



**MATHESON
TRI•GAS**

ask. . .The Gas Professionals™

MATERIAL SAFETY DATA SHEET

Prepared to U.S. OSHA, CMA, ANSI and Canadian WHMIS Standards

1. PRODUCT IDENTIFICATION

CHEMICAL NAME; CLASS: DIBORANE 0.4-2.5%/ HYDROGEN (BALANCE) GAS MIXTURE

CHEMICAL FAMILY: Boron Hydride / Hydrogen Mixture

PRODUCT USE: Various Uses

MANUFACTURER

MATHESON TRI-GAS, INC.

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EMERGENCY PHONE:

CHEMTREC (NORTH AMERICA): 1-800-424-9300

CHEMTREC INTERNATIONAL: 1-703-527-3887

CANUTEC (CANADA): 1-613-996-6666

NOTE: All WHMIS required information is included. It is located in appropriate sections based on the ANSI Z400.1-1998 format. This product has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.
See Section 16 for Definitions of Terms Used.

2. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW: Product Description: This gas mixture is a colorless gas mixture with a repulsive, sweet odor (due to the presence of Diborane). **Health Hazards:** Pure Diborane is a powerful caustic irritant to skin, eyes and mucous membranes; this gas mixture can present the same hazard when Diborane reaches the higher level possible in the mixture. Contact with the skin and eyes can cause burns and systemic poisoning. **Flammability Hazards:** This gas mixture is extremely flammable. Mixtures in air and presents an extreme fire hazard when accidentally released. Releases which have not ignited must be considered extremely dangerous, and should not be approached. **Reactivity Hazards:** Pure Diborane reacts violently with a broad range of materials, including air and may lead to reactions of this gas mixture. **Environmental Hazards:** This product may cause harm to terrestrial and aquatic organisms if accidentally released. **Emergency Response Procedures:** Releases which have not ignited must be considered extremely dangerous, and should not be approached. Emergency responders must wear the proper personal protective equipment suitable for the situation to which they are responding.

SYMPTOMS OF OVER-EXPOSURE BY ROUTE OF EXPOSURE: The most significant routes of over-exposure for this gas are by inhalation, skin or eye contact. Symptoms of exposure by all routes of exposure may be delayed.

INHALATION: This gas mixture can cause severe health effects, due to the presence of Diborane, which is extremely toxic at very low levels. Inhalation exposure to low concentrations of Diborane can produce symptoms of central nervous system depression, including, light-headedness, headache, fatigue and drowsiness. Inhalation of high levels of this gas mixture could severely irritate the respiratory system. Inhalation of gas mixtures containing Diborane will cause a heat-producing reaction with moisture in the lungs, producing corrosive boric acid. Exposures to high concentrations of Diborane can include tightening of the chest, pre-cordial pain, shortness of breath, non-productive cough, wheezing and nausea. Severe inhalation over-exposures can result in pulmonary edema and pulmonary hemorrhage. The onset of symptoms may be delayed by several days. Inhalation of high concentrations may be fatal. It should be noted that, since Diborane can be pyrophoric, before central nervous system or other health effects could occur, the lower flammability limit of Diborane in air would be exceeded; possibly causing an explosive atmosphere.

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MATHESON TRI-GAS

2. HAZARD IDENTIFICATION (Continued)

INHALATION (continued): Inhalation overexposures of this gas mixture could also lead to systemic poisoning, with symptoms such as tremors, general lassitude, chills, vertigo, fever and muscle fasciculation (involuntary muscle movements or twitching). Persistent irritation of the respiratory system may occur from repeated, low-level inhalation overexposure.

Although high concentrations of this gas mixture can cause an oxygen-deficient environment, the toxic effects of Diborane will be a more significant hazard than oxygen deficiency. Individuals breathing an oxygen-deficient atmosphere may experience symptoms which include headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting, and depression of all the senses. Under some circumstances of overexposure, death may occur. The effects associated with various levels of oxygen are as follows:

CONCENTRATION OF OXYGEN

12-16% Oxygen:

10-14% Oxygen:

6-10% Oxygen:

Below 6%:

OBSERVED EFFECT

Breathing and pulse rate increase, muscular coordination slightly disturbed.

Emotional upset, abnormal fatigue, disturbed respiration.

Nausea, vomiting, collapse, or loss of consciousness.

Convulsive movements, possible respiratory collapse, and death.

CONTACT WITH SKIN or EYES: Direct exposure to the skin from this gas mixture can cause severe burns, due to the presence of Diborane. Minor contact with the gas mixture can result in local inflammation, blisters, redness and swelling. Contact with the eyes, even briefly, will cause irritation. Contact of longer duration and concentration can cause serious injury to the eyes, possibly blindness, due to the formation of boric acid. In addition, contact with rapidly expanding gases (which are released under high pressure) may cause frostbite.

SKIN ABSORPTION: No evidence exists that pure Diborane will be absorbed by intact skin; however upon decomposition as a result of contact with moisture in the skin, Diborane forms higher hydrides, which will penetrate the skin, causing systemic poisoning. Systemic poisoning symptoms can include those described in inhalation exposure.

OTHER HEALTH EFFECTS: Exposure to mixtures containing Diborane may cause injuries to the central nervous system, liver and kidneys, as pure Diborane has caused such problems in experimental animals. Similar observations have been reported in humans, resulting in symptoms resembling those of metal fume fever, such as, a metallic or sweet taste in the mouth, dryness or irritation of the throat, and coughing. Later symptoms (after 4-48 hours) can include sweating, shivering, headache, fever, chills, thirstiness, muscle aches, nausea, vomiting, weakness, and tiredness. These effects may occur after overexposure to this gas mixture.

HEALTH EFFECTS OR RISKS FROM EXPOSURE: Over-exposure to this gas mixture may cause the following health effects:

ACUTE: Acute exposure by inhalation can cause irritation to the eyes, skin, respiratory system and mucous membranes. Severe over-exposure by inhalation can cause damage to the respiratory system including the extremely dangerous condition of pulmonary edema (an accumulation of fluid in the lungs) and may be fatal. Acute exposure to the skin or eyes can cause irritation, or in cases of extreme contamination, burns and damage to tissue. Blindness to the eyes may result. Systemic poisoning can result after acute exposure by all routes of exposure.

CHRONIC: Persistent irritation may result from repeated exposures to low levels of this gas mixture. Chronic exposure to relatively minor levels may cause permanent loss of lung efficiency, due to irreversible lung damage. Damage may also occur to the central nervous system, kidneys and liver. Refer to Section 11 (Toxicology Information) for additional data.

TARGET ORGANS: ACUTE: Respiratory system, skin, eyes, central nervous system. CHRONIC: Respiratory system, central nervous system, skin, liver and kidneys.

HMSI RATING: HEALTH HAZARD = 4 FLAMMABILITY HAZARD = 4 PHYSICAL HAZARD = 3

Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe

3. COMPOSITION and INFORMATION ON INGREDIENTS

(10,000 ppm = 1%)

CHEMICAL NAME	CAS #	mole %
Diborane	19287-45-7	0.4-2.5%
Hydrogen	1333-74-0	Balance

4. FIRST-AID MEASURES

GENERAL INFORMATION: RESCUERS SHOULD NOT ATTEMPT TO RETRIEVE VICTIMS OF EXPOSURE TO THIS GAS MIXTURE WITHOUT ADEQUATE PERSONAL PROTECTIVE EQUIPMENT.

At a minimum, **Self-Contained Breathing Apparatus and Fire-Retardant clothing must be worn.** Remove to fresh air, as quickly as possible. Only trained personnel should administer supplemental oxygen and/or cardio-pulmonary resuscitation, if necessary. **Seek medical attention immediately.**

SKIN EXPOSURE: Rinse exposed skin for 15 minutes if any irritation adverse effects occur. If release of this gas mixture has resulted in frostbite, warm affected area slowly. Seek immediate medical attention.

EYE EXPOSURE: If release of this gas mixture has affected the eyes, seek immediate medical attention.

THERMAL BURNS: In the event personnel are burned as a result of a release, if burns are first degree or second degree with closed blisters, flush area with cold water until pain subsides. Apply loose, moist, sterile dressings, and bandage. Treat for shock. If burns are second degree with open blisters or third degree, apply loose, dry, sterile dressings and bandage. Treat for shock. Transport victim immediately to hospital or emergency center. Burns over an area of 20% or more of body are life-threatening, medical attention should be immediately sought.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Due to the presence of Diborane, pre-existing dermatitis, other skin conditions, and respiratory disorders may be aggravated by over-exposure to this gas mixture. Additionally, over-exposures may aggravate problems with the eyes, liver, kidneys and central nervous system.

