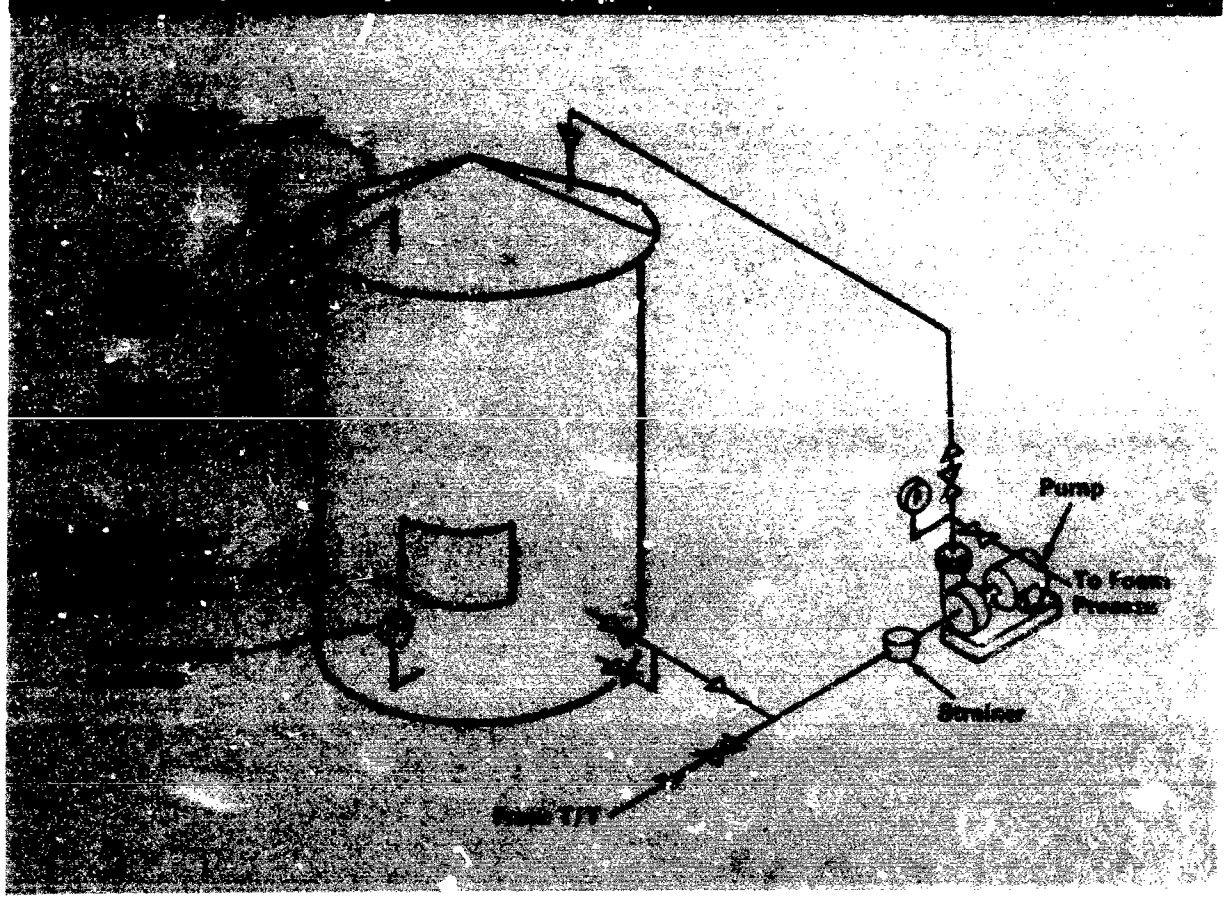
- All liquid bulk storage systems should be hydrostatically tested prior to lining, insulation, or use.

- All systems, new or old, should be provided with adequate waste control and disposal facilities, as well as sources of air, water, steam, and electric power for both systems operations and cleaning.

