



**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: ETHANE RICH NATURAL GAS MIX WITH SULFUR SPECIES

CHEMICAL FAMILY: Hydrocarbons/Sulfur Species Gases /Carbon Dioxide/Nitrogen Gas Mixture

PRODUCT USE: Research Gas

MANUFACTURER

MATHESON TRI-GAS, INC.

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PARSIPPANY, NJ 07054-0624
USA

Phone: 973/257-1100

EMERGENCY PHONE: CHEMTREC (U.S. DOMESTIC): 1-800-424-9300
CHEMTREC INTERNATIONAL: 1-703-527-3887
CANUTEC (CANADA): 1-613-996-6666

2. COMPOSITION and INFORMATION ON INGREDIENTS

(10,000 ppm = 1%)

CHEMICAL NAME	CAS #	Mole %	EXPOSURE LIMITS IN AIR							
			ACGIH-TLV		OSHA-STEL		NIOSH-RELS		NIOSH	OTHER
			TWA ppm	STEL ppm	TWA ppm	STEL ppm	TWA ppm	STEL ppm	IDLH ppm	
Hydrogen Sulfide	7783-06-4	0.0061%	10 NIC = 1	15 NIC = 5	10 (vacated 1989 PEL)	20 (ceiling) 10 min. peak, once per 8-hr shift 15 (vacated 1989 PEL)	NE	10 (ceiling) 10 min.	100	DFG MAKs: TWA = 10 PEAK = 2•MAK 15 min. average value, 1-hr interval Carcinogen: EPA- I
2-Propanethiol	75-33-2	0.0056%	NE	NE	NE	NE	NE	NE	NE	NE
Carbonyl Sulfide	463-58-1	0.0031%	NE	NE	NE	NE	NE	NE	NE	NE
Propanethiol	107-03-9	0.004%	NE	NE	NE	NE	NE	0.5 (ceiling) 15 min.	NE	NE
2-Methyl-2-Propanethiol	75-66-1	0.02%	NE	NE	NE	NE	NE	NE	NE	NE

NE = Not Established

NIC = Notice of Intended Change

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.
(Table Continued on Following Page)

FLAMMABLE, DELPHI-2 GAS MIXTURE MSDS

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EFFECTIVE DATE: AUGUST 8, 2006

MATH0093

MATHESON TRI-GAS

2. COMPOSITION and INFORMATION ON INGREDIENTS (Continued)

(10,000 ppm = 1%)

CHEMICAL NAME	CAS #	Mole %	EXPOSURE LIMITS IN AIR							
			ACGIH-TLV		OSHA-STEL		NIOSH-RELs		NIOSH	OTHER
			TWA ppm	STEL ppm	TWA ppm	STEL ppm	TWA ppm	STEL ppm	IDLH ppm	
Hexane	110-54-3	0.01-0.2%	50 (skin)	NE	500; 50 (vacated 1989 PEL)	NE	50	NE	2100 (based on 10% of LEL)	DFG MAKs: TWA = 50 (skin) PEAK = 8•MAK 15 min. average value, 1-hr interval DFG MAK Pregnancy Risk Classification: C
Pentane	109-66-0	0.1-1.0%	600	NE	100	750 (vacated 1989 PEL)	120	610, 15 min. (skin)	1500 (based on 10% of LEL)	DFG MAKs: TWA = 1000 PEAK = 2•MAK 15 min. average value, 1-hr interval DFG MAK Pregnancy Risk Classification: D
Isopentane	78-78-4	0.1-1.0%	600	NE	1000	NE	120	610, 15 min. (skin)	NE	DFG MAKs: TWA = 1000 PEAK = 2•MAK 15 min. average value, 1-hr interval DFG MAK Pregnancy Risk Classification: D
Butane	106-97-8	0.2-4.0%	1000	NE	800 (vacated 1989 PEL)	NE	800	NE	NE	DFG MAKs: TWA = 1000 PEAK = 4•MAK 15 min., momentary value, 1-hr Interval
Isobutane	75-28-5	0.2-4.0%	NE	NE	800 (vacated 1989 PEL)	NE	800	NE	NE	DFG MAKs: TWA = 1000 PEAK = 4•MAK 15 min., momentary value, 1-hr value
Propane	74-98-6	0.5-7.0%	1000	NE	1000	NE	1000	NE	2100 (based on 10% of LEL)	DFG MAKs: TWA = 1000 PEAK = 4•MAK 60 min., momentary value
Carbon Dioxide	124-38-9	0.5-15.0%	5000	30,000	5000 10,000 (vacated 1989 PEL)	30,000 (vacated 1989 PEL)	5000	30,000	40,000	DFG MAKs: TWA = 5000 PEAK = 4•MAK 60 min., momentary value
Ethane	74-84-0	3.0-35.0%	1000	NE	NE	NE	NE	NE	NE	NE
Methane	74-82-8	15.0-93.0%	1000	NE	NE	NE	NE	NE	NE	NE
Nitrogen	7727-37-9	Balance	There are no specific exposure limits for Nitrogen. Nitrogen is a simple asphyxiant (SA). Oxygen levels should be maintained above 19.5%.							

NE = Not Established.

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.

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW: Product Description: This is a colorless, flammable gas mixture, with a distinct "rotten egg" odor, due to the presence of Hydrogen Sulfide and the other sulfur species. **Health Hazards:** This gas mixture can cause significant, adverse health effects at relatively low concentrations, due to the presence of Hydrogen Sulfide. Overexposure can cause dizziness, headache, nausea, respiratory arrest, coma, collapse or unconsciousness. This gas mixture can also cause significant, adverse health effects at relatively low concentrations, due to the presence of Carbon Dioxide. Overexposure can cause nausea, dizziness, headaches, and collapse.

3. HAZARD IDENTIFICATION (Continued)

EMERGENCY OVERVIEW (continued): Health Hazards (continued): Additionally, releases of this gas mixture may produce oxygen-deficient atmospheres. Individuals in such atmospheres may be asphyxiated. This gas mixture may also cause central nervous system effects such as drowsiness and dizziness and may be slightly irritating to the mucous membranes. **Flammability Hazards:** This gas mixture presents a serious fire hazard if accidentally released. Releases of this gas mixture will spread long distances; ignition or flash-back from a distance is possible. Flame or high temperature impinging on a localized area of the cylinder can cause cylinder to rupture violently or explosively. **Environmental Hazards:** Release to the environment should be avoided if possible. **Emergency Response Considerations:** Provide adequate fire protection during emergency response.

