Polyurethane
MDI
Handbook
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1. Introduction

MDI (diphenylmethane diisocyanate) is a member of the diisocyanate family associated with polyurethane chemistry. The term polyurethane applies to a large number of polymers formed through the polyaddition of polyfunctional isocyanates and reactive polyfunctional compounds. Polyurethanes are some of the most versatile of the polymers in existence today. They exist in numerous forms ranging from lightweight rigid foams to dense solid compositions and from soft flexible foams to tough elastomeric moldings.

BASF Commitment to the Polyurethane Industry

The worldwide polyurethane operations of the BASF Group include a broad range of activities such as:

- Urethane Chemicals
- MDI (diphenylmethane diisocyanate)
- TDI (toluene diisocyanate)
- Polyols (polyether, polyester)
- Polyurethane Systems
- Polyurethane Elastomers/Thermoplastics

These activities are coordinated on a global basis to assure a high level of quality to polyurethane processors and users throughout the world.

Since its founding in 1865, BASF Aktiengesellschaft has placed major emphasis on research and development. Today, the results of widely based research activities in Europe and North America are directly available to all independently operating companies in the BASF Group. This constant interchange of technical expertise among companies in the BASF Group ensures that BASF customers will benefit from the very latest know-how of polyurethane technology within the Group. Figure 1 illustrates the worldwide geographic spread of the BASF Group products.

BASF manufactures and markets three of the key urethane chemicals - MDI, TDI, and Polyols. MDI is produced by BASF Antwerpen N.V. at Antwerp, Belgium by BASF Corporation at Geismar, LA, U.S.A., by BASF Schwarzheide GmbH at Schwarzheide, Germany, BASF Polyurethanes-Asia Pacific at Yeochon, Korea. These facilities produce a full line of MDI products, marketed under the trademarks Lupranate®, Lupranat®, to supply a wide range of polymer applications.

Like many reactive chemicals, “MDI products” can create hazards if handled carelessly. The purpose of this publication is to outline certain precautions, the observance of which will reduce these hazards in handling diisocyanates under normal and emergency situations. All persons associated with the transportation, storage, or handling of MDI products must be fully conversant with the potential hazards and trained in the recommended normal and emergency handling procedures.

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1 In this handbook, the term “MDI products” is often used interchangeably with terms such as “MDI”, “MDI-containing products”, “MDI materials”
This publication is intended to provide general guidance only. In some countries, specific regulations supplement or modify the guidance given herein. All users of MDI products must be fully informed on the most current guidelines and the regulations of all applicable authorities. Users of MDI are strongly urged to consult the appropriate regulatory authorities before finalizing specifications for processing, handling, and storage equipment.

The current Material Safety Data Sheet (MSDS) should be used in conjunction with this publication because the MSDS is updated as changes in regulatory requirements occur. Material Safety Data Sheets can be obtained directly from your BASF sales office.
2. The MDI Products

MDI Production Process
In the MDI process, aniline is condensed with formaldehyde to produce methylene dianiline (MDA), which in turn reacted with phosgene to form MDI. The flexibility of the BASF process makes it possible to control and modify the properties of a broad range of MDI products. This process is designed with the flexibility that allows BASF to be a highly reliable source of MDI for the polyurethane industry. Figure 2 gives a view of the production steps to produce MDI.

MDI Product Family, Properties and Applications
MDI (diphenylmethane diisocyanate) and its different modified forms are reactive chemicals which may be supplied as a liquid or solid. In combination with polyols (polyesters, polyethers), they are used for the manufacture of cellular (foamed) and non-cellular (compact) PUR polymers including coatings, elastomers, adhesives, textiles, and paints.

![Figure 2: Steps in the production of MDI](image)
MDI in its many forms is widely used in a range of markets such as automotive, furniture, construction, appliances, insulation, and recreation. MDI is available in three broad types of compositions:

- Polymeric MDI (PMDI)
- Monomeric MDI (MMDI)
- Modified MDI

The typical physical and chemical properties of the three MDI types MMDI, Modified MDI and PMDI are listed in Figure 3.

**Polymeric MDI (PMDI)**
Polymeric MDI is a brownish liquid. It is a mixture of MDI and other MDI isomers (2,4', 2,2') and higher molecular weight oligomers. The average functionality of this mixture varies from 2.1 or 3.0.

PMDI starts to decompose at temperatures above 230°C [446°F with the evolution of carbon dioxide (CO₂)]. At 25°C (77°F), it has a low vapor pressure of 10⁻⁵ mbar (7.5X10⁻⁶ mm HG).

PMDI’s principal use is in rigid foam insulation for the construction and refrigeration industrial. It is also used in producing high resilience flexible, semi-rigid and packaging polyurethane foams and in a number of non-foam applications such as carpet backing, adhesives, plywood patching compounds, and foundry core binder.
Monomeric MDI (MMDI)
Monomeric MDI is a purified material distilled from a polymeric MDI mixture. It consists of over 97% 4,4′-MDI with small amounts of 2,4′-MDI and traces of the 2,2′-isomer. It is a solid with a melting point of about 38.5°C (101.3°F), and a boiling point of 210°C (410°F) at 7 mbar (5 mm Hg). It starts to decompose at about 230°C (446°F). At 25°C (77°F), it has a low vapor pressure of 10-5 mbar (7.5X10^-6 mm Hg). The functionality is 2.0.

MMDI is used in a multitude of thermoplastic and cast elastomer applications, and is the starting material for a variety of modified MDI products. It is also used to prepare coatings, adhesives, sealants, and synthetic fibers.

Modified MDI
Modified MDIs are chemically tailored to the requirements of specific applications and processes. They are used in producing reaction injection molded (RIM) polyurethane automotive body parts, microcellular elastomers, integral skin foams, flexible foams, adhesives, coatings, and sealants.

Chemical Properties
MDI is denser than water and will sink to the bottom of water-filled containers. Although it reacts with water, the rate of reaction is very slow at temperatures below 50°C (122°F). At higher temperatures or in the presence of catalysts/basic materials, the reaction becomes progressively more vigorous.
and can be violent. The reaction of MDI with water liberates CO₂ gas and forms insoluble polyureas.

MDI reacts with basic materials such as sodium hydroxide, ammonia, amines and reacts with alcohols and acids. These reactions may be violent, generating heat, which can result in an increased evolution of isocyanate vapor and/or a buildup of pressure within closed containers.