Caution

- Toxicology: Virtually all chemicals possess some degree of toxicity. Before handling a new chemical, therefore, it is essential that its toxicological properties, as well as any potential hazards associated with its handling and use, be thoroughly studied and understood. Based upon this study, appropriate health and safety standards should then be established and maintained.
- Isocyanate: Equipment containing copper, zinc, or tin, or their alloys, including brass, bronze, or galvanized materials, should not be exposed to liquid isocyanate or its vapors. Also, do not expose either rubber or synthetics — except Teflon fluorocarbon or Viton fluoroelastomer — to isocyanate liquid or vapor.
- Silica gel charges: Silica gel charges in tanks must be removed and the system must be thoroughly cleaned, dried, and purged with a dry pad gas prior to use.

Figure 4 — Isocyanate Component Storage System



Appendix A

Equipment Manufacturers and Suppliers (Bulk Handling and Storage)

The following is a representative list of manufacturers and suppliers of equipment which may be used in the design and construction of systems for bulk handling and storage of VORANATE T-80 Isocyanate. (Note: Specific questions about the specifications or suitability of any of the products offered by these firms should be addressed to the firm in question.* The Dow Chemical Company neither endorses the products offered nor guarantees their performance.)

COUPLINGS-QUICK

Ever-Tite Coupling Co., Inc.
256 W. 54 St.
New York, N.Y. 10019
212-265-1420

OPW Div. of Dover Corp.
9393 Princeton-Glendale Rd.
P.O. Box 40240
Cincinnati, O. 45240
513-870-3100

DRUM FILLING

Berkel Inc.
1 Berkel Dr.
LaPorte, Ind. 46350
219-362-3165

Crandall Filling Machinery, Inc.
1391 Niagara St.
Buffalo, N.Y. 14213
716-885-2228

*The names, addresses, zip codes, and telephone numbers listed here are accurate as of the date of publication. For current information, consult *Thomas Register, Standard & Poor's,* or the *Dun & Bradstreet Reference Book of Manufacturers.*

DRYERS

C.M. Kemp Mfg. Co.
S. Ferndale
Glen Burnie, Md. 21061
301-761-5100

Lectrodryer Div.
(Div. Ajax Magnethermic Corp.)
P.O. Box 4599
Pittsburgh, Pa. 15205
412-923-2970

Midland Specialties Co.
P.O. Box 247, Dept. TR
Brookfield, Ill. 60513
312-865-0575

Pall Trinity Micro Corp.
Western Rd.
Cortland, N.Y. 13045
607-756-7535

FILTERS

AMF Cuno Div.
(AMF Incorporated)
402 Research Pky.
Meriden, Conn. 06450
203-237-5541

Commercial Filters Div.
The Carborundum Co.
State Rd. 32W
Lebanon, Ind. 46052
317-482-3900

Filterite Corp.
Timonium, Md. 210931
301-252-0800

GAF Corporation
Felt & Filter Products Div.
Glenville Station
Greenwich, Conn. 06830
203-531-8807

Milipore Corp.
Wiggins Ave.
Bedford, Mass. 01730
617-275-9200

Ronningen-Petter Div.
(Dover Corporation)
P.O. Box 188
Portage, Mich. 49081
616-323-1313

GASKETS

Crane Packing Co.
6410 Oakton St.
Morton Grove, Ill. 60053
312-967-2400

Flexitallic Gasket Co.
Point & Linden Sts.
Camden, N.J. 08102
609-963-1130

Garlock Inc.
Mechanical Rubber Division
402 Main St.
Palmyra, N.Y. 14522
315-597-4811

Johns-Manville
Greenwood Plaza
P.O. Box 5108
Denver, Colorado 80217
303-770-1000

GAUGES, PRESSURE

Dresser Industries, Inc.
Dresser Industrial Valve
& Instrument Div.
250 E. Main St.
Stratford, Conn. 06497
203-378-8281