RECOMMENDATIONS TO PHYSICIANS: Administer oxygen. Treatment is symptomatic and supportive. Be observant for initial signs of pulmonary edema.

5. FIRE-FIGHTING MEASURES

FLASH POINT: Not determined for mixture. **[for Diborane]:** -90°C (-130°F) **[for Hydrogen]:** Flammable Gas

AUTOIGNITION TEMPERATURE: Not determined for mixture. **[for Diborane]:** 38-52°C (100-125°F) The autoignition temperature of Diborane varies due to possible impurities. **[for Hydrogen]:** 500-571°C (932-1059.8°F)

FLAMMABLE LIMITS (in air by volume, %): Not determined for mixture.

	<u>Lower (LEL):</u>	<u>Upper (UEL):</u>
For Diborane:	0.9%	98.0%
For Hydrogen:	4.0%	75.0%

FIRE EXTINGUISHING MATERIALS: Extinguish fires of this gas mixture by shutting-off the source of the gas. Use a flooding quantity of water as a spray. **Do not use halogenated fire-extinguishing agents.** Diborane reacts with these materials and will form shock sensitive and thermally sensitive mixtures. Cool fire-exposed cylinders with water spray, from the maximum distance possible.

FIRE EXTINGUISHING MATERIALS NOT TO BE USED: Water and halon extinguishers should NOT be used to fight fires of this material as it will react violently and possibly explosively.

UNUSUAL FIRE AND EXPLOSION HAZARD: DANGER! Releases which have not spontaneously ignited must be considered extremely dangerous, and should not be approached. This gas is extremely flammable and readily forms explosive mixtures with air over a very wide range. If released into a confined space, an extreme fire hazard exists. As the Diborane component of this gas mixture is very toxic via inhalation, eye and skin contact; this gas presents an extreme health hazard to firefighters. Mixtures, which contain high levels of Diborane present an extreme fire hazard as the mixture can be readily capable of detonation or explosive decomposition or reaction in air to oxygen or moisture and a variety of organic and inorganic materials. In the event of fire, cool containers of this product with water to prevent failure. Do not direct water directly onto the Diborane release, as Diborane will react to water and may intensify the fire. **DANGER!** Fires impinging (direct flame) on the outside surface of cylinders or storage vessels can be very dangerous. Direct flame exposure on the cylinder wall can cause an explosion due to pressure-build-up. The resulting fire and explosion can result in severe equipment damage and personnel injury or death over a large area around the vessel. For massive fires in large areas, use unmanned hose holder or monitor nozzles; if this is not possible, withdraw from area and allow fire to burn.

5. FIRE-FIGHTING MEASURES (Continued)

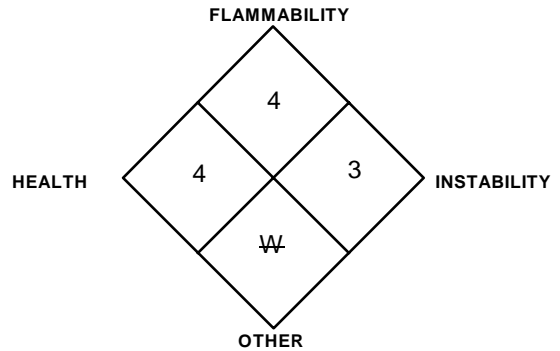
EXPLOSION SENSITIVITY TO MECHANICAL IMPACT:

Due to the Diborane component, this mixture may become shock and thermally sensitive in the presence of impurities such as oxygen, water, halogenated hydrocarbons and other materials, when the Diborane level is at its highest.

EXPLOSION SENSITIVITY TO STATIC DISCHARGE: May be sensitive.

SPECIAL FIRE-FIGHTING PROCEDURES: Evacuate all personnel from danger area. Immediately cool cylinders with water spray from maximum distance, taking care to NOT extinguish flames if source of gas has not been stopped. Stop the leak and flow of gas before extinguishing fire. If release is still occurring, explosive re-ignition may occur. In event that fire is extinguished before the leak is stopped, attempt to increase ventilation to area to prevent formation of explosive air/gas mixtures. Incipient fire responders should wear eye protection. Structural fire fighters must wear Self-Contained Breathing Apparatus and full protective equipment. When cool, move cylinders from fire area if this can be done without risk to firefighters. Other information for pre-planning can be found in the American Petroleum Institute Publications 2510 and 1510A, and the North American Emergency Response Guidebook (Guide Number 119).

NFPA RATINGS



Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate
3 = Serious 4 = Severe

6. ACCIDENTAL RELEASE MEASURES

LEAK RESPONSE: Evacuate immediate area. Uncontrolled releases should be responded to by trained personnel using pre-planned procedures. Eliminate any possible source of ignition and provide maximum explosion-proof ventilation. Proper protective equipment, including fire protection, should be used in the event of a significant release from a single cylinder. Use only non-sparking tools. Call CHEMTREC (1-800-424-9300) for emergency assistance. Or if in Canada, call CANUTEC (613-996-6666).

Attempt to close the main source valve prior to entering the area. If this does not stop the release (or if it is not possible to reach the valve), allow the gas to release in-place or remove it to a safe area and allow the gas to be released there. Protect personnel attempting to shut-off with water spray. Monitor the surrounding area for combustible gas levels and the level of Oxygen. The atmosphere must have not more than 10% of the LEL of each component gas (see Section 5, Fire-Fighting Measures), and the level of component gases must be 10% below the exposure levels given in Section 8 (Exposure Controls-Personal Protection) and at least 19.5 percent Oxygen before non-emergency personnel can be allowed in the area without Self-Contained Breathing Apparatus and fire protection.

7. HANDLING and USE

WORK PRACTICES AND HYGIENE PRACTICES: Be aware of any signs of dizziness or fatigue; exposures to fatal concentrations of this gas mixture could occur without any significant warning symptoms, due to oxygen deficiency. All areas where gas mixtures that include Diborane are used should be monitored with very sensitive gas detection instruments. Detection of concentrations above 50% of the PEL (PEL = 0.1 ppm) should trigger immediate response and corrective action. Detection of higher levels should initiate an alarm calling for evacuation of all personnel with the potential to be exposed. Due to the extreme corrosivity and toxicity of Diborane and pyrophoric qualities of Diborane, all contaminated clothing should be removed and placed in a sealed container for proper disposal. Avoid all contact with this gas. All employees who handle this material should be trained to handle it safely. Working alone with this mixture should be avoided when possible.

Do not eat or drink while handling chemicals.

Safety showers should be available in the event of an emergency. Special eye-wash fountains or similar equipment should be available for eye irrigation.

All areas in which mixtures containing Diborane is used must have adequate monitoring equipment to detect a release and appropriate fire protection equipment.

7. HANDLING and USE (Continued)

WORK PRACTICES AND HYGIENE PRACTICES (continued):

Proper respiratory protection equipment must be provided and workers using such equipment must be carefully trained in its operation and limitations.

Be aware of all potential exposure symptoms; exposures to a fatal levels of this mixture or to oxygen-deficient atmosphere could occur without any significant warning symptoms.

All work operations should be monitored in such a way that emergency personnel can be immediately contacted in the event of a release.

Workers who handle this gas mixture should wear protective clothing, as listed in Section 8 (Exposure Controls and Personal Protection).

If ventilation controls are not adequate to provide sufficient oxygen content, proper respiratory protection equipment should be provided and workers using such equipment should be carefully trained in its operation and limitations.

Precautions must always be taken to prevent suck-back of foreign materials into the cylinder by using a check-valve, or vacuum break, since suck-back may cause dangerous pressure changes within the cylinder.