SYMPTOMS OF OVER-EXPOSURE BY ROUTE OF EXPOSURE: The most significant route of over-exposure for this product is by inhalation.

INHALATION: One of the components of this gas mixture, Hydrogen Sulfide, is toxic and can cause adverse effects at the concentrations present in this gas mixture. Inhalation of Hydrogen Sulfide can cause dizziness, headache, nausea, respiratory arrest, coma, or unconsciousness. Exposure to Hydrogen Sulfide for more than 30 minutes at concentrations of greater than 600 ppm has been fatal. Continuous inhalation of low concentrations may cause olfactory fatigue, so that the odor is no longer an effective warning of the presence of Hydrogen Sulfide. A summary of exposure concentrations and observed effects are as follows:

<u>CONCENTRATION of HYDROGEN SULFIDE</u>	<u>EXPOSURE SYMPTOM</u>
0.3-30 ppm:	Odor is obvious and unpleasant.
50 ppm:	Eye irritation. Dryness and irritation of nose, throat.
Slightly higher than 50 ppm:	Irritation of the respiratory system.
100-150 ppm:	Temporary loss of smell.
200-250 ppm:	Headache, vomiting, nausea. Prolonged exposure may lead to lung damage. Exposures of 4-8 hours can be fatal.
300-500 ppm:	Swifter onset of symptoms. Death occurs in 1-4 hours.
500 ppm:	Headache, excitement, staggering, stomach after brief exposure. Death occurs from 0.5 - 1 hour.
> 600 ppm:	Rapid onset of unconsciousness, coma, death.
> 1000 ppm:	Immediate respiratory arrest.

Severe exposures to Hydrogen Sulfide which do not result in death may cause long-term symptoms such as memory loss, paralysis of facial muscles, or nerve tissue damage.

High concentrations of this gas can cause an oxygen-deficient environment. Individuals breathing such an atmosphere may experience symptoms which include headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting, and depression of all the senses. The skin of a victim may have a blue color. Under some circumstances of over-exposure, death may occur, due to the displacement of oxygen. The following effects associated with various levels of oxygen given on below.

<u>OXYGEN CONCENTRATION</u>	<u>OBSERVED EFFECT</u>
12-16% Oxygen:	Breathing and pulse rate increase, muscular coordination slightly disturbed.
10-14% Oxygen:	Emotional upset, abnormal fatigue, disturbed respiration.
6-10% Oxygen:	Nausea, vomiting, collapse, or loss of consciousness.
Below 6%:	Convulsive movements, possible respiratory collapse, and death.

It should be noted that before adverse health effects or suffocation could occur, the lower flammability limits of the components of this gas mixture in air may be exceeded, possibly causing an explosive atmosphere as well as an oxygen-deficient environment.

The Carbon Dioxide component is an asphyxiant and a powerful cerebral vasodilator. If the concentration of Carbon Dioxide reaches 10% or more, suffocation can occur within minutes. At concentrations between 2 and 10%, Carbon Dioxide can cause nausea, dizziness, headache, mental confusion, increased blood pressure and respiratory rate. Carbon Dioxide initially stimulates respiration and then causes respiratory depression. High concentrations result in narcosis. Repeated inhalation of low concentrations (3-5%), have no known permanent harmful effects. Symptoms in humans are described on the following page:

3. HAZARD IDENTIFICATION (Continued)

INHALATION (continued):

CARBON DIOXIDE CONCENTRATION

1%

2%

3%

4-5%

5-10%

50-100%

OBSERVED EFFECT

Slight increase in breathing rate.

Breathing rate increases to 50% above normal level. Prolonged exposure can cause headache, tiredness.

Breathing increases to twice normal rate and becomes labored. Weak narcotic effect. Impaired hearing, headache, increase in blood pressure and pulse rate.

Breathing increases to approximately four times normal rate, symptoms of intoxication become evident and slight choking may be felt.

Characteristic sharp odor noticeable. Very labored breathing, headache, visual impairment and ringing in the ears. Judgment may be impaired, followed within minutes by loss of consciousness.

Unconsciousness occurs more rapidly above 10% level. Prolonged exposure to high concentrations may eventually result in death from asphyxiation.

Inhalation of high concentrations of this gas mixture may cause adverse effects on the central nervous system. Symptoms may include headaches, nausea, dizziness, drowsiness, confusion, and unconsciousness. In addition, due to the presence of the pentanes in this gas mixture, inhalation may cause anesthetic effects. Repeated or prolonged overexposures to Pentane isomers, especially at high concentrations, can cause cardiac arrest due to sensitization of the heart to adrenaline and nor-adrenaline and can cause liver damage.

The following effects are associated with the inhalation of varying concentrations of pentanes:

PENTANES

CONCENTRATION

Brief (10 minute)

up to 5,000 ppm:

Higher than 5,000 ppm:

130,000 ppm:

Long term:

OBSERVED EFFECT

No symptoms.

Exhilaration, dizziness and headache can occur.

Collapse and death

Can cause chronic neurological disorder causing damage to the nerves in the hands and feet (peripheral neuropathy).

Due to presence of Hexane in this mixture, inhalation may cause the following symptoms.

HEXANE

CONCENTRATION

Brief (10 minute)

at 1,500 ppm:

5000 ppm:

Long term at 500 ppm:

OBSERVED EFFECT

Irritation of the respiratory tract, nausea and headache.

Dizziness and drowsiness can occur.

Can affect the nerves in the arms and legs. Effects include numbing or tingling sensations in the fingers and toes, tiredness, muscle weakness, cramps and spasms in the leg, difficulty in holding objects or walking, abdominal pains, loss of appetite, weight loss, cold pulsation in extremities, blurred vision, anorexia. More serious exposures can cause damage to the nerves in the hands and feet (peripheral neuropathy).