Ametek Inc.
U.S. Gauge Div.
P.O. Box 152
Sellersville, Pa. 18960
215-257-6531

GREASE LUBRICANTS *(Solvent Resistant)*

Penreco
(Div. Pennzoil)
2686 Lisbon Rd.
Cleveland, O. 44104

HEATERS

Crane Company
(Cochrane Environmental Systems Div.)
Dept. TR
P.O. Box 191
King of Prussia, Pa. 19406
215-265-5050

HEAT EXCHANGERS

American Standard, Inc.
Heat Transfer Div.
175 Standard Pky.
Buffalo, N.Y. 14227
716-897-2800

Nooter Corp.
1414 S. Third St.
St. Louis, Mo. 63166
314-621-6000

Patterson-Kelley Co.
Div. Taylor-Wharton Co.
Harsco Corp.
115 Burson St.
East Stroudsburg, Pa. 18301
717-421-7500

Smithco Engineering
P.O. Box 7070
602 W. 41 St.
Tulsa, Okla. 74105
918-446-4406

Struthers Wells Corp.
1093 Pennsylvania Ave. W.
P.O. Box 8
Warren, Pa. 16365
814-726-1000

Vilter Mfg. Corp.
2223 S. First St.
Milwaukee, Wis. 53207
414-744-0111

HOSE
(Metal)

Aeroquip Corp.
300 S. East Ave.
Jackson, Mich. 49203
517-783-2585

Federal Hose Manufacturing Corp.
23 Florence Ave.
Painesville, O. 44077
216-352-8927

Flexonics Division
Universal Oil Products, Inc.
300 E. Devon Ave.
Bartlett, Ill. 60103
312-837-1811

Pennsylvania Flexible Metallic Tubing Co.
P.O. Box 415-T
Paoli, Penn. 19301
215-644-7400

Universal Metal Hose Co.
2135 S. Kedzie Ave.
Chicago, Ill. 60623
312-277-0700

HOSE
(Synthetic)

Goodall Rubber Co.
493 Whitehead Rd.
Trenton, N.J. 08604
609-587-4000

Goodyear Tire & Rubber Co.
1144-T E. Market St.
Akron, O. 44316
216-794-2121

Raybestos-Manhattan
100 Oakview Dr.
Trumbull, Conn. 06611
203-371-0101

Uniroyal, Inc.
1230 Ave. of the Americas
New York, N.Y. 10020
212-247-5060

HOSE REELS

Clifford B. Hannay & Sons, Inc.
4900 E. Main St.
Westerlo, N.Y. 12193
518-797-3791

INSULATION

The Dow Chemical Company
2020 Dow Center
Midland, Michigan 48640
517-636-1000

Pittsburgh Corning Corp.
Dept. TR
800 Presque Isle Dr.
Pittsburgh, Pa. 15239
412-327-6100

JOINTS
(See "SWIVEL JOINTS")

LEVEL INDICATORS

Emerson Electric
VAREC Div.
301 E. Alondra Blvd.
Gardena, Cal. 90247
213-770-1500

LEVEL INDICATORS (MAGNETIC)

Midland Mfg. Corp.
7733 Gross Point Rd.
Skokie, Ill. 60076
312-677-0333

LEVEL SWITCHES

Magnetrol International
5300 Belmont Rd.
Downers Grove, Ill. 60515
312-969-4000

National Sonics Corp.
(Div. Envirotech Corp.)
250-T Marcus Blvd.
Hauppauge, N.Y. 11787
516-273-6600

LININGS

Ameron Corp.
(Protective Coatings Div.)
201 N. Berry St.
Brea, Cal. 92621
714-625-7741

Bisonite Co., Inc.
2248 Military Rd.
Tonawanda, N.Y. 14150
716-693-6130

Heresite & Chemical Co.
822 S. 14th St.
Manitowoc, Wis. 54220
414-684-6646

Wisconsin Protective Coating Corp.
616 Elizabeth St
Green Bay, Wis. 54305
414-437-6561

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METERS

Brooks Instrument
(Div. Emerson Electric)
407 W. Vine St.
Hatfield, Pa. 19440
215-368-2000