STORAGE AND HANDLING PRACTICES: Cylinders should be stored upright and be firmly secured to prevent falling or being knocked-over. Cylinders can be stored in the open, but in such cases, should be protected against extremes of weather and from the dampness of the ground to prevent rusting. Cylinders should be stored in dry, well-ventilated areas away from sources of heat or ignition. Do not allow the area where cylinders are stored to exceed 52°C (125°F). Cylinders should be separated from oxygen cylinders, or other oxidizers, by a minimum distance of 20 ft., or by a barrier of non-combustible material at least 5 ft. high, having a fire-resistance rating of at least 0.5 hours. Isolate from other incompatible chemicals (refer to Section 10, Stability and Reactivity). Storage areas must meet national electrical codes for Class 1 Hazardous Areas. Post "No Smoking or Open Flames" signs in storage or use areas. Consider installation of leak detection and alarm for storage and use areas. Have appropriate extinguishing equipment in the storage area (i.e. sprinkler system, portable fire extinguishers). Keep the smallest amount on-site as is necessary. Full and empty cylinders should be segregated. Use a first-in, first-out inventory system to prevent full containers from being stored for long periods of time. Use non-sparking ventilation systems, approved explosion-proof equipment, and appropriate electrical systems. Electrical equipment used in gas-handling operations, or located in storage areas, should be non-sparking or explosion proof. Use a check valve in the discharge line to prevent hazardous backflow. Never tamper with pressure relief devices in valves and cylinders.

SPECIAL PRECAUTIONS FOR HANDLING GAS CYLINDERS: Compressed gases can present significant safety hazards. The following rules are applicable to work situations in which cylinders are being used.

Before Use: Move cylinders with a suitable hand-truck. Do not drag, slide or roll cylinders. Do not drop cylinders or permit them to strike each other. Secure cylinders firmly. Leave the valve protection cap (where provided) in-place until cylinder is ready for use.

During Use: Use designated CGA fittings and other support equipment. Do not use adapters. Do not use oils or grease on gas-handling fittings or equipment. Immediately contact the supplier if there are any difficulties associated with operating the cylinder valve. Never insert an object (e.g wrench, screwdriver, pry bar, etc.) into valve cap openings. Doing so may damage the valve, causing a leak to occur. Use an adjustable strap wrench to remove over-tight or rusted caps. Never strike an arc, on a compressed gas cylinder or make a cylinder part of and electric circuit.

After Use: Close main cylinder valve. Replace valve protection cap. Close valve after each use and when empty. Mark empty cylinders "EMPTY".

PROTECTIVE PRACTICES DURING MAINTENANCE OF CONTAMINATED EQUIPMENT: Refer to current CGA Guidelines for information on protective practices during maintenance of contaminated equipment.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION

VENTILATION AND ENGINEERING CONTROLS: Use with adequate, explosion-proof ventilation to ensure compliance with exposure limits described in this section, if applicable. Local exhaust ventilation is preferred, because it prevents dispersion of this gas mixture into the work place by eliminating it at its source. If appropriate, install automatic monitoring equipment to detect the level of Diborane and Oxygen.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION (Continued)

EXPOSURE LIMITS:

CHEMICAL NAME	CAS #	EXPOSURE LIMITS IN AIR							
		ACGIH-TLVS		OSHA-STEL		NIOSH-RELS		NIOSH	OTHER
		TWA ppm	STEL ppm	TWA ppm	STEL ppm	TWA ppm	STEL ppm	IDLH ppm	
Diborane	19287-45-7	0.1	NE	0.1	NE	0.1	NE	15	NE
Hydrogen	1333-74-0	There are no specific exposure limits for Hydrogen. Hydrogen is a simple asphyxiant (SA). Oxygen levels should be maintained above 19.5%.							

See Section 16 for Definitions of Terms Used.

RESPIRATORY PROTECTION: Maintain the Oxygen level above 19.5% in the workplace. If necessary, use only respiratory protection authorized in the U.S. Federal OSHA Respiratory Protection Standard (29 CFR 1910.134), or equivalent U.S. State standards and Canadian CSA Standard Z94.4-93. Oxygen levels below 19.5% are considered IDLH by OSHA. In such atmospheres, use of a full-facepiece pressure/demand SCBA or a full facepiece, supplied air respirator with auxiliary self-contained air supply is required under OSHA's Respiratory Protection Standard (1910.134-1998). The following NIOSH respiratory protection recommendations are for Diborane.

CONCENTRATION

Up to 1 ppm:

Up to 2.5 ppm:

Up to 5 ppm:

Up to 15 ppm:

Emergency or Planned Entry into Unknown Concentrations or IDLH Conditions: Any SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode, or any SAR that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in pressure-demand or other positive-pressure mode.

Escape:

RESPIRATORY PROTECTION

Any Supplied-Air Respirator (SAR).

Any SAR operated in a continuous-flow mode.

Any SAR that has a tight-fitting facepiece and is operated in a continuous-flow mode, or any Self-Contained Breathing Apparatus (SCBA) with a full facepiece, or any SAR with a full facepiece.

Any SAR operated in a pressure-demand or other positive-pressure mode.

Any Air-Purifying, Full-Facepiece Respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against Diborane, or any appropriate escape-type, SCBA.

EYE PROTECTION: Splash goggles or safety glasses. If necessary, refer to U.S. OSHA 29 CFR 1910.133 or and the Canadian CSA Standard Z94.3-M1982, *Industrial Eye and Face Protectors*.

HAND PROTECTION: Wear mechanically-resistant gloves when handling cylinders containing this gas mixture. If necessary, refer to U.S. OSHA 29 CFR 1910.138, or appropriate Standards of Canada.

BODY PROTECTION: Use body protection appropriate for task. Transfer of large quantities under pressure may require protective equipment appropriate to the task. If necessary, refer to the OSHA Technical Manual (Section VII: Personal Protective Equipment) or appropriate Standards of Canada. If a hazard of injury to the feet exists due to falling objects, rolling objects, where objects may pierce the soles of the feet or where employee's feet may be exposed to electrical hazards, use foot protection, as described in U.S. OSHA 29 CFR 1910.136 and the Canadian CSA Standard Z195-02, *Protective Footwear*.

9. PHYSICAL and CHEMICAL PROPERTIES

The following information is for Hydrogen, the main component of this gas mixture:

GAS DENSITY: 0.00521 lb/cu ft (0.08342 kg/m³)

SPECIFIC GRAVITY (air = 1): 0.06860

SOLUBILITY IN WATER: 0.019

EXPANSION RATIO: Not applicable.

ODOR THRESHOLD: Not applicable.

VAPOR PRESSURE (psia): Not applicable.

COEFFICIENT WATER/OIL DISTRIBUTION: Not applicable.

EVAPORATION RATE (nBuAc = 1): Not applicable.

FREEZING POINT: -259.2°C (-434.55°F)

BOILING POINT (@ 1 atmos.): -252.8°C (-423.9°F)

SPECIFIC VOLUME (ft³/lb): 192.0

MOLECULAR WEIGHT: 2.016

9. PHYSICAL and CHEMICAL PROPERTIES (Continued)

The following information is for the Diborane component of this gas mixture.

BOILING POINT @ 1 atm: -92.5°C (-134.5°F) **pH:** Not applicable.
EVAPORATION RATE (nBuAc = 1): Not applicable. **MOLECULAR WEIGHT:** 27.67
VAPOR PRESSURE @ 15.5°C (60°F) psia: 536.55 **EXPANSION RATIO:** Not applicable.
ODOR THRESHOLD: 1.8-3.5 ppm **SPECIFIC VOLUME @ 1 atm and 0°C(ft³/lb):** 12.84
SOLUBILITY IN WATER: Decomposes to form boric acid and hydrogen.
GAS DENSITY @ 21.1°C (70°F) and 1 atm: 0.0779 lb/ft³ (1.25 kg/m³)
SPECIFIC GRAVITY (air = 1) @ 0°C (32°F) and 1 atm: 0.952
FREEZING/MELTING POINT @ 1 atm: -165.5°C (-265.9°F)

The following information is pertinent to this product:

APPEARANCE, ODOR AND COLOR: This gas mixture is a colorless gas mixture with a repulsive, sweet odor (due to the presence of Diborane).

HOW TO DETECT THIS SUBSTANCE (warning properties): The odor cannot be relied upon as a reliable warning property for this gas mixture, as the odor threshold for Diborane is above its TLV. Monitoring systems must be used for detection of this gas.

10. STABILITY and REACTIVITY

STABILITY: Pure Diborane mixes readily with air to form explosive mixtures and may ignite spontaneously, which may affect the stability of this gas mixture when the Diborane component is at a high level. Pure Diborane reacts violently with a broad range of materials, including air and may lead to reactions of this gas mixture.

DECOMPOSITION PRODUCTS: Thermal: Boric acid and hydrogen. Hydrolysis: Boric acid and hydrogen.