MDI is not generally corrosive towards metals or other materials at normal temperatures, but the presence of a small amount of acidity in polymeric MDI can produce some corrosion with copper alloys and aluminum. Copper, zinc or their alloys must be avoided as they may cause product deterioration. Mild steel is the recommended material for MDI containers. Stainless steel is the recommended material of construction for pumps, discharge pipelines, and valves. MDI will attack and embrittle many plastic and rubber materials in a short time, which may lead to cracking of these materials.

Figure 4 gives molecular formula and constants. The single MDI forms have been characterized by several identity numbers as made up in this table.

Figure 5 gives the actual applications of MDI products, classified as Monomeric, modified, and polymeric MDI.
3. Health Considerations

Acute Hazards
MDI and products containing unreacted MDI are potentially hazardous materials. Therefore, a thorough knowledge of potential dangers, with strict adherence to recommended safety practices, is essential before MDI products are handled, stored, or used. Workers must be properly instructed and supervised in the handling of MDI products.

MDI can be potentially hazardous in liquid, vapor, mist (aerosol), or dust form. Aerosols are airborne droplets and are present anywhere MDI is sprayed. These droplets may present a risk even at normal temperatures. A dust hazard may arise whenever solid MMDI or MDI is absorbed on finely divided materials when handled.

Exposure limits have been established by regulatory agencies and industry groups for MDI. Figure 6 identifies some of the current regulatory limits in effect. Permissible workplace exposure limits (PEL) are ceiling limits and should be sufficiently low to prevent sensitization in most individuals. However, allergic reactions may occur in sensitized individuals at concentrations well below these values.

The odor threshold of MDI is approximately 0.2-0.4 ppm, therefore odor does not provide sufficient warning of overexposure.

MDI can produce local irritation upon contact with the skin, upper respiratory tract (nose, throat, lungs), eyes, and mucous membranes.

If vapors, mists, or dusts are inhaled, MDI can cause respiratory symptoms similar to those caused by all other isocyanates, with labored breathing in some individuals.

Aerosols may also be formed when MMDI or MDI is heated, such as melting pure MDI or certain applications, and allowed to cool in the ambient air.

Furthermore, some individuals may develop an allergic respiratory reaction (sensitization) to these MDI exposures. Sensitized individuals may thereafter be affected by very low concentrations. After serious vapor exposure, pulmonary edema can occur.

Effects on the Respiratory System
High concentrations of MDI vapor, aerosol, or dust may irritate the mucous membranes of the nose, throat, and lungs. It may cause throat dryness and tightness in the chest and breathing difficulties. Overexposure symptoms may be delayed. Allergic reactions can appear in susceptible persons. The health of all personnel coming into contact with MDI should be regularly monitored.

The inhalation LC\textsubscript{50} (aerosol-4 hours rat) has been determined to be approximately 180 mg/m\textsuperscript{3} (MMDI) and 490 mg/m\textsuperscript{3} (PMDI). The MDI concentration in a saturated atmosphere 13 ppb is approximately 4000 times lower than the LC\textsubscript{50}. No mortality in rats was observed at this concentration.

Effects on Eyes
Direct eye contact with MDI products may produce severe watering, irritation and inflammation of mucous membranes. Corneal opacity and discharge may result.

**Effects on Skin**
Skin contact with MDI may result in irritation and a mild tanning action, depending on the amount and length of contact. Direct contact may produce skin sensitization, contact dermatitis, and eczema from repeated exposure. An animal study indicates that MDI may induce respiratory hypersensitivity upon dermal exposure.

**Effects on Ingestion**
The effects of ingestion include irritation and burning of the mouth, esophagus, and stomach. The LD₅₀ (oral-rat) for MDI is greater than 5000 mg/kg.

**Chronic Hazards**
Repeated exposure of the skin, the eyes, nose or upper respiratory tract may cause chronic irritation.
Some individuals may develop a hypersensitivity to MDI vapors and, upon exposure to minute amounts of this material, can develop spasms of the bronchial tubes which may produce difficulty in breathing. Long-term overexposure to diisocyanates has also been reported to cause lung damage, including reduced lung function, which may be permanent.

Results from a lifetime inhalation study in rats indicate that MDI aerosol was carcinogenic at 6 mg/m³, the highest dose tested. This is 120 times above the recommended workplace exposure limit of 5 ppb (0.05mg/m³). Only irritation was noted at the lower concentrations of 0.2 mg/m³ and 1 mg/m³. In Germany, DFG has included MDI respirable aerosol in its category III B, as a compound that is suspected of having carcinogenic potential.

Some in vitro (test tube) mutagenicity studies on MDI, have shown positive results. However, the majority of these studies have been negative. Furthermore, MDI did not produce mutagenic effects when tested in whole living animals.²

**Sensitization**
Sensitization is an effect whereby a physiological response (e.g., respiratory, dermal) is caused by re-exposure to lower the concentrations of the material. The response may be immediate, delayed, or both.

The symptoms associated with respiratory sensitization by diisocyanates are those of asthma. Difficulty in breathing, chest tightness, wheezing, and coughing are common. If sensitized individuals continue to work with MDI, the delay between exposure and onset of symptoms may be shortened, and the severity of the symptoms may increase. It is believed that cross-sensitization may occur between different diisocyanates. Individuals who are sensitized to other diisocyanates may also demonstrate sensitization to MDI. Upon removal from MDI exposure, the sensitized individuals’ respiratory problems usually improve. If a sensitized person continues to be exposed, their respiratory problems can become permanent. Therefore, early recognition of sensitization and prevention of subsequent exposure is important to protect the respiratory health of sensitized workers.

The determination of what constitutes a MDI exposure can be difficult. The minimum concentration of MDI in the atmosphere that will cause subjective symptoms and objective physical findings in any given individual is unknown, especially in sensitized individuals. If anyone experiences an exposure severe enough to develop symptoms, no matter how mild

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² For a summary of carcinogenic effects, see CIVO-TNO (ISOPA).
those symptoms may appear, a physician should be consulted prior to resumption of work with MDI.

First Aid

First Aid in Case of Inhalation
Affected persons should move from the contaminated area to fresh air supply immediately. Remove all contaminated clothing and contact medical personnel immediately. Keep affected persons comfortable and warm. Medication will rarely be necessary if adequate fresh air is available. If there has been a severe exposure and breathing stops, artificial respiration should be initiated immediately. If oxygen inhalation equipment is available, oxygen should be administered by a physician or authorized person.

Never attempt to give anything by mouth to an unconscious person. Medication should be given only by an attending physician. In the event of breathing difficulty, a physician or authorized person should treat with medication\(^3\) to protect from over-reaction of the immune system and to prevent pulmonary edema.