Eyes and Vision:

Abnormal color perception and pigment changes in the eyes have been reported among industrial workers exposed to 423-1280 ppm for 5 years or more.

Blood Cells:

Mild forms of anemia have also been associated with exposure to hexane. These are of temporary nature.

CONTACT WITH SKIN or EYES: Due to the presence of Hydrogen Sulfide, this gas mixture may be irritating to the skin. Inflammation and irritation of the eyes can occur at very low airborne concentrations (less than 10 ppm Hydrogen Sulfide). Exposure over several hours may result in "gas eyes" or "sore eyes" with symptoms of scratchiness, irritation, tearing and burning. Above 50 ppm, there is an intense tearing, blurring of vision, and pain when looking at light. Exposed individuals may see rings around bright lights. Most symptoms disappear when exposure ceases; however, in serious cases, the eye can be permanently damaged. Due to the presence of Carbon Dioxide in this mixture, moisture in the air could lead to the formation of carbonic acid, which can be irritating to the eyes. Contact with the eyes can cause damage to the retinal ganglion cells due to the presence of Carbon Dioxide. Due to the presence of the Pentane, Isopentane and Hexane components, prolonged skin exposure may cause defatting of the skin and dermatitis. Symptoms are dry, red, cracked skin. Pentane isomers can cause sensitization of the heart to epinephrine. In addition, contact with rapidly expanding gases (which are released under high pressure) may cause frostbite.

3. HAZARD IDENTIFICATION (Continued)

SKIN ABSORPTION: The pentane isomers in this gas mixture can be absorbed via intact skin. If a large enough area of the skin is affected, symptoms as described under 'Inhalation' may occur.

OTHER HEALTH EFFECTS: Chronic overexposures to this gas mixture may cause damage to the nerves in hands and feet (peripheral neuropathy) due to the presence of the Pentane Isomers and Hexane. Abnormal color perception and pigment changes in the eyes have been reported among persons exposed to 420 -1300 ppm of Hexane for five years. Based on animal tests, the Ethane and Propane components of this gas mixture may cause weak cardiac sensitization. Chronic exposure to oxygen-deficient atmospheres (below 18% oxygen in air) may affect the heart and nervous system.

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

ACUTE: Due to the presence of Hydrogen Sulfide, inhalation of relatively low concentrations of this gas mixture can cause dizziness, headache, and nausea. Exposure to higher concentrations of this gas mixture can result in respiratory arrest, coma, and may be fatal due to the toxicity of Hydrogen Sulfide and oxygen deficiency. Continuous inhalation of low concentrations may cause olfactory fatigue, so that the odor of Hydrogen Sulfide is no longer an effective warning of over-exposure to this gas mixture. Additionally this gas mixture may cause skin and eye irritation. This gas mixture can also produce adverse health effects such as adverse central nervous system effects, Carbon Dioxide overexposure or oxygen deficiency. Severe inhalation overexposures can be fatal. This gas mixture can be irritating to the eyes.

CHRONIC: Reversible effects on the acid-base balance in the blood, blood pressure, and circulatory system may occur after prolonged exposure to elevated Carbon Dioxide levels. Chronic exposure to this gas mixture may cause damage to the peripheral nervous system. Due to the presence of Hydrogen Sulfide, severe exposures which do not result in death may cause long-term symptoms such as memory loss, paralysis of facial muscles, or nerve tissue damage. Refer to Section 11 (Toxicological Information) of this MSDS for further information.

TARGET ORGANS: ACUTE: Respiratory system, skin, eyes, central nervous system. CHRONIC: Cardiovascular system, skin peripheral nervous system.

HMIS RATING: HEALTH HAZARD = 2* FLAMMABILITY HAZARD = 4 PHYSICAL HAZARD = 0
Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe * Chronic

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. Adequate fire protection must be provided during rescue situations.** 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.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing acute or chronic respiratory conditions may be aggravated by overexposure to this gas mixture.

RECOMMENDATIONS TO PHYSICIANS: Administer oxygen, treat symptoms and eliminate exposure. Administer oxygen and continue even after spontaneous breathing is established. If pulmonary edema ensues, treat accordingly. In severe poisonings, treat with amyl nitrite and sodium nitrite as for cyanide poisoning, but omit sodium thiosulfate injection. Use of antibiotics should be considered at the first sign of pulmonary infection. Atropine sulfate may contribute some symptomatic relief. In event of eye contamination, conjunctivitis may be relieved by instillation of 1 drop of olive oil and sometimes by 3 to 4 drops of epinephrine solution (1:1000) at frequent intervals (e.g. 5 minutes). Occasionally, local anesthetics and hot or cold compresses are necessary to control pain.

5. FIRE-FIGHTING MEASURES

FLASH POINT: Not determined for mixture. The following are available for the main flammable components:

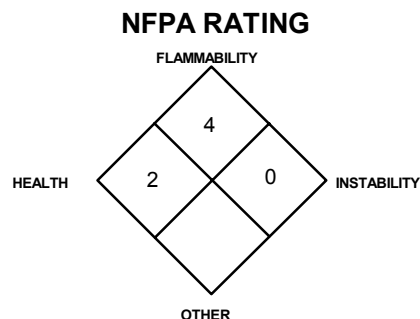
Butane: -60°C (-76°F)	Isopentane: < -51°C (< -60°F)
Ethane: Flammable Gas	Methane: Flammable Gas
Hexane: -2°C (-76°F)	Pentane: < -40°C (< -40°F)
Isobutane: Flammable Gas	Propane: Flammable Gas

AUTOIGNITION TEMPERATURE: Not determined for mixture. The following are available for the main flammable components:

Butane: 287°C (550°F)	Isopentane: 420°C (788°F)
Ethane: 472°C (882°F)	Methane: 537°C (999°F)
Hexane: 225°C (437°F)	Pentane: 260°C (500°F)
Isobutane: 460°C (860°F)	Propane: 450°C (842°F)

FLAMMABLE LIMITS (in air by volume, %): Not determined for mixture. The following are available for the main flammable components:

	Lower (LEL)	Upper (UEL)
Butane:	1.9%	8.5%
Ethane:	3.0%	12.5%
Hexane:	1.1%	7.5%
Isobutane:	1.8%	8.4%
Isopentane:	1.4%	7.6%
Methane:	5.0%	15.0%
Pentane:	1.5%	7.8%
Propane:	2.1%	9.5%



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

FIRE EXTINGUISHING MATERIALS: Extinguish fires of this gas mixture by shutting-off the source of gas. Use water spray to cool fire-exposed structures and equipment.