MATERIALS WITH WHICH SUBSTANCE IS INCOMPATIBLE: Diborane will react explosively with moisture in the air. Diborane will react explosively with tetravinyl lead, octanol oximine and sodium hydroxide mixtures, benzene. Diborane will react violently with halocarbon liquids, strong oxidizers (i.e. chlorine gas) or boron hydrides. Diborane reacts with aluminum and lithium to form complex hydrides that can ignite spontaneously in air. In the presence of oxygen and halogenated hydrocarbons Diborane will form shock sensitive and thermally sensitive mixtures. Diborane will attack some forms of rubber and plastics. The Hydrogen component is incompatible with strong oxidizers, halogen compounds (e.g. bromine, chlorine, fluorine), lithium, Xenon trifluoride, oxygen difluoride. Finely divided platinum and some other metals will cause hydrogen to react explosively with oxygen in air.

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Contact with incompatible materials and exposure to the air and/or moisture. Cylinders exposed to high temperatures or direct flame can rupture or burst.

11. TOXICOLOGICAL INFORMATION

TOXICITY DATA: Hydrogen is a simple asphyxiant (SA), which acts to displace oxygen in the environment. No toxicity data are applicable. The following are toxicity data for the Diborane component of this gas mixture:

DIBORANE:

LC₅₀ (Inhalation-Rat) 40 ppm/4 hours
LC₅₀ (Inhalation-Rat) 60 mg/m³/4 hours
LC₅₀ (Inhalation-Mouse) 29 ppm/4 hours: Sense Organs and Special Senses (Olfaction): effect, not otherwise specified; Lungs, Thorax, or Respiration: acute pulmonary edema, dyspnea
LCLo (Inhalation-Dog) 125 ppm/2 hours: Brain and Coverings: changes in surface EEG; Lungs, Thorax, or Respiration: acute pulmonary edema; Blood: hemorrhage
LCLo (Inhalation-Hamster) 50 ppm/8 hours: Lungs, Thorax, or Respiration: acute pulmonary edema

DIBORANE (continued):

TCLo (Inhalation-Rat) 100 ppb/6 hours/8 weeks-intermittent: Lungs, Thorax, or Respiration: other changes; Blood: pigmented or nucleated red blood cells; Nutritional and Gross Metabolic: changes in sodium
TCLo (Inhalation-Mouse) 5 ppm/6 hours/4 weeks-intermittent: Lungs, Thorax, or Respiration: changes in lung weight; Blood: changes in erythrocyte (RBC) count; Biochemical: Enzyme inhibition, induction, or change in blood or tissue levels: phosphatases
Mutation in Microorganisms (Bacteria-*Salmonella typhimurium*) 2000 ppm
Mutation in Microorganisms (Bacteria-*Salmonella typhimurium*) 5000 ppm

CARCINOGENIC POTENTIAL OF COMPONENTS: The components of this gas mixture are not found on the following lists: U.S. EPA, U.S. NTP, U.S. OSHA, U.S. NIOSH, GERMAN MAK, IARC, or ACGIH, and therefore are not considered to be, nor suspected to be a cancer-causing agent by these agencies.

IRRITANCY OF PRODUCT: This gas mixture may be mildly to severely irritating to contaminated tissue, depending on the duration of contact. Diborane reacts with water or moisture, slowly producing corrosive phosphoric acid; therefore, this gas can be severely irritating and corrosive to the skin, the eyes, and mucous membranes.

11. TOXICOLOGICAL INFORMATION (Continued)

SENSITIZATION TO THE PRODUCT: The components of this gas mixture are not known to cause human skin or respiratory sensitization.

REPRODUCTIVE TOXICITY INFORMATION: Listed below is information concerning the effects of the components of this gas mixture on the human reproductive system.

Mutagenicity: The components of this gas mixture are not reported to cause mutagenic effects in humans. There are mutation data for microorganisms for the Diborane component.

Embryotoxicity: The components of this gas mixture are not reported to cause embryotoxic effects in humans.

Teratogenicity: The components of this gas mixture are not reported to cause teratogenic effects in humans.

Reproductive Toxicity: The components of this gas mixture are not reported to cause reproductive effects in humans.

BIOLOGICAL EXPOSURE INDICES (BEIs): Currently, there are no Biological Exposure Indices (BEIs) determined for the components of this gas mixture.

12. ECOLOGICAL INFORMATION

ALL WORK PRACTICES MUST BE AIMED AT ELIMINATING ENVIRONMENTAL CONTAMINATION.

MOBILITY: As a gas mixture, this product does not present a hazard of mobility in the soil.

PERSISTENCE AND BIODEGRADABILITY: The components of this gas mixture will volatilize and degrade into other organic compounds.

BIO-ACCUMULATION POTENTIAL: The components of this gas mixture do not present a hazard of bio-accumulation.

ECOTOXICITY: This gas mixture has not been tested for aquatic or animal toxicity. All release to terrestrial, atmospheric and aquatic environments should be avoided. The Diborane component will form boric acid in water, and can be detrimental to aquatic life. If a release this gas mixture occurs near a river or other body of water, the release has the potential to kill fish and other aquatic life. The following aquatic toxicity data for boric acid is presented, to provide additional information:

LC₅₀ (trout eggs) = 100 ppm/ soft

LC₅₀ (trout eggs) = 79 ppm/ hard

LC₅₀ (catfish eggs) = 155 ppm/ soft

LC₅₀ (catfish eggs) = 22 ppm/ hard

LC₅₀ (goldfish eggs) = 46 ppm/ soft

LC₅₀ (goldfish eggs) = 75 ppm/ hard

LC₅₀ (*Daphnia magna*) = 133 mg/L/ 48 hours

OTHER ADVERSE EFFECTS: The components of this gas mixture are not listed as having ozone depletion potential.

ENVIRONMENTAL EXPOSURE CONTROLS: Controls should be engineered to prevent release to the environment, including procedures to prevent spills, atmospheric release and release to waterways.

13. DISPOSAL CONSIDERATIONS

PREPARING WASTES FOR DISPOSAL: Waste disposal must be in accordance with appropriate Federal, State, and local regulations. Return cylinders with any residual product to Matheson Tri-Gas. Do not dispose of locally.

14. TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION REGULATIONS: This product is classified as dangerous goods, per U.S. DOT regulations, under 49 CFR 172.101.

PROPER SHIPPING NAME: Compressed gas, toxic, flammable n.o.s. (Diborane, Hydrogen)

HAZARD CLASS NUMBER and DESCRIPTION: 2.3 (Toxic Gas); 2.1 (Flammable Gas)

UN IDENTIFICATION NUMBER: UN 1953

PACKING GROUP: Not applicable.

D.O.T HAZARD LABEL: Class 2.3 (Toxic Gas); Class 2.1 (Flammable Gas)

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MARINE POLLUTANT: The components of this gas mixture are not classified by the DOT as Marine Pollutant (as defined by 49 CFR 172.101, Appendix B).

SPECIAL PROVISION: Shipments must be described as "Poison Inhalation Hazard - ZONE D", for mixtures which contain Diborane from 1.6% to less than 2.67%.

SPECIAL SHIPPING INFORMATION: Cylinders should be transported in a secure position, in a well-ventilated vehicle. The transportation of compressed gas cylinders in automobiles or in closed-body vehicles present serious safety hazards and should be discouraged.

NOTE: Shipment of compressed gas cylinders which have not been filled with the owner's consent is a violation of Federal law [49 CFR, Part 173.301 (b)].

14. TRANSPORTATION INFORMATION (Continued)

TRANSPORT CANADA TRANSPORTATION OF DANGEROUS GOODS REGULATIONS: This gas mixture is classified as dangerous goods, per regulations of Transport Canada.

PROPER SHIPPING NAME: Compressed gas, toxic, flammable n.o.s. (Diborane, Hydrogen)
HAZARD CLASS NUMBER and DESCRIPTION: 2.3 (Toxic Gas); 2.1 (Flammable Gas)
UN IDENTIFICATION NUMBER: UN 1953
PACKING GROUP: Not Applicable
HAZARD LABEL: Class 2.3 (Toxic Gas); Class 2.1 (Flammable Gas)
SPECIAL PROVISIONS: 16, 38
EXPLOSIVE LIMIT AND LIMITED QUANTITY INDEX: 0
ERAP INDEX: 0
PASSENGER CARRYING SHIP INDEX: Forbidden
PASSENGER CARRYING ROAD VEHICLE OR PASSENGER CARRYING RAILWAY VEHICLE INDEX: Forbidden

NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2004): 119

NOTE: Shipment of compressed gas cylinders via Public Passenger Road Vehicle is a violation of Canadian law (Transport Canada Transportation of Dangerous Goods Act, 1992).