The Foxboro Company
86 Neponset Ave.
Foxboro, Mass. 02035
617-543-8750

Halliburton Services
(Div. Halliburton Company)
427 S. Boston St.
Tulsa, Okla. 74103
918-587-3117

Liquid Controls Corp.
P.O. Box 101
N. Chicago, Ill. 60064
312-689-2400

Rockwell Manufacturing Co.
662 N. Lexington Ave.
Pittsburgh, Pa. 15208
412-247-3500

Smith Meter Systems
(Div. Geosource Inc.)
1602 Wagner Ave.
Erie, Pa. 16512
814-899-0661

MOISTURE DETECTORS

Beckman Instruments Inc.
2500-TR Harbor Blvd.
Fullerton, Cal. 92632
714-871-4848

E.I. duPont de Nemours & Co., Inc.
1007 Market St.
Wilmington, Del. 19898
302-774-2421

Teledyne Analytical Instruments
333 W. Mission Dr.
San Gabriel, Cal. 91776
213-576-1633

PUMPS
(Canned)

Crane Company
(Chempump Div.)
Dept. TR
Warrington Industrial Park
Warrington, Pa. 18976
215-343-6000

PUMPS
(Centrifugal)

Allis-Chalmers Corp.
(Custom Pump Div.)
P.O. Box 512
Milwaukee, Wis. 53201
414-475-4479

Goulds Pumps, Inc.
240 Fall St.
Seneca Falls, N.Y. 13148
315-568-5811

The Duriron Company, Inc.
N. Findlay & Thomas Sts.
Dayton, O. 45401
513-226-4000

Ingersoll-Rand
Woodcliff Lake, N.J. 07675
201-573-0123

PUMPS
(Positive Displacement)

Blackmer Pump
(Div. Dover Corp.)
1809 Century Ave., S.W.
Grand Rapids, Mich. 49509
616-241-1611

Roper Pump Co.
P.O. Box 269
Commerce, Ga. 30529
404-335-5551

Viking Pump
(Div. Houdaille Industries, Inc.)
George & Wyth Sts.
Cedar Falls, Iowa 50613
319-266-1741

Waukesha Foundry Co., Inc.
(Div. Abex Corp.)
5510 Lincoln Ave.
Waukesha, Wis. 53186
414-542-0741

Zenith Products Co.
428 Cherry St.
West Newton, Mass. 02165
617-244-1707

REFRIGERATION UNITS

Carrier Air Conditioning Co.
(Carrier Corp.)
Carrier Pky.
Syracuse, N.Y. 13201
315-432-6000

Dunham-Bush, Inc.
178 South St.
West Hartford, Conn. 06110
203-249-8671

Ronningen-Petter Div.
(Dover Corp.)
P.O. Box 188
Portage, Mich. 49081
616-323-1313

Vilter Mfg. Corp.
2223 S. First St.
Milwaukee, Wis. 53207
414-744-0111

SAFETY EQUIPMENT

American Optical Corp.
(Safety Products Div.)
14 Mechanic St.
Southbridge, Mass. 01550
617-765-9711

Bausch & Lomb Inc.
(Ophthalmic and Consumer Products Div.)
1400 N. Goodman St.
Rochester, N.Y. 14602
716-338-6000

E.D. Bullard Co.
2682 Bridgeway
Sausalito, Cal. 94965
415-332-0410

Mine Safety Appliances Company
408 Penn Center Blvd.
Pittsburgh, Pa. 15235
412-241-5900

STRAINERS

AMF Cuno Div.
(AMF Incorporated)
400 Research Pky
Meriden, Conn. 06450
203-237-5541

OPW Div. of Dover Corp.
9393 Princeton-Glendale Rd.
P.O. Box 40240
Cincinnati, O. 45240
513-870-3100

SWIVEL JOINTS

Continental-Emsco
(Youngstown Sheet & Tube Co.)
P.O. Box 359
Dallas, Texas 75221
214-747-9261

FMC Corporation
Fluid Control Operation
10516 Old Katy Rd.
P.O. Box 19465
Houston, Texas 77024
713-461-3100