In cases of severe exposures to mists or liquid MDI, MMDI, early attention to decontamination is essential. First responders should avoid direct skin contact with contaminated surfaces, skin and clothing. Responders should wear respiratory protection.

First Aid in Case of Eye Contact
In the event MDI comes in contact with the eyes, immediately flush affected area with running water for at least 15 minutes. The eyelids should be held apart during washing to ensure contact of water with all affected tissues of the eyes and preferably from an eye specialist, as soon as possible. The affected person should receive medical attention, preferably from an eye specialist, as soon as possible.

First Aid in Case of Skin Contact
Immediately move the affected person to a safety shower or other source of large amounts of water. Remove all contaminated clothing while under the shower and thoroughly wash affected areas with soap and water or polypropylene glycol for skin cleaning. Medical treatment should be given if affected skin experiences persistent irritation, including redness, swelling, or burning sensation. Launder contaminated clothing before reusing and destroy in cases of severe contamination. (In both cases taking precaution against additional exposure).

First Aid in Case of Ingestion
The affected person should immediately drink large amounts of water to reduce the concentration of the chemical. Vomiting should not be induced. Care for physical repose, and protect against loss of body heat. The person should be transported to a medical facility as quickly as possible. If vomiting should occur, more water should be given immediately. Never give fluids or induce vomiting if the person is unconscious or having convulsions.

\(^3\) E.g., Dexamethason inhaler (Dexamethason-21-isonicotinate).
Medical Considerations
Preplacement testing considerations should be given to individuals being assigned to work with MDI. All personnel should receive a health appraisal, including examination of the upper respiratory tract and lungs.4

Caution is warranted when assigning individuals with active asthma or other lung diseases to positions where diisocyanates may be contacted.

The incidence of illness due to working with MDI will be minimized if reasonable and acceptable industrial hygiene measures are consistently enforced. Once sensitized, an individual will tend to remain sensitive to MDI. Therefore, any sensitized individual exposure to minute amounts of MDI should be assigned to work in a diisocyanate-free environment.

Industrial Hygiene
The potential hazards associated with MDI can be avoided if workers are adequately instructed and supervised on the proper procedures of handling MDI. Every worker should be trained to realize that exposure to a hazardous chemical requires immediate washing of affected areas using large amounts of soap and water, and that immediate attention may markedly decrease the severity of any health effects. (See First Aid.) Do not wash affected area with solvents.

Protective clothing, gloves, boots and eye protection must be worn whenever there is any possibility of MDI exposure. Protective clothing shall be made of impervious materials. Soiled or contaminated clothing should be laundered or destroyed.

Proper respiratory protective equipment should be readily available and in good working order. Exhaust and ventilating equipment should be inspected and tested regularly to assure MDI vapors / aerosols are being controlled to acceptable levels.

Properly designed emergency showers and eyewash fountains should be placed in convenient locations wherever MDI is used. All employees should know the location and operation of this equipment. All equipment must be frequently inspected to make sure they are in proper working condition.

4 Tests may include but are not limited to pulmonary function or spirogram with emphasis on Forced Vital Capacity (FVC) and Forced Respiratory Volume (FEV 1-sec).
4. Safe Handling of MDI Products

MDI and products containing MDI are reactive and hazardous chemicals. MDI should only be handled by knowledgeable and well-trained personnel who thoroughly understand the hazards associated with the transportation, storage, and use of the chemical. Eating and drinking should not be allowed where MDI is handled or stored. Contaminated clothing must be washed before reuse. Discard severely contaminated clothing. Never reuse contaminated footwear or leather gloves.

Employee Training and Education

The investment in employee education and training on proper storage and handling procedures for MDI is extremely important. Hazardous situations may be created by poorly trained personnel even in well-designed operations. All personnel that may come into contact with MDI products should be included in a Hazard Communication training program. Employee training and education programs must include the regulations of all applicable agencies. Local regulations and requirements must be obtained from the local authorities.

Operating procedures, including all safety rules should be reviewed by all personnel regularly. Safety procedures and rules should be posted in work areas accessible to all individuals. Safety equipment should be available and maintained in good working order.

Engineering Considerations

Building design considerations can reduce the potential hazards associated with the storage and handling of MDI. Careful consideration should be given to the design of the building’s ventilation system. MDI aerosols or vapors should be monitored and controlled below applicable regulatory limits. MDI should be processed within closed systems. There are some applications where this is impractical, however, such as in laminate board production or in spray systems and laboratory areas. Special consideration should be given to ventilation design in these applications.

The guidelines established by OSHA, ACGIH, NIOSH, DFG, and others represent current thinking and are believed to be conservative. There is no guarantee of absolute safety.

Regulations involving hazardous chemicals are continually evolving and thus exposure guidelines are reviewed regularly and modified whenever new information dictates change. It is important that all companies handling MDI products are aware of the current legislative requirements in each jurisdiction.

Personal Protective Equipment

Personal protective equipment is not an adequate substitute for safe working conditions. However, in many instances including emergency situations, it may be the only means of protecting the worker. Only individuals wearing this equipment are protected. Unprotected personnel should be removed from any work area where there is the potential for exposure to MDI products.
Eye Protection
Chemical safety goggles are required for all persons handling MDI. Cup-type or rubber-framed goggles equipped with the approved impact resistant glass or plastic lens are recommended. Cover-all type should be used for complete eye protection.

Respiratory Protection
MDI vapor concentrations exceeding permissible exposure levels may occur. Such occasions included (but are not limited to) the following:

- Spray operations
- The opening of tank car hatches, truck man-way covers, or drum plugs that have been heated
- Connecting or disconnecting of hoses and pipes
- Equipment operation or repair
- The breaking or failure of MDI piping or equipment
- Any spill or leak of MDI which is heated.

No one should enter an area where MDI vapor concentrations or aerosols may exceed the recommended exposure limits without appropriate personal protective equipment.

Personnel who may be exposed to spills and anyone involved in generating MDI aerosols, as in spraying operations, or in the high temperature processing of MDI products, must be provided with adequate respiratory protection. Respirators must be approved by all applicable authorities.

In the United States, respiratory equipment must be an air-supplied or self-contained breathing apparatus with full-face piece operating pressure-demand or other positive pressure mode.