SPECIAL SHIPPING INFORMATION: Cylinders should be transported in a secure position, in a well-ventilated vehicle. The transportation of compressed gas cylinders in automobiles or in closed-body vehicles present serious safety hazards and should be discouraged.

NOTE: Shipment of compressed gas cylinders which have not been filled with the owner's consent is a violation of Federal law (49 CFR, Part 173.301 (b)).

15. REGULATORY INFORMATION

ADDITIONAL U.S. REGULATIONS:

U.S. SARA REPORTING REQUIREMENTS: The Diborane component of this gas mixture is subject to the reporting requirements of Sections 302, 304 and 313 of Title III of the Superfund Amendments and Reauthorization Act, as follows:

CHEMICAL NAME	SARA 302 (40 CFR 355, Appendix A)	SARA 304 (40 CFR Table 302.4)	SARA 313 (40 CFR 372.65)
Diborane	Yes	Yes	No

U.S. SARA SECTION 302 EXTREMELY HAZARDOUS THRESHOLD PLANNING QUANTITY (TPQ):
Diborane = 100 lb (45.4 kg)

U.S. SARA SECTION 304 EXTREMELY HAZARDOUS REPORTABLE QUANTITY (RQ): Diborane = 100 lb (45.4 kg)

U.S. SARA HAZARD CATEGORIES (SECTION 311/312, 40 CFR 370-21): ACUTE: Yes; CHRONIC: Yes; FIRE: Yes; REACTIVE: Yes; SUDDEN RELEASE: Yes

U.S. CERCLA REPORTABLE QUANTITY (RQ): Diborane has no CERCLA reportable quantity.

U.S. TSCA INVENTORY STATUS: Components of this product are listed on the TSCA Inventory.

OTHER U.S. FEDERAL REGULATIONS: Diborane is subject to the reporting requirements of Section 112(r) of the Clean Air Act. The threshold quantity for this gas is 2,500 lbs (1,135 kg). Diborane is subject to the reporting requirements of Section 112(r) of the Clean Air Act. The Threshold Quantity for this gas is 2,500 lbs (1125 kg). Diborane is subject to requirements of CFR 29 1910.1000. Diborane is listed in Table Z.1. Diborane is listed in 40 CFR, Part 68 (Risk Management for Chemical Release Prevention), Table 1, as an extremely hazardous and flammable substance. The threshold quantity for Diborane under this regulation is 100 lbs (45.53 kg). Depending on specific operations involving the use of this gas mixture, the regulations of the Process Safety Management of Highly Hazardous Chemicals may be applicable (29 CFR 1910.119). Under this regulation Diborane is listed in Appendix A. The threshold quantity for Diborane, under this regulation is 100 lbs (45.53 kg). Under this regulation any process that involves a flammable gas on-site, in one location, in quantities of 10,000 lbs (4,554 kg) or greater is covered under this regulation unless it is used as a fuel. Hydrogen is subject to the reporting requirements of Section 112(r) of the Clean Air Act. The threshold quantity for this gas is 10,000 lbs (4,540 kg). Hydrogen is listed as Regulated Substances in quantities of 10,000 lbs (4,540 kg) or greater, per 40 CFR, Part 68 of the Risk Management for Chemical Accidental Release. Any process that involves a flammable gas on-site, in one location, in quantities of 10,000 lbs (4,540 kg) or greater has requirements under the Process Safety Management of Highly Hazardous Chemicals (29 CFR 1910.119), unless the gas is used as a fuel.

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):
Components of this gas mixture are not on the California Proposition 65 lists.

15. REGULATORY INFORMATION (Continued)

ADDITIONAL U.S. REGULATIONS (continued):

LABELING: Cylinders of this gas mixture should be labeled for precautionary information per the guidelines of the CGA. Refer to the CGA for further information.

ADDITIONAL CANADIAN REGULATIONS:

CANADIAN DSL/NDL INVENTORY STATUS: The components of this product are listed on the DSL Inventory.

OTHER CANADIAN REGULATIONS: Not applicable.

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) PRIORITIES SUBSTANCES LISTS: The components of this product are not on the CEPA Priorities Substances Lists.

CANADIAN WHMIS CLASSIFICATION and SYMBOLS: This gas mixture would be categorized as a Controlled Product, Hazard Classes: **A** (compressed gas), **B1** (Flammable and Combustible Material), **D1A** (Poisonous and Infectious Materials-Immediate and Serious Effects: Very Toxic), **D2A** (Chronic Toxicity: Very Toxic), and **D2B** (Poisonous and Infectious Materials-Immediate and Serious Effects: Materials Causing Other Toxic Effects: Toxic). **E:** Corrosive Material; and **F:** Dangerously Reactive Material. The following symbols are required for WHMIS compliance for this gas mixture.



16. OTHER INFORMATION

CREATION DATE: February 28, 2008

REVISION DATE: New

MIXTURES: When two or more gases or liquefied gases are mixed, their hazardous properties may combine to create additional, unexpected hazards. Obtain and evaluate the safety information for each component before you use the mixture. Consult an Industrial Hygienist or other trained person when you make your safety evaluation of the end product. Remember, gases and liquids have properties which can cause serious injury or death.

Further information can be found in the following pamphlets published by: Compressed Gas Association Inc. (CGA), 421 Walney Road, 5th Floor, Chantilly, VA 20151. Telephone: (703) 788-2700, Fax: (703) 961-1831.

"Safe Handling of Compressed Gases in Containers" (P-1, 1999)

"Safe Handling and Storage of Compressed Gases" (AV-1, 1999)

"Handbook of Compressed Gases" (1992)

PREPARED BY:

CHEMICAL SAFETY ASSOCIATES, Inc.
PO Box 3519, La Mesa, CA 91944-3519
800/441-3365 • 619/670-0609

16. OTHER INFORMATION (Continued)

DEFINITIONS OF TERMS

A large number of abbreviations and acronyms appear on a MSDS. Some of these which are commonly used include the following:

CAS #: This is the Chemical Abstract Service Number that uniquely identifies each constituent.

EXPOSURE LIMITS IN AIR:

CEILING LEVEL: The concentration that shall not be exceeded during any part of the working exposure.

DFG MAK Germ Cell Mutagen Categories: **1:** Germ cell mutagens which have been shown to increase the mutant frequency in the progeny of exposed humans. **2:** Germ cell mutagens which have been shown to increase the mutant frequency in the progeny of exposed mammals. **3A:** Substances which have been shown to induce genetic damage in germ cells of human or animals, or which produce mutagenic effects in somatic cells of mammals *in vivo* and have been shown to reach the germ cells in an active form. **3B:** Substances which are suspected of being germ cell mutagens because of their genotoxic effects in mammalian somatic cell *in vivo*; in exceptional cases, substances for which there are no *in vivo* data, but which are clearly mutagenic *in vitro* and structurally related to known *in vivo* mutagens. **4:** Not applicable (Category 4 carcinogenic substances are those with non-genotoxic mechanisms of action. By definition, germ cell mutagens are genotoxic. Therefore, a Category 4 for germ cell mutagens cannot apply. At some time in the future, it is conceivable that a Category 4 could be established for genotoxic substances with primary targets other than DNA [e.g. purely aneugenic substances] if research results make this seem sensible.) **5:** Germ cell mutagens, the potency of which is considered to be so low that, provided the MAK value is observed, their contribution to genetic risk for humans is expected not to be significant.

DFG MAK Pregnancy Risk Group Classification: **Group A:** A risk of damage to the developing embryo or fetus has been unequivocally demonstrated. Exposure of pregnant women can lead to damage of the developing organism, even when MAK and BAT (Biological Tolerance Value for Working Materials) values are observed. **Group B:** Currently available information indicates a risk of damage to the developing embryo or fetus must be considered to be probable. Damage to the developing organism cannot be excluded when pregnant women are exposed, even when MAK and BAT values are observed. **Group C:** There is no reason to fear a risk of damage to the developing embryo or fetus when MAK and BAT values are observed. **Group D:** Classification in one of the groups A-C is not yet possible because, although the data available may indicate a trend, they are not sufficient for final evaluation.

LOQ: Limit of Quantitation.

MAK: Federal Republic of Germany Maximum Concentration Values in the workplace.

NE: Not Established. When no exposure guidelines are established, an entry of NE is made for reference.