SYNTHETICS

E.I. duPont de Nemours & Co., Inc.
1007 Market St.
Wilmington, Del. 19898
302-774-2421

TANKS

Buffalo Tank Div.
South Ave.
Dunellen, N.J. 08812
201-968-5200

TAPE

E.I. duPont de Nemours & Co., Inc.
1007 Market St.
Wilmington, Del. 19898
302-774-2421

THERMOMETERS

almer Instruments, Inc.
5131 Wasson Rd.
Cincinnati, O. 45209
513-871-7800

Precision Thermometer & Inst. Co.
1020 Industrial Highway
Southampton Industrial Park
Southampton, Pa. 18966
215-355-1500

(Note: Most manufacturers of thermometers also supply thermowells.)

VALVES

Aloyco Inc.
1400 W. Elizabeth Ave.
Linden, N.J. 07036
201-925-4600

Crane Co.
300 Park Ave.
New York, N.Y. 10022
212-752-3600

Hills-McCanna Company
400 Maple Ave.
Carpentersville, Ill. 60110
312-426-4851

Jamesbury Corp.
659 Lincoln St.
Worcester, Mass. 01605
617-852-0200

KTM Industries Inc.
6904 Harwin Dr.
Houston, Texas 77036
713-781-8543

The Lunkenheimer Co.
Beekman St. at Waverly Ave.
Cincinnati, O. 45214
513-921-3400

VALVES (CONTROL)

Fisher Controls Co.
1900 Fisher Bldg.
Marshalltown, Iowa 50158
515-754-3556

Masoneilan International, Inc.
63 Nahatan St.
Norwood, Mass. 02062
617-762-4600

VALVES (REFLIEF/VENTS)

Crosby Valve & Gage Co.
43 Kendrick St.
Wrentham, Mass. 02093
617-384-3121

Johnston & Jennings Co.
(Pettibone-Mulliken Corp.)
4700 W. Division St.
Chicago, Ill. 60651
312-772-9300

Midland Specialties Co.
P.O. Box 247, Dept. TR
Brookfield, Ill. 60513
312-865-0575

The Protectoseal Co.
227 Foster Ave.
Bensenville, Ill. 60106
312-595-0800

Vapor Recovery Systems Co.
(Varec Division Emerson Electric Co.)
301 E. Alondra Blvd.
Gardena, Cal. 90247
213-770-1500

VAPOR DETECTORS

MDA Scientific, Inc.
808 Busse Highway
Park Ridge, Ill. 60068
312-696-4250

National/Draeger, Inc.
401 Parkway View Dr.
Pittsburgh, Pa. 15205
412-787-1131

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Appendix B

Equipment Manufacturers and Suppliers (Respiratory Protective Equipment)

The following list of manufacturers and suppliers* of NIOSH approved respiratory protective equipment was obtained from the National Institute For Occupational Safety and Health, Morgantown, West Virginia 26505.

Acme Automotive Finishes
101 Prospect Ave.
Cleveland, O. 44115
216-566-3076

American Optical Corp.
Safety Products Division
14 Mechanic St.
Southbridge, Mass. 01550
617-765-9711

Anderson Manufacturing Co.
1014 Fox Chase Road
Rockledge, Pa. 19111
215-379-8080

Binks Manufacturing Co.
9205 W. Belmont Ave.
Franklin Park, Ill. 60131
312-671-3000

BioMarine Industries, Inc.
88 Great Valley Center
Malvern, Pa. 19355
215-647-7200

Bowen Tools, Inc.
2429 Crockett St.
P.O. Box 3186
Houston, Texas 77001
713-869-6711

Bullard, E.D., Co.
2682 Bridgeway
Sausalito, Cal. 94965
415-332-0410, Ext. 1000

Cesco Safety Products
(Parmelee Industries, Inc.)
100 E. 16th St.
Kansas City, Mo. 64108
816-842-8500