In Europe, pressure demand airline respirator equipment may also be used for protection against MDI materials, but only where conditions will permit safe escape in the event of an air supply failure. In Germany, employees working with MDI materials and using masks must be subjected to occupational health checks.5

Respiratory protection equipment must be carefully maintained, inspected, and cleaned regularly. Location of equipment should be easily accessible and personnel should be thoroughly trained on the proper selection, maintenance, and use of equipment.

Head, Skin, Hand, and Foot Protection
Head protection should be worn to protect from falling objects, overhead leaks, and splashes. A long sleeved, impervious protective suit should be worn whenever there is possibility of exposure to MDI. Impervious gloves* should be worn whenever the possibility of spills or splashes exists.

*See MSDS for recommendations SPI glove permeation data.

5 Basic regulation G26/Employers’ Accident Insurance Association
Personnel handling MDI drums and cans should wear protective safety shoes with built-in steel toecaps. Rubber overshoes may be worn with ordinary work boots. Never wear uncovered leather shoes. Leather will absorb MDI, making decontamination of leather products such as gloves or shoes difficult. Surfaces should be thoroughly washed with soap and water after mild contamination.

**Fire Hazards**
Due to its high flash point (200°C/392°F), liquid MDI does not constitute a severe fire hazard. However, it is important that the proper fire-fighting equipment be available in case it should be needed.

Water spray is effective for extinguishing fires covering large areas. Automatic sprinkler systems may be helpful in certain applications. When water is used to extinguish MDI fires, it should be applied in large amounts. Small amounts may only react with the hot MDI and worsen the fire situation. CO₂, protein foam, or dry chemical extinguishers are also effective.

Do not inhale gases or fumes from burning MDI. They can contain carbon monoxide, nitrogen oxides, MDI, and small amounts of hydrogen cyanide.

Fire fighters should wear self-contained breathing apparatus. The usual fireman’s body protection should be worn: turnout coat, boots, and helmet.
5. Shipment of MDI Products

MDI and MDI-containing products can be distributed and handled safely provided that appropriate precautions are observed.\(^6\)

**Regulations**

The shipment of MDI and MDI-containing products is subject to regulation within the United States above 5,000 pounds of 4’4 MDI in a single container. In addition, the international movement of these products by road, rail or sea is subject to international agreements which lay down specific requirements concerning shipment which must be observed by all parties involved.

The transportation equipment for MDI products must meet the design and construction requirements of national and international regulations. Figure 7 is a partial list of transportation regulations.

BASF uses only professional transportation companies whose personnel are competent and well trained in handling of MDI products. Accompanying all shipments of MDI products is a transport emergency card (Tremcard in Europe) and/or a Bill of Lading.\(^7\)

**Shipping Containers**

MDI products are generally shipped in 200-liter (55-gallon) steel drums or in bulk. Bulk deliveries are generally made in tank trucks (road tankers) and demountable tanks containing approximately 20 tons (44,000 pounds) or tank cars (rail tank wagons) containing up to 100 tons (200,000 pounds). Each container clearly displays a tag, placard, and/or label warning of potential hazards.

The MDI product quality can be affected by temperature. The recommended temperature must be maintained throughout transit to maintain product quality. Refer to the specific product information for the temperature requirements of individual products in the BASF Technical Leaflets or Bulletins.

MDI containers must remain closed until use to prevent moisture contamination. Only trained workers wearing appropriate personal protective equipment are allowed to open containers of MDI products. When a MDI container is opened, make-up dry air or nitrogen should be provided.

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\(^6\) ISOPA has published some recommendations for the distribution of MDI products in Europe. See References: Guidelines for the Distribution of Toluene Diisocyanate (TDI) and Diphenylmethane Diisocyanate (MDI) (ISOPA, March 1992).

\(^7\) For further information concerning distribution refer to:

a) Technical Data Sheets of MDI products Lupranate®, Lupranat®, (See Appendices).
b) Guidelines for the Distribution of Toluene Diisocyanate (TDI) and Diphenylmethane Diisocyanate (MDI) (ISOPA, March 1992) (See References) MDI Transportation Guidelines, API 1996.
c) Guidelines for the Reception and Bulk Storage of Toluene Diisocyanate (TDI) and Diphenylmethane Diisocyanate (MDI) (DIA, 1989 (CISHEC) (See References).
d) Specific regulations for Europe, America/U.S.A., Asia (See Appendices).
BASF has the responsibility to ensure that all MDI shipments leaving BASF facilities are properly prepared to comply with all the appropriate regulatory transportation requirements. Depending on the method of transportation, the rail carriers, truck lines or airlines are responsible for the safe shipment of MDI products from the shipping point to the final destination. Emergency situations en route, such as accidents or leaking containers, must be reported immediately to appropriate regulatory authorities and to BASF. (See Section 7.)

Unloading Operations
The operation of unloading (or loading) any tank truck, iso tank container, tank car or small container of MDI is potentially hazardous operation. Unloading facilities must be designed and located giving due regard to the potential hazards of MDI products.

Written operating procedures covering all aspects of the unloading operation of MDI products must be prepared and available to all involved parties. All necessary personal protective equipment and emergency equipment must be available for the unloading operations. Personnel must be trained in the procedures and correct use of all protective clothing and emergency equipment. (See Section 4).

Bulk Unloading
Unloading of MDI products from bulk containers should be performed with a self-priming, sealless pump and a vapor return line connected between the storage tank and the bulk delivery container. Due to the MMDI freezing point, MMDI transfer lines must be heated. Dry nitrogen or dry air must be available to purge the unloading lines and vapor return line after unloading is completed. The storage tank must be equipped with a high-level device which will stop the unloading automatically if the maximum tank level is reached.

Self-priming sealless pumps such as magnetic drive pumps have been successfully used by BASF. The sealless design eliminates potential seal failure.

If dry air or nitrogen pressure is used to transfer MDI products from a bulk container to the storage tank, the pressure must be regulated below the maximum safe operating pressure...
of the bulk container and the storage tank vent must be sized accordingly. After disconnecting hoses, all exposed fittings and hoses must be protected with caps or plugs.

The dimensions and physical arrangement of bulk containers vary. Contact your local BASF office for unloading instructions on specific container types.

**Drum Handling**

The handling of MDI drums is a potentially hazardous operation. Operators must have the proper personal protective equipment.

Drums should be transported by lifting to avoid damage caused by sliding or rolling. Only equipment designed for handling drums should be used, such as forklift trucks equipped with “parrot beaks” or drum clamps. Drums should be handled and unloaded carefully to prevent damage. Improperly equipped fork trucks may result in punctured or damaged drums. Each shipment should be closely examined for damaged or leaking drums. If leaking drums are found or damage occurs in movement, refer to Section 7 for procedures on proper handling of leaks or spills.