UNUSUAL FIRE AND EXPLOSION HAZARD: DANGER! 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.

EXPLOSION SENSITIVITY TO MECHANICAL IMPACT: Not sensitive.

EXPLOSION SENSITIVITY TO STATIC DISCHARGE: Static discharge may cause this gas mixture to ignite explosively.

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. If possible, stop the leak and flow of gas before extinguishing fire. If release is still occurring after the fire has been extinguished, there is a possibility that 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 115).

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.

6. ACCIDENTAL RELEASE MEASURES (Continued)

LEAK RESPONSE (continued): The atmosphere must have not more than 10% of the LEL of each component gas (see Section 5, Fire-Fighting Measures) and at least 19.5 percent Oxygen before non-emergency personnel can be allowed in the area without Self-Contained Breathing Apparatus, chemically-resistant clothing and fire protection.

7. HANDLING and USE

WORK PRACTICES AND HYGIENE PRACTICES

Do not eat or drink while handling chemicals.

Be aware of all potential exposure symptoms; exposures to a fatal 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 keep exposure limits of components below levels below those listed in Section 2, Composition and Information on Ingredients and 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 leak detection and alarm for storage and use areas. Have appropriate extinguishing equipment in storage area (i.e. sprinkler system, portable fire extinguishers).

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 Section 2 (Composition and Information on Ingredients). 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 Oxygen and the presence of potentially explosive air-gas mixtures.

The following information on appropriate Personal Protective Equipment is provided to assist employers in complying with OSHA regulations found in 29 CFR Subpart I (beginning at 1910.132) or equivalent standard of Canada. Please reference applicable regulations and standards for relevant details.

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 guidelines are based on NIOSH respiratory protection recommendations for those components that reach the guideline levels.

CARBON DIOXIDE CONCENTRATION

Up to 40,000 ppm:

RESPIRATORY EQUIPMENT

Supplied Air Respirator (SAR); or full-facepiece Self-Contained Breathing Apparatus (SCBA).

Emergency or Planned Entry Into Unknown Concentrations or IDLH Conditions: Positive pressure, full-facepiece SCBA; or positive pressure, full-facepiece SAR with an auxiliary positive pressure SCBA.

Escape:

Escape-type SCBA.

n-HEXANE CONCENTRATION

Up to 500 ppm:

Up to 1100 ppm:

RESPIRATORY PROTECTION

Any Supplied-Air Respirator (SAR).

Any SAR operated in a continuous-flow mode, or any Self-Contained Breathing Apparatus (SCBA) with a full facepiece, or any SAR with a full facepiece.

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 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:

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

HYDROGEN SULFIDE CONCENTRATION

Up to 100 ppm:

RESPIRATORY PROTECTION

Any Powered, Air-Purifying Respirator (PAPR) with cartridge(s), or any Air-Purifying, Full-Facepiece Respirator (gas mask) with a chin-style, front- or back-mounted canister, or any Supplied-Air Respirator (SAR), or any Self-Contained Breathing Apparatus (SCBA) with a full facepiece.

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:

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

PENTANES CONCENTRATION

Up to 1200 ppm:

Up to 1500 ppm:

RESPIRATORY EQUIPMENT

Supplied Air Respirator (SAR).

SAR operated in continuous-flow mode, full facepiece Self-Contained Breathing Apparatus (SCBA), or full facepiece SAR.

Emergency or Planned Entry into Unknown Concentration or IDLH Conditions: Positive pressure, full facepiece SCBA or positive pressure, full facepiece SAR with an auxiliary positive pressure SCBA.

Escape:

Gas mask with organic vapor cartridge or escape-type SCBA should be used.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION (Continued)

RESPIRATORY PROTECTION (continued): NIOSH Respiratory Guidelines, continued:

PROPANE

CONCENTRATION

Up to 2100 ppm:

Emergency or Planned

Escape:

RESPIRATORY PROTECTION

Any Supplied-Air Respirator (SAR), or any Self-Contained Breathing Apparatus with a full facepiece (SCBA).

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.

Any appropriate escape-type, SCBA.

EYE PROTECTION: Splash goggles or safety glasses. If necessary, refer to U.S. OSHA 29 CFR 1910.133, or appropriate Canadian Standards.

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 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, foot protection should be used, as described in U.S. OSHA 29 CFR 1910.136.

9. PHYSICAL and CHEMICAL PROPERTIES

The physical and chemical properties of this gas mixture have not been determined. The following information is for the main components of this gas mixture, **Carbon Dioxide, Ethane, Methane** and **Nitrogen**, which will define the most significant physical and chemical properties of the mixture.

The following information is for the **Carbon Dioxide** component of this gas mixture:

GAS DENSITY @ 21.1°C and 1 atm: 0.1144 lb/ft³ (1.833 kg/m³)

SOLUBILITY IN WATER vol/vol 20°C and 1 atm: 0.90

LIQUID DENSITY @ 21.1°C and 838 psig (5778 kPa): 47.35 lb/ft³ (761.3 kg/m³)

FREEZING/MELTING POINT: (sublimation temperature) -78.5°C (-109.3°F)

TRIPLE POINT: -55.6°C (-69.9°F) @ 60.4 psig (416 kPa)

pH: 3.7 at 1 atm (form carbonic acid)

ODOR THRESHOLD: Odorless.

EXPANSION RATIO: Not applicable.

SUBLIMATION POINT: -78.5°C (-109.3°F)

VAPOR PRESSURE @ 21.1°C (70°F) psig: 838 psig (5778 kPa)

COEFFICIENT WATER/OIL DISTRIBUTION: Not applicable.

