

# 1,4-Dioxane

sc-208794

Material Safety Data Sheet



The Power is Question

Hazard Alert Code Key:

EXTREME

HIGH

MODERATE

LOW

## Section 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

### PRODUCT NAME

1,4-Dioxane

### STATEMENT OF HAZARDOUS NATURE

CONSIDERED A HAZARDOUS SUBSTANCE ACCORDING TO OSHA 29 CFR 1910.1200.

### NFPA



### SUPPLIER

Company: Santa Cruz Biotechnology, Inc.

Address:

2145 Delaware Ave

Santa Cruz, CA 95060

Telephone: 800.457.3801 or 831.457.3800

Emergency Tel: CHEMWATCH: From within the US and Canada:

877-715-9305

Emergency Tel: From outside the US and Canada: +800 2436 2255

(1-800-CHEMCALL) or call +613 9573 3112

### PRODUCT USE

Used as a solvent in high performance liquid chromatography. Solvent for cellulose acetate, benzyl cellulose, resins, oils, waxes, oil and spirit soluble dyes. Antioxidant

### SYNONYMS

C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>, p-dioxane, p-dioxane, "diethylene dioxide", "1, 4-diethylene dioxide", "1, 4-diethylene dioxide", "diethylene ether", diokan, "1, 4-dioxacyclohexane", "1, 4-dioxacyclohexane", dioxane, dioxan, "dioxane-1, 4", "dioxethylene ether", "glycoethylene ether", tetrahydro-p-dioxan, tetrahydro-p-dioxan, "tetrahydro-1, 4-dioxin", "tetrahydro-1, 4-dioxin", para-dioxane

## Section 2 - HAZARDS IDENTIFICATION

### CANADIAN WHMIS SYMBOLS



### EMERGENCY OVERVIEW

#### RISK

May form explosive peroxides.

Limited evidence of a carcinogenic effect.

Irritating to eyes and respiratory system.  
Highly flammable.  
Repeated exposure may cause skin dryness and cracking.

## POTENTIAL HEALTH EFFECTS

### ACUTE HEALTH EFFECTS

#### SWALLOWED

- Accidental ingestion of the material may be damaging to the health of the individual.
- Ingestion of certain dioxanes has produced liver hypertrophy and enlargement (hepatomegaly). An aspiration hazard may exist.

#### EYE

• There is evidence that material may produce eye irritation in some persons and produce eye damage 24 hours or more after instillation. Severe inflammation may be expected with pain. There may be damage to the cornea. Unless treatment is prompt and adequate there may be permanent loss of vision. Conjunctivitis can occur following repeated exposure.

#### SKIN

- Repeated exposure may cause skin cracking, flaking or drying following normal handling and use.
- Skin contact with the material may damage the health of the individual; systemic effects may result following absorption.
- There is some evidence to suggest that the material may cause mild but significant inflammation of the skin either following direct contact or after a delay of some time. Repeated exposure can cause contact dermatitis which is characterized by redness, swelling and blistering.
- Absorption of some dioxanes through the skin has resulted in damage to the liver, kidney and brain.
- Open cuts, abraded or irritated skin should not be exposed to this material.
- Entry into the blood-stream, through, for example, cuts, abrasions or lesions, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

#### INHALED

- The material can cause respiratory irritation in some persons. The body's response to such irritation can cause further lung damage.
- Inhalation of vapors or aerosols (mists, fumes), generated by the material during the course of normal handling, may be damaging to the health of the individual.
- Dioxane was widely used as an epoxy resin solvent in 1950-1960's but toxicity concerns has caused replacement by less hazardous substitutes. Symptoms of sub-acute exposures include gastric distress, drowsiness, vertigo, dyspnea and tenderness in the lumbar and abdominal regions.

Dioxane is metabolically converted to beta-hydroxyethoxyacetic acid (HEAA) in man and rats. If man oxidises dioxane as rapidly as the rat, sub-lethal doses may induce severe metabolic acidosis.

Since the odour of dioxane is not irritating, atmospheric concentrations high enough to produce anaesthesia and organ damage may not provoke alarm.

Inhalation of concentrated vapours has caused anaesthesia, renal and hepatic damage and death due to acute renal failure in five humans. Pathological findings included haemorrhagic nephritis and central necrosis of the liver.

Several cases of death in humans have been documented after exposure to high concentrations of 1,4-dioxane. Five deaths that occurred within a period of 2 weeks among factory workers engaged in a process that involved primarily exposure to 1,4-dioxane vapors, although minimal dermal exposure could have not been avoided. Three of the subjects suffered from abdominal pain and vomiting before death occurred. Post-mortem examination of the subjects showed extensive gross and microscopic lesions to the liver and kidneys. Based on observations, it was suggested that the effects on the kidneys may have been responsible for the fatal outcome and that liver necrosis, although widespread, was compatible with recovery. No exposure levels were available in these case reports. An additional fatal case of a worker exposed to 1,4-dioxane for only 1 week has been described; whose post-mortem examination showed kidney and liver alterations. The room in which the patient had worked had no exhaust ventilation and the worker was not provided a respirator. The minimum concentration of 1,4-dioxane in the room was 208 ppm and the maximum was in excess of 650 ppm; the average concentration was 470 ppm. In addition, dermal exposure may have been considerable in this case.