Liquid MDI products which have solidified through cooling should be liquefied by careful heating as soon as possible. For correct heating methods and temperatures, see the appropriate Technical Data Sheet. Drums can be emptied using a standard immersion pump or gravity discharged. Air displaced from the receiving tank should be discharged to the vapor exhaust system. A silica gel filter can be connected to the open drum vent (small bung) to prevent drums from collapsing while being emptied. This will also prevent moisture from entering the drum. The opening of MDI drums should be minimized to reduce moisture contamination. Water contamination of drums must be avoided. This can result in a pressure build-up in closed containers by the generation of CO₂ gas from the water-MDI reaction. Drums showing evidence of pressure buildup must be vented immediately with caution, otherwise there is a potential for a violent drum rupture. Refer to Section 6 for storage of MDI drums and Section 8 for recommendations on the neutralization and disposal of empty MDI drums.

**Sample Shipments**

In order to insure that small packages are safe for transport, customers should contact BASF for information concerning the regulations and restrictions that apply. This is especially true when the customer does not normally ship small samples of potentially hazardous materials and may not have the proper packaging material. BASF will not accept unsolicited samples of MDI products.
6. Storage

Storage and Handling Considerations
A thorough knowledge of the chemical and physical properties of MDI, as well as all federal and local regulations and building codes, is necessary for the safe handling and storage of MDI products.

When designing storage systems for MDI, extreme care must be exercised to avoid contamination with water, strong bases or other active hydrogen-containing compounds. Acids, bases and other polyurethane catalysts should not be stored in the same area as MDI.

The reaction of MDI with moisture, even from ambient air, will produce polyurea solids and CO₂ gas. These insoluble polyureas will deposit on surfaces of pipes and tanks causing line restrictions and filtration problems. The generated CO₂ could present a pressure hazard, including the potential of a violent rupture of an under-vented tank or vessel.

Although MDI is relatively non-flammable (flash point 200°F/392°F), MDI should not be stored adjacent to highly flammable materials. Water, dry chemical, protein foam, or CO₂ fire extinguishers should be available in all storage and processing areas. Automatic fire or smoke detection equipment as well as automatic sprinklers should be installed in all MDI processing and storage areas.

Polymeric MDI (PMDI)
To maintain product quality, it is important that polymeric MDI products must be stored and handled correctly.

It is imperative that polymeric MDI products be stored under dry conditions. Storage tanks should be maintained under positive pressure pads with dry air or dry nitrogen (dew point less than -40°C/-40°F).

The storage temperature will affect the handling characteristics and product quality of the polymeric isocyanates. The most favorable temperature for storage is 20 to 30°C (68 to 86°F). The recommended storage temperatures for specific polymeric MDIs from BASF are also reported in our Technical Leaflets or Technical Bulletins.

The viscosity of polymeric MDI is temperature-dependent. At temperatures below those recommended, PMDI may be difficult to pump or pour. Raising storage temperatures to the recommended levels will return PMDI viscosity’s to their typical levels. At extreme low temperatures, it is possible for some of the material to crystallize. The crystals can be melted by heating the material in a hot air oven to 60 to 70°C (140 to 158°F) maximum. Once the material has melted, the product should return to the recommended storage temperatures. PMDI should not be held at 70°C (158°F) for more than 4 hours or the product will begin to degrade. If the product is stored above the indicated temperature range, degradation may also occur. This will be indicated by slow, irreversible buildup in viscosity. If these directions are followed, a storage life of six months can be expected.
Monomeric MDI (MMDI)
MMDI will degrade quickly unless it is stored and handled correctly. Excess dimer formation will result in turbidity or the precipitation of dimer solids in the liquid.

The optimum storage condition for solid MMDI is as cold as possible (e.g., <0°C/<32°F). Below this temperature, the rate of dimer formation is minimized. If it is kept under dry atmosphere and oxygen is excluded (dew point less than -40°C/-40°F), the product may be stored up to three months after date of manufacture without a change in properties. If MMDI is stored as a solid, melting for use is best accomplished by rolling the drum in a hot air oven at 80 to 100°C (176 to 212°F). The drum contents should not be heated above 70°C (158°F) to minimize dimer formation. Heating by electrical means is not recommended due to the danger of local overheating. Melting MMDI in a water bath or with steam is likewise not recommended because of the potential danger of drum leakage.

When MMDI is to be stored or processed as a liquid, the optimum temperature for storage is between 40 and 44°C (104 and 111°F). Liquid MMDI when stored with a dry nitrogen blanket will retain its properties for up to 14 days. If the product is kept outside this range, it will degrade quickly. The rate of dimer formation is greatest near the melting point (38°C/100°F) for the solid, and above 50°C (122°F), for the liquid. Liquid MMDI must be stored under dry nitrogen (dew point less than -40°C/-40°F) because contamination with air may produce oxidation or yellowing of the product. Bulk storage tanks should also be kept under a dry nitrogen blanket.

Modified MDI, MDI Prepolymers
As with all diisocyanates, modified MDI products will react with moisture. It is imperative that these products also be stored under dry air (dew point less than -40°C/-40°F) or a dry nitrogen pad to prevent contamination. The optimum storage temperatures for the modified MMDI variants vary depending on the product.

The recommended storage temperatures for specific modified MDI products are reported in the respective BASF Product Leaflets or Technical Bulletins.
If the material is stored below the suggested temperature range, it may begin to crystallize. The crystallized material contains a high concentration of MMDI and will exhibit similar dimerization characteristics. Action must be taken quickly to solubilize the material by heating the product to 60°C (140°F). To minimize additional dimer formation, the drum contents should not be heated above 70°C (158°F). Recommended procedures for heating drums are detailed in the Technical Leaflet or Technical Bulletin for that product. If these materials are stored above the recommended temperatures, the product will begin to degrade. This degradation is indicated by a slow increase in viscosity, slight turbidity and sediment formation. If these products are stored in the recommended temperature range and moisture is excluded, a shelf life of six months can be expected.

**Storage Tank Design**

All MDI Storage tanks must be blanketed with dry air or nitrogen. For MMDI, dry nitrogen must be used. Storage tanks should be maintained under slight positive pressure (1 mbar). Storage tanks should be pressure-controlled, preferably by nitrogen or dried air. Storage tank ventilation can be accomplished by pressure control through an activated carbon filter, appropriate washing equipment, or knockout pots. The ventilation lines and the carbon filters must be maintained frequently for proper function. In all instances, MDI venting procedures must comply with applicable codes, regulations, and permits.