NIC: Notice of Intended Change.

NIOSH CEILING: The exposure that shall not be exceeded during any part of the workday. If instantaneous monitoring is not feasible, the ceiling shall be assumed as a 15-minute TWA exposure (unless otherwise specified) that shall not be exceeded at any time during a workday.

NIOSH RELs: NIOSH's Recommended Exposure Limits.

PEL-Permissible Exposure Limit: OSHA's Permissible Exposure Limits. This exposure value means exactly the same as a TLV, except that it is enforceable by OSHA.

The OSHA Permissible Exposure Limits are based in the 1989 PELs and the June, 1993 Air Contaminants Rule (*Federal Register*: 58: 35338-35351 and 58: 40191). Both the current PELs and the vacated PELs are indicated. The phrase, "Vacated 1989 PEL," is placed next to the PEL that was vacated by Court Order.

SKIN: Used when there is a danger of cutaneous absorption.

STEL-Short Term Exposure Limit: Short Term Exposure Limit, usually a 15-minute time-weighted average (TWA) exposure that should not be exceeded at any time during a workday, even if the 8-hr TWA is within the TLV-TWA, PEL-TWA or REL-TWA.

TLV-Threshold Limit Value: An airborne concentration of a substance that represents conditions under which it is generally believed that nearly all workers may be repeatedly exposed without adverse effect. The duration must be considered, including the 8-hour.

TWA-Time Weighted Average: Time Weighted Average exposure concentration for a conventional 8-hr (TLV, PEL) or up to a 10-hr (REL) workday and a 40-hr workweek.

IDLH-Immediately Dangerous to Life and Health: This level represents a concentration from which one can escape within 30-minutes without suffering escape-preventing or permanent injury.

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM

HAZARD RATINGS: This rating system was developed by the National Paint and Coating Association and has been adopted by industry to identify the degree of chemical hazards.

HEALTH HAZARD:

0 (Minimal Hazard): No significant health risk, irritation of skin or eyes not anticipated. *Skin Irritation:* Essentially non-irritating. PII or Draize = "0". *Eye Irritation:* Essentially non-irritating, or minimal effects which clear in < 24 hours [e.g. mechanical irritation]. Draize = "0". *Oral Toxicity LD₅₀ Rat:* < 5000 mg/kg. *Dermal Toxicity LD₅₀Rat or Rabbit:* < 2000 mg/kg. *Inhalation Toxicity 4-hrs LC₅₀ Rat:* < 20 mg/L.; **1 (Slight Hazard):** Minor reversible injury may occur; slightly or mildly irritating. *Skin Irritation:* Slightly or mildly irritating. *Eye Irritation:* Slightly or mildly irritating. *Oral Toxicity LD₅₀ Rat:* > 500-5000 mg/kg. *Dermal Toxicity LD₅₀Rat or Rabbit:* > 1000-2000 mg/kg. *Inhalation Toxicity LC₅₀ 4-hrs Rat:* > 2-20 mg/L.; **2 (Moderate Hazard):** Temporary or transitory injury may occur. *Skin Irritation:* Moderately irritating; primary irritant; sensitizer. PII or Draize > 0, < 5. *Eye Irritation:* Moderately to severely irritating and/or corrosive; reversible corneal opacity; corneal involvement or irritation clearing in 8-21 days. Draize > 0, ≤ 25. *Oral Toxicity LD₅₀ Rat:* > 50-500 mg/kg. *Dermal Toxicity LD₅₀Rat or Rabbit:* > 200-1000 mg/kg. *Inhalation Toxicity LC₅₀ 4-hrs Rat:* > 0.5-2 mg/L.; **3 (Serious Hazard):** Major injury likely unless prompt action is taken and medical treatment is given; high level of toxicity; corrosive. *Skin Irritation:* Severely irritating and/or corrosive; may destroy dermal tissue, cause skin burns, dermal necrosis. PII or Draize > 5-8 with destruction of tissue. *Eye Irritation:* Corrosive, irreversible destruction of ocular tissue; corneal involvement or irritation persisting for more than 21 days. Draize > 80 with effects irreversible in 21 days. *Oral Toxicity LD₅₀ Rat:* > 1-50 mg/kg. *Dermal Toxicity LD₅₀Rat or Rabbit:* > 20-200 mg/kg. *Inhalation Toxicity LC₅₀ 4-hrs Rat:* > 0.05-0.5 mg/L.; **4 (Severe Hazard):** Life-threatening; major or permanent damage may result from single or repeated exposure. *Skin Irritation:* Not appropriate. Do not rate as a "4", based on skin irritation alone. *Eye Irritation:* Not appropriate. Do not rate as a "4", based on eye irritation alone. *Oral Toxicity LD₅₀ Rat:* ≤ 1 mg/kg. *Dermal Toxicity LD₅₀Rat or Rabbit:* ≤ 20 mg/kg. *Inhalation Toxicity LC₅₀ 4-hrs Rat:* ≤ 0.05 mg/L).

FLAMMABILITY HAZARD:

0 (Minimal Hazard-Materials) that will not burn in air when exposure to a temperature of 815.5°C [1500°F] for a period of 5 minutes.; **1 (Slight Hazard-Materials)** that must be pre-heated before ignition can occur. Material require considerable pre-heating, under all ambient temperature conditions before ignition and combustion can occur, including: Materials that will burn in air when exposed to a temperature of 815.5°C (1500°F) for a period of 5 minutes or less; Liquids, solids and semisolids having a flash point at or above 93.3°C [200°F] (e.g. OSHA Class IIIB, or; Most ordinary combustible materials [e.g. wood, paper, etc.]); **2 (Moderate Hazard-Materials)** that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Materials in this degree would not, under normal conditions, form hazardous atmospheres in air, but under high ambient temperatures or moderate heating may release vapor in sufficient quantities to produce hazardous atmospheres in air, including: Liquids having a flash-point at or above 37.8°C [100°F]; Solid materials in the form of coarse dusts that may burn rapidly but that generally do not form explosive atmospheres; Solid materials in a fibrous or shredded form that may burn rapidly and create flash fire hazards (e.g. cotton, sisal, hemp; Solids and semisolids that readily give off flammable vapors.); **3 (Serious Hazard- Liquids and solids)** that can be ignited under almost all ambient temperature conditions. Materials in this degree produce hazardous atmospheres with air under almost all ambient temperatures, or, unaffected by ambient temperature, are readily ignited under almost all conditions, including: Liquids having a flash point below 22.8°C [73°F] and having a boiling point at or above 38°C [100°F] and below 37.8°C [100°F] [e.g. OSHA Class IB and IC]; Materials that on account of their physical form or environmental conditions can form explosive mixtures with air and are readily dispersed in air [e.g., dusts of combustible solids, mists or droplets of flammable liquids]; Materials that burn extremely rapidly, usually by reason of self-contained oxygen [e.g. dry nitrocellulose and many organic peroxides]; **4 (Severe Hazard-Materials)** that will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or that are readily dispersed in air, and which will burn readily, including: Flammable gases; Flammable cryogenic materials;

16. OTHER INFORMATION (Continued)

DEFINITIONS OF TERMS (Continued)

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM HAZARD RATINGS (continued):

FLAMMABILITY HAZARD (continued):

4 (continued): Any liquid or gaseous material that is liquid while under pressure and has a flash point below 22.8°C [73°F] and a boiling point below 37.8°C [100°F] [e.g. OSHA Class IA; Material that ignite spontaneously when exposed to air at a temperature of 54.4°C [130°F] or below [e.g. pyrophoric].