SPECIFIC VOLUME (ft³/lb): 8.76

SPECIFIC GRAVITY (air = 1) 21.1°C: 1.522

EVAPORATION RATE (nBuAc = 1): Not applicable.

MOLECULAR WEIGHT: 44.01

The following information is for **Ethane**, a main component of this gas mixture:

GAS DENSITY @ 101.325 kPa @ 25°C (air = 1): 1.048

FREEZING/MELTING POINT (@ 10 psig): -183.1°C (-297.9°F)

SPECIFIC GRAVITY (air = 1) @ 21.1°C: 1.048

SOLUBILITY IN WATER vol/vol @ 20°C: 0.047

EVAPORATION RATE (nBuAc = 1): Not applicable.

ODOR THRESHOLD: Not applicable.

VAPOR PRESSURE @ 21.1°C (70°F) psig: 544

COEFFICIENT WATER/OIL DISTRIBUTION: Not applicable.

pH: Not applicable.

MOLECULAR WEIGHT: 30.08

EXPANSION RATIO: Not applicable.

SPECIFIC VOLUME (ft³/lb): 12.5151

BOILING POINT: -88.6°C (-127.5°F)

The following information is for **Methane**, a main component of this gas mixture:

GAS DENSITY: 0.04235 lb/cu ft (6784 kg/m³)

SPECIFIC GRAVITY (air = 1): 0.55491

SOLUBILITY IN WATER: Slight.

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: -82.2°C (-115.96°F)

BOILING POINT (@ 1 atmos.): -161.5°C (-258.6°F)

SPECIFIC VOLUME (ft³/lb): 23.6113

MOLECULAR WEIGHT: 16.02

9. PHYSICAL and CHEMICAL PROPERTIES (Continued)

The following information is for the **Nitrogen** component of this gas mixture:

GAS DENSITY @ 21.1°C: 0.072 lb./ft³ (1.153 kg/m³) **CRITICAL PRESSURE:** 492.9 psia (3399 kPa abs)
BOILING POINT @ 1 atm: -195.8°C (-320.4°F) **MOLECULAR WEIGHT:** 28.01
SPECIFIC GRAVITY (air = 1) @ 21.1°C: 0.906 **SPECIFIC VOLUME @ 21.1°C:** 13.8 lb./ft³ (0.867 m³/kg)
FREEZING/MELTING POINT @ 1 atm: -210°C (-345.8°F)
SOLUBILITY IN WATER vol/vol at 0°C and 1 atm: 0.023
COEFFICIENT WATER/OIL DISTRIBUTION: Not applicable.

The following information is pertinent to this product:

APPEARANCE, ODOR AND COLOR: This is a colorless, flammable gas mixture, with a distinct "rotten egg" odor, due to the presence of Hydrogen Sulfide and the other sulfur species.

HOW TO DETECT THIS SUBSTANCE (warning properties): The odor of this gas mixture is not a good warning property in the event of a release due to the possibility of olfactory fatigue. In terms of leak detection, fittings and joints can be painted with a soap solution to detect leaks, which will be indicated by a bubble formation.

10. STABILITY and REACTIVITY

STABILITY: Stable at standard temperatures and pressures.

DECOMPOSITION PRODUCTS: If ignited in air, the components of this gas mixture will generate carbon monoxide, carbon dioxide, sulfur oxides and oxides of nitrogen.

MATERIALS WITH WHICH SUBSTANCE IS INCOMPATIBLE: This gas mixture is incompatible with strong oxidizers such as chlorine, bromine, pentafluoride, oxygen, oxygen difluoride and nitrogen trifluoride. Due to the presence of Carbon Dioxide, this gas mixture may be incompatible with powdered aluminum, beryllium, cerium alloys, chromium, magnesium-aluminum alloys, manganese, thorium, titanium, zirconium, metal acetylides, and alkaline materials.

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Contact with incompatible materials, heat, spark or flame. Cylinders exposed to high temperatures or direct flame can rupture or burst.

11. TOXICOLOGICAL INFORMATION

TOXICITY DATA: The Nitrogen component 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 remaining components of this gas mixture that are in 1% or greater concentration: (Note: not all data available are presented in this MSDS).

BUTANE:

TCLo (Inhalation-Human) 280 mg/m³: Brain and Coverings: changes in surface EEG

LC₅₀ (Inhalation-Rat) 658,000 mg/m³/4 hours

LC₅₀ (Inhalation-Mouse) 680,000 mg/m³/2 hours

CARBON DIOXIDE:

LCLo (Inhalation-Human) 9 pph/5 minutes

LCLo (Inhalation-Human) 11 pph

TCLo (Inhalation-Human) 0.25 pph: Lungs, Thorax, or Respiration: dyspnea; Vascular: other changes

TCLo (Inhalation-Human) 2.5 pph: Cardiac: pulse rate; Behavioral: headache; Vascular: BP elevation not characterized in autonomic section

TCLo (Inhalation-Human) 7 pph: Behavioral: irritability; Brain and Coverings: other degenerative changes; Nutritional and Gross Metabolic: body temperature decrease

TCLo (Inhalation-Rat) 21 pph/1 hour: Cardiac other changes, pulse rate, arrhythmias (including changes in conduction)

TCLo (Inhalation-Rat) 10,000 ppm/24 hours/30 days-continuous: Blood: other changes

TCLo (Inhalation-Rat) 6 pph/24 hours: female 10 day(s) after conception: Reproductive: Specific Developmental Abnormalities: musculoskeletal system, cardiovascular (circulatory) system, respiratory system

TCLo (Inhalation-Rat) 6 pph/24 hours: female 10 day(s) after conception: Reproductive: Effects on Newborn: growth statistics (e.g.%, reduced weight gain)

ETHANE:

Guinea pigs breathing about 2.2 to 5% Ethane for 2 hours showed signs of irregular breathing and slight drowsiness, but no other health effects. At concentrations of 15-19%, when mixed with oxygen, Ethane is a weak cardiac sensitizer. There were no signs of anesthesia in animals breathing an ethane/oxygen mixture (80% ethane/20% oxygen) for up to 3.75 hours.