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8 Dry nitrogen or dry air must have a dew point below –40°C (-40°F).
Each MDI product has its own prescribed storage temperature. The customer must maintain the storage temperatures as recommended for individual products. To maintain the desired product temperature, MDI storage tanks should be equipped with a temperature indicator, heat tracing, and insulation.

The preferred method of temperature control is external heat exchangers using an inert heating medium. External tempered water or electric tracing has been successfully used. Steam should not be used due to the possibility of overheating. Any moisture contamination should be prevented. To eliminate any potential of a coil leak, internal coils are not recommended. Heating coils and heat exchangers should be checked for corrosion regularly.

MDI tanks should be equipped with level indicators and separate high level alarms and cutoffs to prevent accidental overflow. Tank areas must be diked to prevent run off in the event of a MDI release. Diking must be sufficient to contain potential spills and leaks and prevent accidental release of MDI to sewers, waterways or public thoroughfares. Dikes must be designed for 1-1/2 times the tank capacity or as directed by codes and regulations for handling hazardous chemicals. Storage tanks should be able to hold entire MDI shipments, i.e., if shipment is typically by rail car, storage tank should be greater than the capacity of the rail car.

Tanks may be fabricated of unlined mild steel. The steel tanks should be rust-free because trace iron contamination may affect the MDI reactivity. Other satisfactory materials include stainless steel, glass-lined steel, or nickel-clad steel, however, these configurations are expensive.

In the United States, OSHA requires hazard communication labels for all containers containing MDI products.

**Container Storage**

Drum storage areas should be covered and well ventilated. Ideally, MDI drum storage areas should be diked and separated from materials reactive with MDI. Local codes may have specific requirements for the storage of hazardous chemicals.

Intermediate Bulk Containers (IBCs), or totes, may be of interest because they may reduce the problem of drum disposal. Contact your local BASF office to determine the availability of IBCs.

All storage areas should be arranged in an orderly manner, leaving doorways or exit routes clear.

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9 IBCs are not recommended for shipment of MMDI due to its relatively high freezing point (38°C/100°F).
7. Emergency Procedures

Guidelines for Dealing with MDI Product Incidents

All incidents tend to be unique and it is not possible to write guidelines to deal with every circumstance. Each incident must be assessed from the information available.

All people involved with the handling or transportation of MDI must be aware of the hazards associated with MDI, the appropriate emergency procedures and their individual responsibilities in the event of any emergency involving MDI. The primary response to any release of MDI, whether a transportation incident or an in-plant spill, is to evacuate all unprotected people to a safe location. Only then should properly protected and trained personnel evaluate, contain, stop, clean up, and decontaminate any spill.

Depending upon the size, location, and type of release, government agencies or authorities may require notification. In the United States, transportation incidents involving MDI must be reported to the National Response Center (NRC) (1-800-424-8802) for any release over the reportable quantity of 5000 lbs. (approximately 500 gallons). This is a requirement of (U.S.A.) Federal CERCLA regulations. In Europe, most countries have national emergency response programs.

Any release of over 5000 lbs. to the environment must be reported to the NRC and the local planning commission as outlined under EPCRA regulations (U.S.A.).

Regulations involving the release of hazardous chemicals is continually evolving, therefore, it is important that all companies handling MDI be aware of the current legislative requirements in each jurisdiction.

Each plant should have a system for dealing with emergencies within the plant. Such systems are only effective if regularly practiced. It is appropriate to form a plant fire crew and emergency team, so a well-trained team can quickly address an emergency. Everyone, however, should be aware of the hazards involved and the limitations of self-help. The first priority should always be to save life rather than limit physical damage.

The odor threshold of MDI is above the established exposure limits for MDI. Areas should not be considered free of diisocyanate vapors until the area has been monitored.

Spill and Leaks

In the event of a MDI spill or leak, all unprotected people with the potential for MDI exposure should be evacuated to a safe, MDI-free area. Only then should properly trained and equipped personnel (See Section 4) re-enter the area. The spill should then be contained and the leak stopped to prevent further contamination.

It is necessary to distinguish between minor incidents, such as may occur in a laboratory or a workshop handling MDI regularly, and major spills involving, for example, a bulk tank truck. The most important criterion for distinguishing between the two is the ability of the personnel on the spot to deal with the occurrence, rather than the actual size of the incident.

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10 For emergency procedures at incidents for bulk vehicles, drums and IBC’s References e.g.: Guidelines for the Distribution of Toluene Diisocyanate (TDI) and Diphenylmethane Diisocyanate (MDI) {ISOPA, March 1992} (Only for Europe). In the USA, “MDI Transportation Guidelines {API, 1996} (Only for the United States).
**Minor Incidents**

For small spills or leaks, trained people wearing appropriate personal protective equipment should ventilate the area by opening doors and windows, then completely cover the spill with an absorbent material such as an all-purpose oil absorbent, dry sand or kitty litter.

Use more than enough absorbent material to absorb all of the liquid MDI. Shovel or scoop the absorbent into another open top container and remove it to a safe location for neutralization. Do not tightly seal this container since the MDI will react with any moisture present and generate CO₂ gas, which could cause a sealed container to burst.

After the drums are moved to a safe area, fill the container with an appropriate neutralizing solution and allow it to stand at least 48 hours. The container may be sealed after 48 hours. The container should remain vented, however, to prevent any pressure buildup. The contents of the container should be properly disposed of. (See Section 8.)

After the absorbent has been shoveled from the spill site, the site should be washed and scrubbed down with a liquid neutralizer. Once the area is clean, the area should be tested for diisocyanate vapors. If MDI vapors continue to be present, the decontamination should be repeated until the area is free of MDI vapors.

Decontaminating or neutralizing solutions are mixtures of agents that react with the MDI, and agents that promote the reaction. The choice of solution will depend on the location (inside or outside), temperature (below or above freezing) and the flammability requirement for the intended use. A typical decontaminating solution can be made by mixing water (90-95%), household ammonia (3-8%) and liquid detergent (1-7%). The water and ammonia will react to form polyurea solids and CO₂ gas, and the detergent helps promote the reaction. This solution works well indoors at normal room temperatures. It is important to note the hazards of the clean up and neutralizing agents.

Solid neutralizers, which are neutralizers premixed with an absorbent, may be used for the quick clean up of very small spills.

Ammonia may be regulated as a hazardous material. Before using ammonia, refer to any exposure limits and regulations applicable to ammonia.