Clemco Industries
Jerrold at Upton
San Francisco, Cal. 94124
415-282-7290

Cover, H.S., Company
109 E. Alexander St.
Buchanan, Mich. 49107
616-695-9663

Deane & Company
190 Oneida Drive
Pt. Claire, Quebec,
Canada H9R1A8
514-697-3730

DeVilbiss Company
P.O. Box 913
Toledo, O. 43692
419-470-2169

Eastern Safety Equipment Co., Inc.
45-17 Pearson St.
Long Island City, N.Y. 11101
212-392-4100

Empire Abrasive Equipment Corp.
9992 Gantry Rd.
Philadelphia, Pa. 19115
215-676-7700

Encon Manufacturing Co.
P.O. Box 3826-TR
Houston, Texas 77001
713-869-9558

The Fibre-Metal Products Co.
P.O. Box 248
Concordville, Pa. 19331
215-459-5300

Glendale Optical Co., Inc.
130 Crossways Park Dr.
Woodbury, N.Y. 11797
516-921-5800

Globe Safety Products, Inc.
125 Sunrise Place
Dayton, O. 45407
513-224-7468

Kelco Sales & Engineering Co.
Front St. & Paddison Ave.
Norwalk, Cal. 90650
213-868-9861

Mine Safety Appliances Co.
408 Penn Center Blvd.
Pittsburgh, Pa. 15235
412-241-5900

National/Draeger, Inc.
401 Parkway View Dr.
Pittsburgh, Pa. 15205
412-787-1131

Norton Company
Safety Products Division
2000 Plainfield Pike
Cranston, R.I. 02920
401-943-4400

Pauli & Griffin Co.
137 Utah Ave. at Wattis
South San Francisco, Cal. 94080
415-873-4540

Pulmosan Safety Equipment Corp.
30-46 Linden Place
Flushing, N.Y. 11354
212-939-3200

Quaker State Machine & Supply Co.
P.O. Box 605-T
Rushland, Pa. 18956
215-598-3222

Robertshaw Controls Company
333 N. Euclid Way
Anaheim, Cal. 92803
714-535-8151

Safe-Tex Manufacturing Co.
15 Brandon
Toronto, Ontario, Canada
416-534-4223

Scott Aviation
(Div. of A-T-O Inc.)
2225 Erie St.
Lancaster, N.Y. 14086
716-683-5100

*The names, addresses, zip codes, and telephone numbers listed here are accurate as of the date of publication. For current information, consult *Thomas Register, Standard & Poor's,* or the *Dun & Bradstreet Reference Book of Manufacturers.*

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Siebe Gorman Holdings Ltd.
Neptune Works Davis Road
Chessington Surrey,
England KT9

Sellstrom Mfg. Co.
221 S. Hicks Rd.
Palatine, Ill. 60067
312-358-2000

Stewart-Warner
1826 W. Diversey Pkwy
Chicago, Ill. 60614
312-883-6000

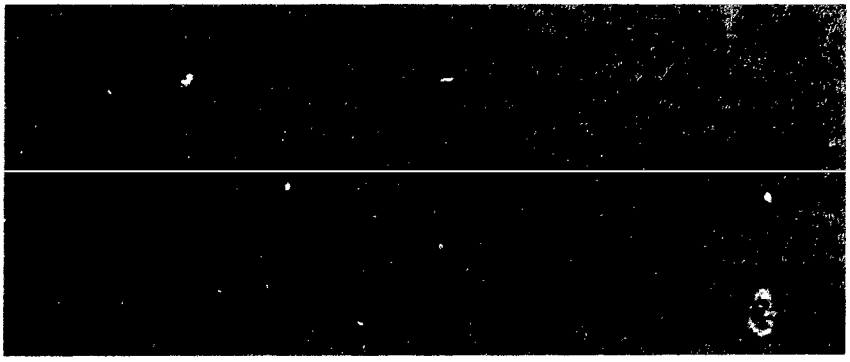
SurvivAir
(Div. U.S. Divers Co.)
3323 W. Warner Ave.
Santa Ana, Cal 92702
714-540-8010