HEXANE:

Standard Draize Test (Eye-Rabbit) 10 mg: Mild

TCLo (Inhalation-Human) 190 ppm/8 weeks: Peripheral Nerve and Sensation: structural change in nerve or sheath

TCLo (Inhalation-Human) 5400 mg/m³/10 minutes: Behavioral: headache; Lungs, Thorax, or Respiration: respiratory obstruction; Gastrointestinal: nausea or vomiting

TCLo (Inhalation-Human) 190 mg/m³/6 years-continuous: Peripheral Nerve and Sensation: paresthesia

LD₅₀ (Oral-Rat) 25 gm/kg

LC₅₀ (Inhalation-Rat) 48,000 ppm/4 hours

LC₅₀ (Inhalation-Rat) 627,000 mg/m³/3 minutes

LC₅₀ (Inhalation-Rat) 150,000 mg/m³/2 hours

ISOBUTANE:

LC₅₀ (Inhalation-Rat) 57 pph/15 minutes: Behavioral: tremor, convulsions or effect on seizure threshold; Lungs, Thorax, or Respiration: respiratory depression

LCLo (Inhalation-Mouse) 1041 gm/m³/2 hours: Behavioral: excitement

11. TOXICOLOGICAL INFORMATION (Continued)

TOXICITY DATA (continued):

ISOPENTANE:

LC_{Lo} (Inhalation-Mouse) 419 gm/m³/2 hours: Behavioral: excitement
 LC₅₀ (Inhalation-Rat) 280,000 mg/m³/4 hours
 LC₅₀ (Inhalation-Mouse) 150,000 mg/m³/2 hours
 TCLo (Inhalation-Rat) 270,000 mg/m³/2 hours: Behavioral: general anesthetic

METHANE:

LC₅₀ (Inhalation-Mouse) 50 pph/2 hours

PROPANE:

Effects on Short-Term Inhalation: Guinea-pigs breathing 5.5% Propane by volume developed tremors after 5 minutes. Nausea, retching, and stupefaction were observed when animals were exposed for 30-120 minutes. All the animals survived a two-hour exposure and had no significant tissue damage. A gas concentration of 89% did not cause anesthesia, but depressed the blood pressure of cats. Inhalation of 10 percent propane by mice and 15% by dogs caused weak cardiac sensitization. Presumably, all of these effects are reversible when exposure ceases. In primates, 10% propane caused some change in heart function. At 20% there was aggravation of these symptoms and respiratory depression. **Effects of Long-Term Inhalation:** No toxicity or abnormalities were observed when monkeys were exposed to approximately 750 ppm for 90 days.

In addition, animal testing on the **Ethane, Isobutane, Butane, Methane and Propane** components of this gas mixture have produced central nervous system effects. The Ethane, Isobutane, Butane, Hexane and Pentane Isomers are also considered to be weak to moderate sensitizers of the cardiac system, producing changes in heart function, based on animal tests.

CARCINOGENIC INFORMATION: The components of this gas mixture are listed by agencies tracking carcinogenic potential as follows:

Hexane: EPA-I (Inadequate Information to Assess Carcinogenic Potential)

Hydrogen Sulfide: EPA-I (Inadequate Information to Assess Carcinogenic Potential)

The remaining components are not found on the following lists: FEDERAL OSHA Z LIST, IARC, NTP, CAL/OSHA, and therefore is not considered to be, nor suspected to be a cancer-causing agent by these agencies.

IRRITANCY OF PRODUCT: Due to the presence of Carbon Dioxide in this mixture, moisture in the air could lead to the formation of carbonic acid, which can be irritating to the eyes. Due to the presence of solvents in this gas mixture, exposure by inhalation or skin contact may cause irritation, especially if exposure is prolonged.

SENSITIZATION TO THE PRODUCT: The components of this product are not known to be human skin or respiratory sensitizers. Ethane, Isobutane, Butane, Propane, Hexane and Pentane isomers, in high concentrations, are considered weak heart sensitizing agents based on animal studies.

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. Animal mutagenic data are available for the Carbon Dioxide component of this gas mixture; these data were obtained during clinical studies on specific animal tissues exposed to relatively high doses of these gases.

Embryotoxicity: The components of this gas mixture are not reported to cause embryotoxic effects in humans. Clinical studies involving test animals exposed to high concentrations of Carbon Dioxide indicate embryotoxic effects (e.g., cardiac and skeletal malformations, stillbirths). Animal tests involving the Hexane component produced embryotoxic effects at levels that also caused maternal toxicity in rats and mice exposed by inhalation.

Teratogenicity: The components of this gas mixture are not reported to cause teratogenic effects in humans. Clinical studies involving test animals exposed to high concentrations of Carbon Dioxide indicate teratogenic effects (e.g., cardiac and skeletal malformations, stillbirths).

Reproductive Toxicity: The components of this gas mixture are not reported to cause reproductive effects in humans. Studies involving test animals exposed to high concentrations of Carbon Dioxide show effects (e.g. changes in testes).

BIOLOGICAL EXPOSURE INDICES (BEIs): There are Biological Exposure Indices (BEIs) determined for the Hexane component of this gas mixture, as follows.

CHEMICAL DETERMINANT	SAMPLING TIME	BEI
n-HEXANE • 2,5-Hexanedione in urine	• End of shift at end of workweek	• 0.4 mg/L

12. ECOLOGICAL INFORMATION

ENVIRONMENTAL STABILITY: This gas mixture will be dissipated rapidly in well-ventilated areas. The following information is available for some of the main components on persistence, bio-concentration and biodegradability of these compounds.

Persistence:

Carbon Dioxide:

The extensive sets of global CO₂ measurements of the National Oceanic and Atmospheric Admin (NOAA) Geophysical Monitoring for Climatic Change (GMCC) division and of the Upper Atmosphere and Space Research Laboratory of Tohoku University are combined with a two-dimensional transport model to derive, in an "inverse" calculation, the latitudinal and seasonal distributions of sources and sinks of CO₂ necessary to reproduce the observed concentration. It is found that the southern oceans are a sink of carbon of 0.8 to 1.5 Gt/yr (1 Gt = 1 x 10¹⁵ g) and that the equatorial areas are a source to the atmosphere of 1.4 to 2.8 Gt. There seems to be significant seasonality in the sources and sinks of CO₂, both in the tropics and in the southern oceans. Seasonal net ecosystem production north of 25 deg N is found to be 6.2 to 8.2 Gt of carbon. The global average net source of atmospheric CO₂ estimated from the Tohoku data is 2.84 Gt C/yr, while for the GMCC data it is 2.98 Gt C/yr.