Soda ash (Na₂CO₃) may be used instead of ammonia resulting in a less active decontamination solution.

The use of sawdust in combination with any decontaminate solution can cause auto-ignition.

**Large Spills**

For large spills of MDI, a “state of emergency” must be declared. This may require notification of local emergency response services such as the fire department. Such an event should be factored into every MDI user’s community awareness program. In Europe, the Seveso Directive covers such incidents.
All persons should be evacuated to a safe location. Properly trained and equipped personnel should then isolate and contain the spill. MDI should be contained and not be allowed to flow into any sewers or waterways.

Once the spill has been isolated and contained, the appropriate clean-up procedures should be used to remove the decontaminate the MDI. For specific instructions or assistance, the BASF emergency help line is available 24 hours a day in the United States (1-800-832-HELP) or in Germany (0-621-6043333).

For transportation incidents in the United States, the Chemical Manufacturers Association (CMA) operates CHEMTREC.

<table>
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<tr>
<th>National Emergency Sytems</th>
<th>Figure 9: Emergency Response Networks</th>
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<td>Belgium</td>
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<td>UK</td>
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<td>U.S.A.</td>
<td>CHEMTREC</td>
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<tr>
<td>BASF Emergency System</td>
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<tr>
<td>BASF Antwerp (Belgium)</td>
<td>(3) 5699232</td>
</tr>
<tr>
<td>BASF Corporation (U.S.A.)</td>
<td>(800) 832-4357</td>
</tr>
<tr>
<td>BASF Ludwigshafen (Germany)</td>
<td>(0621) 6043333</td>
</tr>
<tr>
<td>BASF Schwarzheide (Germany)</td>
<td>(035) 75262312</td>
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</tbody>
</table>

The CHEMTREC number (1-800-424-9300) is available 24 hours a day and is on all BASF Bills of Lading and MSDSs. A call to CHEMTREC will set the emergency response notification process in motion as well as provide emergency response information to response personnel.

In other countries, emergency response networks for handling hazardous chemical emergencies have been established.

In Europe, the European Isocyanate Producers Association (ISOPA) has published a manual designed to augment and strengthen national and company communication systems dealing with MDI. It describes a mutual aid scheme within ISOPA companies.

**MDI Involved in Fires**

All involved personnel must put on self-contained breathing apparatus and complete chemical protection, i.e., rubber gloves, boots, goggles and protective clothing. All nonessential personnel must evacuate the immediate area. The fire should be extinguished using one of the following:

- a) dry chemical powder
- b) protein-based foam
c) CO\textsubscript{2} extinguisher
d) large quantities of water

Once the fire is extinguished, the next step is to prevent any material that spilled from spreading by using collecting containers and absorbers such as sand or earth.

The use of water or foam to extinguish the fire and cool the container makes it likely that moisture will enter the damaged tank or drum. Since water reacts with MDI to form solid polyureas and CO\textsubscript{2}, the danger exists that after the damaged area is plugged, a pressure buildup can occur. To prevent damage to the tank, it must be vented.

Depending on the condition of the tank and/or vehicle, the MDI product should be transferred to another container for disposal. This new tank must also be vented. In any case, the MDI product should not be shipped until the degree of water contamination is clarified.

If the MDI product is stored in the vicinity of a fire but MDI is not directly involved in the fire, the container should be moved clear of the area. If the container or tank cannot be moved away from the fire, a water curtain should be positioned between it and the fire. If this cannot be accomplished safely, the tank should be cooled using a direct water spray. This should prevent damage to the tank body and its contents.

**Pressurized Drums**

A bulging drum of MDI should be assumed to be the result of contamination of the product, usually with water. This slow but unstoppable reaction with a diisocyanate produces CO\textsubscript{2} and an increase in pressure. Since it is not easy to judge the acute risk of bursting, the drum under pressure should be left where it is. A tarpaulin should be placed over the drum.

It is necessary to relieve this pressure safely before the drum bursts. This is best accomplished by puncturing the top of the drum with a long handled spike attached to a locklift. During this action, all uninvolved persons must be removed from the area and the working personnel must have complete chemical protection. The punctured drum must then be placed in an oversized drum with pressure venting capabilities. It must be remembered that the original contamination will probably continue to cause a pressure increase. The container must be regularly vented using proper safety precautions, then contact BASF for disposal recommendations.
**Chemical Reactions**
The combination of polyol and diisocyanate components yields large amounts of heat and probably gas evolution. The reaction, once begun, cannot be stopped and the goal must be to prevent pressure buildup by venting. In most instances, a controlled venting via the safety valve may not be possible because the safety valve may become plugged with foam or solids. If possible, stop uncontaminated material from entering the reaction by pumping it into a separate vessel.

Although difficult with insulated tanks, cooling should be attempted. Any vapors should be knocked down with water spray or foam. The reaction should proceed to end with a minimum of heat and vapor evolution.

An evacuation of the immediate surroundings should be considered because of the potential large amounts of heated MDI vapors that can be evolved. All personnel involved must wear complete protective equipment.

**8. Environmental Considerations**

The following recommendations should be interpreted in light of existing and future legislation. The disposal of liquid MDI wastes and used containers may be regulated by local and federal agencies.

**Disposal of Waste MDI**

MDI products are non-hazardous materials. There are three basic methods for disposing of liquid MDI wastes. The choice of method will depend in part on the amount of waste to be treated and the availability of decontaminates. In Germany, the disposal of hazardous waste is regulated by the Kolinlaufswittschafts-und Abfallgesetz (1994)

**Method 1: Reaction with Waste Polyol**
React with activated waste polyol to make a low quality polyurethane foam which can be sold or used as a manufactured product. If the foam produced is to be disposed of, all regulations must be adhered to. In the United States, all foam produced in this manner for disposal is classified as “Non-Hazardous Waste,” In Europe, such foam, if free or unreacted components can generally be incinerated or disposed of as normal house waste in an authorized waste disposal area. This method should only be used when a correct stoichiometric mixing can be guaranteed. Improper mixing will leave a product containing unreacted MDI or polyol.

**Method 2: Reaction with Liquid Decontaminants**
The waste MDI product should be added slowly and stirred into the liquid decontaminant (See Section 7 for preparation of decontaminant) in an open-top container. MDI should be added to the decontaminant. Adding the decontaminant solution to the MDI may produce excessive heat! The amount of MDI product to be treated should not exceed 10% of the amount of decontaminant used. Leave the treated drum for 48 hours in a properly ventilated area; this will remove the toxic hazard. Decant the liquid and dispose of both the liquid and solid material according to all local and federal regulations.
Method 3: Incineration

Incineration under approved, controlled conditions is the preferred method for all but small amounts of MDI product. It should, however, only be done in properly supervised equipment specifically designed for the disposal of noxious chemical wastes and properly permitted by the local and federal agencies.