PHYSICAL HAZARD:

0 (Water Reactivity): Materials that do not react with water. *Organic Peroxides:* Materials that are normally stable, even under fire conditions and will not react with water. *Explosives:* Substances that are Non-Explosive. *Unstable Compressed Gases:* No Rating. *Pyrophorics:* No Rating. *Oxidizers:* No "0" rating allowed. *Unstable Reactives:* Substances that will not polymerize, decompose, condense or self-react.;

1 (Water Reactivity): Materials that change or decompose upon exposure to moisture. *Organic Peroxides:* Materials that are normally stable, but can become unstable at high temperatures and pressures. These materials may react with water, but will not release energy. *Explosives:* Division 1.5 & 1.6 Substances that are very insensitive explosives or that do not have a mass explosion hazard. *Compressed Gases:* Pressure below OSHA definition. *Pyrophorics:* No Rating. *Oxidizers:* Packaging Group III; *Solids:* any material that in either concentration tested, exhibits a mean burning time less than or equal to the mean burning time of a 3:7 potassium bromate/cellulose mixture and the criteria for Packing Group I and II are not met. *Liquids:* any material that exhibits a mean pressure rise time less than or equal to the pressure rise time of a 1:1 nitric acid (65%/cellulose mixture and the criteria for Packing Group I and II are not met. *Unstable Reactives:* Substances that may decompose, condense or self-react, but only under conditions of high temperature and/or pressure and have little or no potential to cause significant heat generation or explosive hazard. Substances that readily undergo hazardous polymerization in the absence of inhibitors.);

2 (Water Reactivity): Materials that may react violently with water. *Organic Peroxides:* Materials that, in themselves, are normally unstable and will readily undergo violent chemical change, but will not detonate. These materials may also react violently with water. *Explosives:* Division 1.4 – Explosive substances where the explosive effect are largely confined to the package and no projection of fragments of appreciable size or range are expected. An external fire must not cause virtually instantaneous explosion of almost the entire contents of the package. *Compressed Gases:* Pressurized and meet OSHA definition but < 514.7 psi absolute at 21.1°C (70°F) [500 psig]. *Pyrophorics:* No Rating. *Oxidizers:* Packaging Group II *Solids:* any material that, either in concentration tested, exhibits a mean burning time of less than or equal to the mean burning time of a 2:3 potassium bromate/cellulose mixture and the criteria for Packing Group I are not met. *Liquids:* any material that exhibits a mean pressure rise time less than or equal to the pressure rise of a 1:1 aqueous sodium chlorate solution (40%/cellulose mixture and the criteria for Packing Group I are not met. *Unstable Reactives:* Substances that may polymerize, decompose, condense, or self-react at ambient temperature and/or pressure, but have a low potential for significant heat generation or explosion. Substances that readily form peroxides upon exposure to air or oxygen at room temperature);

3 (Water Reactivity): Materials that may form explosive reactions with water. *Organic Peroxides:* Materials that are capable of detonation or explosive reaction, but require a strong initiating source, or must be heated under confinement before initiation; or materials that react explosively with water. *Explosives:* Division 1.2 – Explosive substances that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but do not have a mass explosion hazard. *Compressed Gases:* Pressure \geq 514.7 psi absolute at 21.1°C (70°F) [500 psig]. *Pyrophorics:* No Rating. *Oxidizers:* Packaging Group I *Solids:* any material that, in either concentration tested, exhibits a mean burning time less than the mean burning time of a 3:2 potassium bromate/cellulose mixture. *Liquids:* Any material that spontaneously ignites when mixed with cellulose in a 1:1 ratio, or which exhibits a mean pressure rise time less than the pressure rise time of a 1:1 perchloric acid (50%/cellulose mixture. *Unstable Reactives:* Substances that may polymerize, decompose, condense or self-react at ambient temperature and/or pressure and have a moderate potential to cause significant heat generation or explosion.);

4 (Water Reactivity): Materials that react explosively with water without requiring heat or confinement. *Organic Peroxides:* Materials that are readily capable of detonation or explosive decomposition at normal temperature and pressures. *Explosives:* Division 1.1 & 1.2-explosive substances that have a mass explosion hazard or have a projection hazard.

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM HAZARD RATINGS (continued):

PHYSICAL HAZARD (continued):

4 (continued): A mass explosion is one that affects almost the entire load instantaneously. *Compressed Gases:* No Rating. *Pyrophorics:* Add to the definition of Flammability "4". *Oxidizers:* No "4" rating. *Unstable Reactives:* Substances that may polymerize, decompose, condense or self-react at ambient temperature and/or pressure and have a high potential to cause significant heat generation or explosion.).

NATIONAL FIRE PROTECTION ASSOCIATION HAZARD RATINGS:

HEALTH HAZARD: **0** (materials that, under emergency conditions, would offer no hazard beyond that of ordinary combustible materials): Gases and vapors whose LC₅₀ for acute inhalation toxicity is greater than 10,000 ppm. Dusts and mists whose LC₅₀ for acute inhalation toxicity is greater than 200 mg/L. Materials whose LD₅₀ for acute dermal toxicity is greater than 2000 mg/kg. Materials whose LD₅₀ for acute oral toxicity is greater than 2000 mg/kg. Materials that are essentially non-irritating to the respiratory tract, eyes and skin. **1** (materials that, under emergency conditions, can cause significant irritation): Gases and vapors whose LC₅₀ for acute inhalation toxicity is greater than 5,000 ppm but less than or equal to 10,000 ppm. Dusts and mists whose LC₅₀ for acute inhalation toxicity is greater than 10 mg/L but less than or equal to 200 mg/L. Materials whose LD₅₀ for acute dermal toxicity is greater than 1000 mg/kg but less than or equal to 2000 mg/kg. Materials whose LD₅₀ for acute oral toxicity is greater than 500 mg/kg but less than or equal to 2000 mg/kg. Materials that cause slight to moderate irritation to the respiratory tract, eyes and skin. **2** (materials that, under emergency conditions, can cause temporary incapacitation or residual injury): Gases and vapors whose LC₅₀ for acute inhalation toxicity is greater than 3,000 ppm but less than or equal to 5,000 ppm. Dusts and mists whose LC₅₀ for acute inhalation toxicity is greater than 2 mg/L but less than or equal to 10 mg/L. Materials whose LD₅₀ for acute dermal toxicity is greater than 200 mg/kg but less than or equal to 1000 mg/kg. Materials whose LD₅₀ for acute oral toxicity is greater than 50 mg/kg but less than or equal to 500 mg/kg. Any liquid whose saturated vapor concentration at 20°C (68°F) is equal to or greater than one-fifth its LC₅₀ for acute inhalation toxicity, if its LC₅₀ is less than or equal to 5000 ppm and that does not meet the criteria for either degree of hazard 3 or degree of hazard 4. Compressed liquefied gases with boiling points between -30°C (-22°F) and -55°C (-66.5°F) that cause severe tissue damage, depending on duration of exposure. Materials that are respiratory irritants. Materials that cause severe, but reversible irritation to the eyes or are lachrymators. Materials that are primary skin irritants or sensitizers. **3** (materials that, under emergency conditions, can cause serious or permanent injury): Gases and vapors whose LC₅₀ for acute inhalation toxicity is greater than 1,000 ppm but less than or equal to 3,000 ppm. Dusts and mists whose LC₅₀ for acute inhalation toxicity is greater than 0.5 mg/L but less than or equal to 2 mg/L. Materials whose LD₅₀ for acute dermal toxicity is greater than 40 mg/kg but less than or equal to 200 mg/kg. Materials whose LD₅₀ for acute oral toxicity is greater than 5 mg/kg but less than or equal to 50 mg/kg. Any liquid whose saturated vapor concentration at 20°C (68°F) is equal to or greater than one-fifth its LC₅₀ for acute inhalation toxicity, if its LC₅₀ is less than or equal to 3000 ppm and that does not meet the criteria for degree of hazard 4. Compressed liquefied gases with boiling points between -30°C (-22°F) and -55°C (-66.5°F) that cause frostbite and irreversible tissue damage. Materials that are respiratory irritants. Cryogenic gases that cause frostbite and irreversible tissue damage. Materials that are corrosive to the respiratory tract. Materials that are corrosive to the eyes or cause irreversible corneal opacity. Materials that are corrosive to the skin. **4** (materials that, under emergency conditions, can be lethal): Gases and vapors whose LC₅₀ for acute inhalation toxicity less than or equal to 1,000 ppm. Dusts and mists whose LC₅₀ for acute inhalation toxicity is less than or equal to 0.5 mg/L. Materials whose LD₅₀ for acute dermal toxicity is less than or equal to 40 mg/kg. Materials whose LD₅₀ for acute oral toxicity is less than or equal to 5 mg/kg. Any liquid whose saturated vapor concentration at 20°C (68°F) is equal to or greater than one-fifth its LC₅₀ for acute inhalation toxicity, if its LC₅₀ is less than or equal to 1000 ppm.

FLAMMABILITY HAZARD: **0** Materials that will not burn under typical fire conditions, including intrinsically noncombustible materials such as concrete, stone, and sand: Materials that will not burn in air when exposed to a temperature of 816°C (1500°F) for a period of 5 minutes in according with Annex D.