Ethane: Photolysis or hydrolysis of Ethane gas in aquatic systems is not expected to be important. Based on a calculated vapor pressure of 31,459 mm Hg at 25°C, Ethane is expected to exist entirely in the vapor phase in ambient air. Ethane gas does not absorb UV light in the environmentally significant range, > 290 nm and probably will not undergo direct photolysis in the atmosphere. Vapor phase reactions with photochemically produced hydroxyl radicals in the atmosphere have been shown to occur. Rate constants for Ethane were measured to be about 3.06X10⁻¹³ cu cm/molecule-sec at 25°C, which correspond to atmospheric half lives of about 52 days or greater at an atmospheric concentration of 5X10⁵ hydroxyl radicals per cu cm. Experimental data showed that 1.4% of the Ethane fraction in a dark chamber reacted with Nitrogen Oxide to form the corresponding alkyl nitrate, suggesting nighttime reactions with radical species and nitrogen oxides may contribute to the atmospheric transformation of Ethane. Volatilization is expected to be the dominant fate process. To a lesser extent, adsorption may occur. An estimated range for Koc from 230 to 460 indicates Ethane may partition from the water column to organic matter contained in sediments and suspended materials. An estimated Henry's Law constant of 5.01X10⁻¹ atm-cu m/mole at 25°C suggests extremely rapid volatilization of ethane from environmental waters. Based on this Henry's Law constant, the volatilization half life from a model river has been estimated to be 1.5 hours. The volatilization half life from a model pond, which considers the effect of adsorption, can be estimated to be about 1.9 days.

Methane: Methane exists in the gas-phase in the ambient atmosphere with a vapor pressure of 4.7X10⁵ mmHg. Volatilization is expected to be the most important fate process for Methane in soil based on its vapor pressure of 4.7X10⁵ mm Hg at 25°C. Volatilization of methane from moist soil surfaces is expected to be an important fate process given an estimated Henry's Law constant of 0.66 atm-cu m/mole derived from its vapor pressure, and water solubility, 22 mg/L. Based on a classification scheme, an estimated Koc value of 90, determined from a log Kow of 1.09 and a regression-derived equation, indicates that Methane is not expected to adsorb to suspended solids and sediment. Volatilization from water surfaces is expected to be the dominant fate process in aqueous systems based upon an estimated Henry's Law constant of 0.66 atm-cu m/mole, derived from its vapor pressure, 4.7X10⁵ mmHg, and water solubility, 22 mg/liter. Using this Henry's Law constant and an estimation method, volatilization half-lives for a model river and model lake are both 2 hours. According to a classification scheme, an estimated BCF of 1, from its log Kow and a regression-derived equation, suggests the potential for bioconcentration in aquatic organisms is low.

Biodegradation:

Ethane: The biodegradation of Ethane may occur in soils; however, volatilization is expected to be the dominant fate process. To a lesser extent, adsorption may occur. A calculated Koc range of 230 to 460 indicates a medium mobility class for Ethane in soils. Based upon an estimated Henry's Law constant of 5.01X10⁻¹ atm-cu m/mole at 25°C, Ethane is expected to rapidly volatilize from most surface soils. Biodegradation of Ethane may occur in aquatic environments.

Methane: Gas-phase Methane is very slowly degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be about 6 years, calculated from its rate constant of 6.9X10⁻¹⁵ cu cm/molecule-sec at 25°C. Utilization of Methane by soil microorganisms has been detected from five soil samples collected from sites near Adelaide, South Australia.

Bioaccumulation:

Ethane: Based upon a water solubility of 60.2 ppm at 25°C and a log Kow of 1.81, the bioconcentration factor (log BCF) for Ethane has been calculated, using recommended regression derived equations, to be 1.15 and 1.79, respectively. These bioconcentration factors values do not indicate that bioconcentration in aquatic organisms is important.

Methane: An estimated BCF of 1 was calculated for Methane, using a log Kow of 1.09 and a regression-derived equation. According to a classification scheme, this BCF suggests the potential for bioconcentration in aquatic organisms is low. The biodegradation half-life of methane was estimated to range from 70 days to infinity based on gas exchange biodegradation experiments conducted in model estuarine ecosystems.

EFFECT OF MATERIAL ON PLANTS or ANIMALS: Any adverse effect on animals would be related to oxygen deficient environments.

EFFECT OF CHEMICAL ON AQUATIC LIFE: There are no data on possible adverse effects from this gas mixture on aquatic life. The following are aquatic toxicity data for the Carbon Dioxide and Hydrogen Sulfide component:

CARBON DIOXIDE:

Toxic Effect: Lethal (Trout) 1 hour = 240 mg/L
Toxic Effect: Lethal (Rainbow Trout) 96 hours = 35 mg/L
Toxic Effect: Lethal (Rainbow Trout) 12 hours = 60-240 mg/L
Harmful to some species of aquatic life in concentrations less than 20 mg/L

HYDROGEN SULFIDE:

TLm (*Aseillus*) 96 hours = 0.111 mg/L
TLm (*Cranfonyx* sp) 96 hours = 1.07 mg/L
TLm (*Gammarrus*) 96 hours = 0.84 mg/L

HYDROGEN SULFIDE:

LC₅₀ (fly inhalation) 960 minutes = 380 mg/m³
LC₅₀ (fly inhalation) 7 minutes = 1500 mg/m³
TLm (*Lepomis macrochirus*, bluegill sunfish) 96 hours = 0.0478 mg/L
TLm (*Lepomis macrochirus*, bluegill sunfish) 96 hours = 0.0448 mg/L @ 21-22°C
TLm (*Pimephales promelas*, fathead minnow) 96 hours = 0.0071-0.55 mg/L
TLm (*Salvenilis foninalis*, brook trout) 96 hours = 0.0216-0.038 mg/L @ 8-12.5°C

13. DISPOSAL CONSIDERATIONS

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

FLAMMABLE, DELPHI-2 GAS MIXTURE MSDS

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EFFECTIVE DATE: AUGUST 8, 2006

MATH0093

MATHESON TRI-GAS

14. TRANSPORTATION INFORMATION

THIS GAS MIXTURE IS HAZARDOUS AS DEFINED BY 49 CFR 172.101 BY THE U.S. DEPARTMENT OF TRANSPORTATION.