3M Company
3M Center
St. Paul, Minn. 55101
612-733-1110

United States Safety Service Co.
1535 Walnut St.
Kansas City, Mo. 64108
816-842-8500

Welsh Manufacturing Co.
(See Norton Company)

Willson Products Division
ESB Inc.
P.O. Box 622
Reading, Pa. 19603
215-376-6161



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VORANATE T-80 Isocyanate
Safe Handling and Storage

DOW CHEMICAL U.S.A. — **ORGANIC CHEMICALS DEPARTMENT**

AN OPERATING UNIT OF THE DOW CHEMICAL COMPANY — **MIDLAND, MICHIGAN 48640**

AREA HEADQUARTERS OF THE DOW CHEMICAL COMPANY

DOW CHEMICAL U.S.A.	MIDLAND, Michigan 48640
DOW CHEMICAL LATIN AMERICA	CORAL GABLES, Florida 33134
DOW CHEMICAL EUROPE, S.A.	8810 HORGEN, Switzerland
DOW CHEMICAL PACIFIC	P.O. Box 711, HONG KONG
DOW CHEMICAL OF CANADA, LIMITED	SARNIA, Ontario N7T 7K7

SALES OFFICES OF DOW CHEMICAL U.S.A.

ATLANTA	Suite 2005, 20 Perimeter Center East, Atlanta, GA	30346	404-394-4141
BATON ROUGE	4150 S. Sherwood Forest Blvd., Suite 101, Baton Rouge, LA	70816	504-293-2222
BOSTON	20 William St., Wellesley, MA	02181	617-237-2070
CHARLOTTE	2 Woodlawn Green, Woodlawn Road, Charlotte, NC	28210	704-525-9030
CHICAGO	1400 East Touhy Ave., Des Plaines, IL	60018	312-391-4700
CINCINNATI	Whitehall Park, 8050 Hosbrook Road, Cincinnati, OH	45236	513-793-6200
CLEVELAND	14955 Sprague Road, P.O. Box 8800, Strongsville, OH	44136	216-826-6000
DALLAS	12700 Park Central Place, Suite 600, Dallas, TX	75251	214-387-2211
DETROIT	Travelers Tower, Suite 415, 26555 Evergreen Road, Southfield, MI	48076	313-358-1300
GRAND RAPIDS	611 Cascade West Parkway S.E., Grand Rapids, MI	49506	616-949-9000
HOUSTON	P. O. Box 3387, Attn: Sales Office, Houston, TX	77001	713-626-3170
INDIANAPOLIS	P.O. Box 68511, 9550 N. Zionsville Road, Indianapolis, IN	46268	317-873-7000
KANSAS CITY	Suite 160, 10890 Benson Drive, Shawnee Mission, KS	66210	913-341-2500
LOS ANGELES	P. O. Bin 48, Pasadena, CA	91109	213-577-1515
MEMPHIS	Suite 2210, 5100 Poplar Ave., Memphis, TN	38137	901-767-5000
MINNEAPOLIS	11100 West Bren Road, Minnetonka, MN	55343	612-938-4300
NEW YORK	Park 80 Plaza East, Saddle Brook, NJ	07662	201-845-5000
PHILADELPHIA	P. O. Box 350, Moorestown, NJ	08057	609-234-0400
PITTSBURGH	Four Gateway Center, Suite 1313, Pittsburgh, PA	15222	412-281-3030
RICHMOND	1603 Santa Rosa Road, Richmond, VA	23288	804-288-1601
ROCHESTER	400 Perinton Hills Office Park, Fairport, NY	14450	716-425-1200
ST. LOUIS	800 Pierre Laclede Center, 7733 Forsyth Blvd., St. Louis, MO	63105	314-726-5000
SAN FRANCISCO	2800 Mitchell Drive, Walnut Creek, CA	94596	415-944-2000
SEATTLE	777—106th Ave., N.E., Bellevue, WA	98004	206-455-7250
STAMFORD	Washington Plaza, 1351 Washington Blvd., Stamford, CT	06902	203-353-3300

Printed in U.S.A.

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