DEFINITIONS OF TERMS (Continued)

NATIONAL FIRE PROTECTION ASSOCIATION HAZARD RATINGS (continued):

FLAMMABILITY HAZARD (continued): 1 Materials that must be preheated before ignition can occur. Materials in this degree require considerable preheating, under all ambient temperature conditions, before ignition and combustion can occur: Materials that will burn in air when exposed to a temperature of 816°C (1500°F) for a period of 5 minutes in accordance with Annex D. Liquids, solids and semisolids having a flash point at or above 93.4°C (200°F) (i.e. Class IIIB liquids). Liquids with a flash point greater than 35°C (95°F) that do not sustain combustion when tested using the *Method of Testing for Sustained Combustibility*, per 49 CFR 173, Appendix H or the *UN Recommendation on the Transport of Dangerous Goods, Model Regulations* (current edition) and the related *Dangerous of Tests and Criteria* (current edition). Liquids with a flash point greater than 35°C (95°F) in a water-miscible solution or dispersion with a water non-combustible liquid/solid content of more than 85 percent by weight. Liquids that have no fire point when tested by ASTM D 92 Standard Test Method for Flash and Fire Points by Cleveland Open Cup, up to a boiling point of the liquid or up to a temperature at which the sample being tested shows an obvious physical change. Combustible pellets with a representative diameter of greater than 2 mm (10 mesh). Solids containing greater than 0.5 percent by weight of a flammable or combustible solvent are rated by the closed up flash point of the solvent. Most ordinary combustible materials. 2 Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Materials in this degree would not under normal conditions form hazardous atmospheres with air, but under high ambient temperatures or under moderate heating could release vapor in sufficient quantities to produce hazardous atmospheres with air: Liquids having a flash point at or above 37.8°C (100°F) and below 93.4°C (200°F) (i.e. Class II and Class IIIA liquids.) Solid materials in the form of powders or coarse dusts of representative diameter between 420 microns (40 mesh) and 2 mm (10 mesh) that burn rapidly but that generally do not form explosive mixtures in air. Solid materials in fibrous or shredded form that burn rapidly and create flash fire hazards, such as cotton, sisal and hemp. Solids and semisolids that readily give off flammable vapors. Solids containing greater than 0.5 percent by weight of a flammable or combustible solvent are rated by the closed cup flash point of the solvent. 3 Liquids and solids that can be ignited under almost all ambient temperature conditions. Materials in this degree produce hazardous atmospheres with air under almost all ambient temperatures or, though unaffected by ambient temperatures, are readily ignited under almost all conditions: Liquids having a flash point below 22.8°C (73°F) and having a boiling point at or above 37.8°C (100°F) and those liquids having a flash point at or above 22.8°C (73°F) and below 37.8°C (73°F) and below 37.8°C (100°F) (i.e. Class IB and IC liquids). Materials that, on account of their physical form or environmental conditions, can form explosive mixtures with air and are readily dispersed in air. Flammable or combustible dusts with a representative diameter less than 420 microns (40 mesh). Materials that burn with extreme rapidity, usually by reason of self-contained oxygen (e.g. dry nitrocellulose and many organic peroxides). Solids containing greater than 0.5 percent by weight of a flammable or combustible solvent are rated by the closed cup flash point of the solvent. 4 Materials that will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or that are readily dispersed in air and will burn readily: Flammable gases. Flammable cryogenic materials. Any liquid or gaseous materials that is liquid while under pressure and has a flash point below 22.8°C (73°F) and a boiling point below 37.8°C (100°F) (i.e. Class IA liquids). Materials that ignite when exposed to air. Solids containing greater than 0.5 percent by weight of a flammable or combustible solvent are rated by the closed cup flash point of the solvent.

INSTABILITY HAZARD: 0 Materials that in themselves are normally stable, even under fire conditions: Materials that have an estimated instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) below 0.01 W/mL. Materials that do not exhibit an exotherm at temperatures less than or equal to 500°C (932°F) when tested by differential scanning calorimetry. 1 Materials that in themselves are normally stable, but that can become unstable at elevated temperatures and pressures: Materials that have an estimated instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 0.01 W/mL and below 10 W/mL. 2 Materials that readily undergo violent chemical change at elevated temperatures and pressures: Materials that have an estimated instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 10 W/mL and below 100W/mL.

NATIONAL FIRE PROTECTION ASSOCIATION HAZARD RATINGS (continued):

INSTABILITY HAZARD (continued): 3 Materials that in themselves are capable of detonation or explosive decomposition or explosive reaction, but that require a strong initiating source or that must be heated under confinement before initiation: Materials that have an estimated instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 100 W/mL and below 1000 W/mL. Materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures. 4 Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures: Materials that have an estimated instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) of 1000 W/mL or greater. Materials that are sensitive to localized thermal or mechanical shock at normal temperatures and pressures.

FLAMMABILITY LIMITS IN AIR:

Much of the information related to fire and explosion is derived from the National Fire Protection Association (NFPA). **Flash Point** - Minimum temperature at which a liquid gives off sufficient vapors to form an ignitable mixture with air. **Autoignition Temperature**: The minimum temperature required to initiate combustion in air with no other source of ignition. **LEL** - the lowest percent of vapor in air, by volume, that will explode or ignite in the presence of an ignition source. **UEL** - the highest percent of vapor in air, by volume, that will explode or ignite in the presence of an ignition source.

TOXICOLOGICAL INFORMATION:

Human and Animal Toxicology: Possible health hazards as derived from human data, animal studies, or from the results of studies with similar compounds are presented. Definitions of some terms used in this section are: **LD₅₀** - Lethal Dose (solids & liquids) which kills 50% of the exposed animals; **LC₅₀** - Lethal Concentration (gases) which kills 50% of the exposed animals; **ppm** concentration expressed in parts of material per million parts of air or water; **mg/m³** concentration expressed in weight of substance per volume of air; **mg/kg** quantity of material, by weight, administered to a test subject, based on their body weight in kg. Other measures of toxicity include **TDLo**, the lowest dose to cause a symptom and **TCLo** the lowest concentration to cause a symptom; **TDo**, **LDLo**, and **LDo**, or **TC**, **TCo**, **LCLo**, and **LCo**, the lowest dose (or concentration) to cause lethal or toxic effects. **Cancer Information**: The sources are: **IARC** - the International Agency for Research on Cancer; **NTP** - the National Toxicology Program, **RTECS** - the Registry of Toxic Effects of Chemical Substances, **OSHA** and **CAL/OSHA**. IARC and NTP rate chemicals on a scale of decreasing potential to cause human cancer with rankings from 1 to 4. Subrankings (2A, 2B, etc.) are also used. **Other Information**: **BEI** - ACGIH Biological Exposure Indices, represent the levels of determinants which are most likely to be observed in specimens collected from a healthy worker who has been exposed to chemicals to the same extent as a worker with inhalation exposure to the TLV.

ECOLOGICAL INFORMATION:

BCF = Bioconcentration Factor, which is used to determine if a substance will concentrate in lifeforms which consume contaminated plant or animal matter; **EC** is the Effect Concentration in water; **EC₅₀** is the Effect Concentration for 50% of the organisms exposed; **NOEC** is the No Observed Effect Concentration; **MATC** is the Maximum Acceptable Toxicant Concentration; **NOLC** is the No Observed Lethal Concentration; **TL_m** = median threshold limit; Coefficient of Oil/Water Distribution is represented by **log K_{ow}** or **log K_{oc}** and is used to assess a substance's behavior in the environment.

REGULATORY INFORMATION:

U.S. and CANADA:

ACGIH: American Conference of Governmental Industrial Hygienists, a professional association which establishes exposure limits. This section explains the impact of various laws and regulations on the material. **EPA** is the U.S. Environmental Protection Agency. **NIOSH** is the National Institute of Occupational Safety and Health, which is the research arm of the U.S. Occupational Safety and Health Administration (**OSHA**). **WHMIS** is the Canadian Workplace Hazardous Materials Information System. **DOT** and **TC** are the U.S. Department of Transportation and the Transport Canada, respectively. Superfund Amendments and Reauthorization Act (**SARA**); the Canadian Domestic/Non-Domestic Substances List (**DSL/NDSL**); the U.S. Toxic Substance Control Act (**TSCA**); Marine Pollutant status according to the **DOT**; the Comprehensive Environmental Response, Compensation, and Liability Act (**CERCLA** or **Superfund**); and various state regulations. This section also includes information on the precautionary warnings which appear on the material's package label. **OSHA** - U.S. Occupational Safety and Health Administration.