PROPER SHIPPING NAME: Compressed gases, flammable, n.o.s. (Methane, Ethane)
HAZARD CLASS NUMBER and DESCRIPTION: 2.1 (Flammable Gas)
UN IDENTIFICATION NUMBER: UN 1954
PACKING GROUP: Not Applicable
D.O.T HAZARD LABEL: Class 2.1 (Flammable Gas)
NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2004): 115
MARINE POLLUTANT: The components of this gas mixture are not classified by the DOT as a Marine Pollutants (as defined by 49 CFR 172.101, Appendix B).
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)).

TRANSPORT CANADA TRANSPORTATION OF DANGEROUS GOODS REGULATIONS: This gas is classified as Dangerous Goods, per regulations of Transport Canada. The use of the above U.S. DOT information from the U.S. 49 CFR regulations is allowed for shipments that originate in the U.S. For shipments via ground vehicle or rail that originate in Canada, the following information is applicable.

PROPER SHIPPING NAME: Compressed gases, flammable, n.o.s. (Methane, Ethane)
UN IDENTIFICATION NUMBER: UN 1954
HAZARD CLASS NUMBER and DESCRIPTION: 2.1 (Flammable Gas)
PACKING GROUP: Not Applicable
HAZARD SHIPPING LABEL(S) REQUIRED: Class 2.1 (Flammable Gas)
SPECIAL PROVISIONS: 16
EXPLOSIVE LIMIT & LIMITED QUANTITY INDEX: 0.125
ERAP INDEX: 3000
PASSENGER CARRYING SHIP INDEX: Forbidden
PASSENGER CARRYING ROAD OR RAIL VEHICLE INDEX: Forbidden
NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2004): 115
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).

15. REGULATORY INFORMATION

ADDITIONAL U.S. REGULATIONS:

U.S. SARA REPORTING REQUIREMENTS: The components of this product are 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)
Carbonyl Sulfide	No	No	Yes
Hexane	No	No	Yes
Hydrogen Sulfide	Yes	Yes	Yes

U.S. SARA SECTION 302 EXTREMELY HAZARDOUS SUBSTANCE THRESHOLD PLANNING QUANTITY: Hydrogen Sulfide = 500 lb (227 kg)

U.S. SARA SECTION 304 EXTREMELY HAZARDOUS SUBSTANCE REPORTABLE QUANTITY: Hydrogen Sulfide = 100 lb (45.4 kg)

U.S. SARA HAZARD CATEGORIES (SECTION 311/312, 40 CFR 370-21): ACUTE: Yes; CHRONIC: Yes; FIRE: No; REACTIVE: No; SUDDEN RELEASE: Yes

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

U.S. CERCLA REPORTABLE QUANTITY (RQ): Carbonyl Sulfide = 100 lb (45.4 kg); Hexane = 5000 lb (2270 kg); Hydrogen Sulfide = 100 lb (45.4 kg)

15. REGULATORY INFORMATION (Continued)

ADDITIONAL U.S. REGULATIONS (continued):

OTHER U.S. FEDERAL REGULATIONS: Carbonyl Sulfide and Hydrogen Sulfide are subject to the reporting requirements of Section 112(r) of the Clean Air Act. The threshold quantity for these gases is 10,000 lbs (4,540 kg). Hydrogen Sulfide is listed in Table 1, as a Regulated Substance (Toxic Substance) in quantities of 10,000 lb (4,553 kg) or greater.

Butane, Ethane, Isobutane, Isopentane, Methane, Pentane, and Propane are subject to the reporting requirements of Section 112(r) of the Clean Air Act. The threshold quantity for each of these gases is 10,000 lbs (4,540 kg). Butane, Ethane, Isobutane, Isopentane, Methane, Pentane, and Propane are 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): The components of this gas mixture are not on the California Proposition Lists.

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:

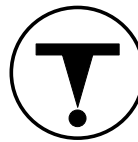
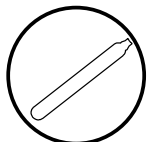
CANADIAN DSL/NDL INVENTORY STATUS: The components of this product are listed on the DSL Inventory.

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.

ADDITIONAL CANADIAN REGULATIONS:

CANADIAN WHMIS SYMBOLS: This gas mixture would be categorized as a Controlled Product, Hazard Classes: **A** (Compressed Gas), **B1** (Flammable), and **D2B** (Materials Causing Other Toxic Effects - Acute and Chronic Toxic Effects). The following symbol is required for WHMIS compliance for this gas mixture.



16. OTHER INFORMATION

CREATION DATE: June 26, 2006

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), 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202-4102. Telephone: (703) 412-0900.

"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

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.

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.

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.

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; 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];

16. OTHER INFORMATION (Continued)

DEFINITIONS OF TERMS (Continued)

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM HAZARD RATINGS (continued):

FLAMMABILITY HAZARD (continued):

4 (continued): Material that ignites 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%) cellulosic 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:* Packing 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%) cellulosic 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:* Packing 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%) cellulosic 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. A mass explosion is one that affects almost the entire load instantaneously.

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM HAZARD RATINGS (continued):

PHYSICAL HAZARD (continued):

4 (continued): *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. **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:

16. OTHER INFORMATION (Continued)

DEFINITIONS OF TERMS (Continued)

NATIONAL FIRE PROTECTION ASSOCIATION HAZARD RATINGS (continued):

FLAMMABILITY HAZARD (continued): 1 (continued): 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 *Manual 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. **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:

NATIONAL FIRE PROTECTION ASSOCIATION HAZARD RATINGS (continued):

INSTABILITY HAZARD (continued): 3 (continued): 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/NDL**); 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.