Decontamination and Disposal of Used Containers

MDI products may be delivered in drums. These drums are designed to be one-way packages and cannot be returned to the suppliers. The handling of empty MDI-drums in Europe is subject to the directive 94/62/EG and its national (sometimes more stringent) implementations. In general, producers and or tollers of MDI are responsible for proper disposal of the empty drums.

Residual MDI product will remain in the drum after good draining (0.1-2.0 kilograms, depending on product and drum type).

Local and federal regulations vary concerning the disposal of empty containers. Empty MDI drums are potentially hazardous and should therefore only be handled by trained personnel. Personnel should be trained to empty MDI drums completely. All MDI drums, after being well drained, should be decontaminated with a prepared decontaminant solution using the following procedure:

a) Spray or pour 5 to 30 liters (2 to 8 gallons) into the drum, making sure the walls are well rinsed. This can be achieved by use of a spray head or by rolling the drum for several minutes. The use of high-pressure spray equipment can significantly improve the speed and effectiveness of drum cleaning.

b) Leave drum standing unsealed for at least 48 hours to allow complete reaction. Sealing of the drum must be avoided to prevent pressure buildup by evolved CO$_2$.

c) Pour out liquid decontaminant into a storage vessel. This solution can be used several times.\[^11\] This procedure is required to assist reconditioning firms and is often mandatory for the acceptance of the waste drums for reconditioning. Only after proper cleaning, drums can be recycled or scrapped without any hazard. In most countries, organizations of drum scrappers have been formed. They should be consulted for details concerning the collection and reprocessing of both cleaned and uncleaned MDI drums.

If decontaminated drums are to be disposed of, they should be punctured to prevent reuse. Independent of the method used, cleaned MDI drums must not be used for the storage of

\[^11\] There are two disadvantages to using this simple method. The resulting crust can conceal unreacted diisocyanate, especially in the case of drums not having been adequately drained. Furthermore, it is difficult to remove the crust from the walls of the drum.
food or animal fodder. All local and federal regulations must be complied with when cleaning and disposing of empty MDI drums.

Some nations allow well-drained drums to be sent to a permitted reconditioner without being decontaminated. If this is allowed, the drums must be labeled analogous to the filled ones and all closures must be tight to prevent water contamination. Water contamination can cause CO₂ gas to be evolved which could pressurize the drum and create a serious hazard.

Under no circumstances should empty MDI drums be burned or cut open with a gas or electric torch, as toxic decomposition products may be liberated.

**Ecological Effects**

Ecotoxicologic investigations to date have shown that MDI products are not appreciably toxic to fish, bacteria, and Daphnia.

The reaction products of MDI and water are not biodegradable but chemically inert (See Guidelines for the Distribution of Toluene Diisocyanate (TDI) and Diphenylmethane Diisocyanate (MDI) (2604/ISOPA DH/March 1992).

MDI is classified in Germany in water pollution class (WGK) 1.
## 9. References

Among others, the following literature has been used for this MDI Manual:

<table>
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<tr>
<th>Reference</th>
<th>Description</th>
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<tr>
<td>(1) BRMA:</td>
<td>Toxicity and Safe Handling of Diisocyanates and Ancillary Chemicals, A code of Practice for Polyurethane Flexible Foam Manufacture (July 1991)</td>
</tr>
<tr>
<td>(2) CIA:</td>
<td>Guidelines for the Reception and Bulk Storage of TDI and MDI (Aug. 1989)</td>
</tr>
</tbody>
</table>
| (3) ISOPA:| ▪ Guidelines for Safe Loading/Unloading, Transportation and Storage of Toluene Diisocyanate (TDI) and Diphenylmethane Diisocyanate (MDI) (2604/ISOPA. DH/1995) (Only for Europe)  
▪ European Isocyanate Producers Association  
  4 Avenue Van Nieuwenhuyse  
  B-1160 Bruxelles, Belgium  
  Tel. (02) 676 74 75  
  [www.isopa](http://www.isopa) |
  MDI Transportation Guidelines (1996)  
  ▪ Hyperactivity and other Health Effects of Diisocyanates: Guidelines for Medical personnel (1999)  
  ▪ Technical Bulletin “Guidelines for the disposal of empty Diisocyanate containers”  
  ▪ Test Methods for Polyurethane Raw Materials, 1988  
  ▪ Bestimmung von Isocyanaten am Arbeitsplatz-Stand der Technik (Polyurethane World Congress SPI/FSK 1987)  
  ▪ Alliance for the Polyurethanes Industry  
  1300 Wilson Boulevard, Suite 800  
  Arlington, VA 22209  
  Tel. (703) 253-0656  
  Fax (703) 253-0658  
  [www.polyurethane.org](http://www.polyurethane.org) |
| (5) BGChemie: | Polyurethanherstellung, Isocyanate, Merkblatt M 044 (Okt. 87) |
| (6) VCI:   | ▪ Verwertungs- und Entsorgungskonzept für Verpackungen in Industrie und Gewerbe  
  ▪ Leistungsverzeichnis für Unternehmen des Bundesverbandes der Deutschen Entsorgungswirtschaft e.V. (VPS), die Abfallbehandlungsanlagen betreiben  
  ▪ Leistungsverzeichnis für Unternehmen des Bundesverbandes Sonderabfallwirtschaft e.V. (BPS)  
  ▪ Firmen für Leergebinde-Entsorgung  
  ▪ Leistungsverzeichnis für Unternehmer des Verbandes des Deutschen Fachgrobhandels e.V. (VDF), (Ausgabe 4/90)  
  ▪ Verband der Chemischen Industrie e.V.  
  KarlstraBe 21, Postf. 111943  
  6000 Frankfurt, Germany  
  Tel. 069-25560 |
| (7) VDF:   | Verband der Deutschen Fabverwertungsbetriebe e.V., Kaiserwerther StraBe 135  
  4000 Dusseldorf 30 (VDF-Leistungsprofil) |
10. Other Considerations

The regulations for handling MDI and MDI variants as well as other hazardous chemicals are continually evolving. Also, regulations and procedures vary widely from country to country. The body of this publication contains general information for handling MDI and MDI products.

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