In a group of six individuals exposed to 2,000 ppm 1,4-dioxane vapors for 3 minutes in a 10 m<sup>3</sup> chamber, there were no complaints of nasal discomfort, but one out of four subjects exposed to 1,000 ppm for 5 minutes complained of constriction of the throat; however, the exposure concentrations were not verified. Exposure of five subjects to about 278 ppm for a few minutes (unspecified) produced slight mucous membrane irritation, and 1,390 ppm caused a slight prickling in the nose, and scratchiness and dryness in the throat. Exposure to 300 ppm 1,4-dioxane for 15 minutes produced nose and throat irritation among a group of 12 volunteers. At 200 ppm, the report does not indicate the presence or absence of symptoms, but considers the exposure acceptable. A 10-minute exposure to 1,600 ppm 1,4-dioxane produced slight nose and throat irritation that persisted throughout the test in a group of five individuals. In another experiment by the same investigators, exposure of the same five persons to 5,500 ppm 1,4-dioxane for 1 minute resulted in a burning sensation to the nose and throat. Exposure of four men to 50 ppm for 6 hours reportedly caused no adverse respiratory signs or alterations in respiratory function, assessed 24 hours and 2 weeks after exposure; however, no data were provided in the study. Exposure of 12 volunteers (6 males and 6 females) to 20 ppm 1,4-dioxane for 2 hours caused no significant respiratory effects during exposure or up to 3 hours after exposure.

Short-term exposure of humans to concentrations that eventually caused death produced serious liver damage. Five lethal cases, in which postmortem examination of the patients was undertaken, revealed an enlarged liver and centrilobular necrosis of the liver cells. Swollen kidneys with hemorrhage was seen in subjects who died following exposure to unknown amounts of 1,4-dioxane in the air. These subjects showed oliguria and/or anuria and in one case there was bloody urine. Microscopic examination showed hemorrhage around the glomeruli with some necrosis. No evidence of kidney damage was found in a cross-sectional study of 74 workers exposed to concentrations of 1,4-dioxane between 0.006 and 14.3 ppm for an average length of exposure of almost 25 years.

Studies in animals, mostly early studies, provide information on lethality of relatively high concentrations of 1,4-dioxane in several species and also indicate that the kidneys and liver, and in some cases, the lungs, are the main targets of high airborne concentrations of 1,4-dioxane. Short-term exposure to 5,000 ppm 1,4-dioxane was lethal to rats, mice, and rabbits, whereas 10,000 ppm was lethal to guinea pigs). A 4-hour LC50 of 14,261 ppm was calculated for rats. An additional study in guinea pigs reported that the minimum period of exposure that caused the death of the majority of a group of six animals was 180 minutes to 30,000 ppm; no deaths occurred in groups exposed to up to 10,000 ppm for up to 480 minutes. One out of four rabbits exposed to 2,000 ppm 1,4-dioxane 3 hours/day, 5 days/week died on week 4 of exposure, and the cause of death was attributed to renal and hepatic lesions.

Data in volunteers acutely exposed to vapors of 1,4-dioxane suggest that the chemical is readily and almost completely absorbed through the lungs. Studies in animals also show that 1,4-dioxane is readily absorbed after inhalation and oral exposure, but much less 1,4-dioxane is absorbed through the skin.








In animals injected with radiolabelled 1,4-dioxane, 1,4-dioxane-derived radioactivity distributed widely throughout the body, and no organ seemed to preferentially accumulate radiolabel. In humans and animals, 1,4-dioxane is metabolized to  $\beta$ -hydroxyethoxyacetic acid (HEAA) by mixed-function oxidase enzymes; HEAA can be converted to 1,4-dioxane-2-one under acidic conditions. Both of these products are rapidly and extensively eliminated in the urine. Unchanged 1,4-dioxane can also be excreted in the urine and in exhaled air, but mainly after high-dose exposure. Studies have shown that the metabolism of 1,4-dioxane in rats is saturable at high doses. There is virtually no information regarding the toxicokinetics of 1,4-dioxane in humans following oral or dermal exposure. There is no indication that 1,4-dioxane or HEAA accumulates in the body.

### CHRONIC HEALTH EFFECTS

- There has been concern that this material can cause cancer or mutations, but there is not enough data to make an assessment. Long-term exposure to respiratory irritants may result in disease of the airways involving difficult breathing and related systemic problems. Prolonged or repeated skin contact may cause drying with cracking, irritation and possible dermatitis following.
- Limited evidence suggests that repeated or long-term occupational exposure may produce cumulative health effects involving organs or biochemical systems.
- Chronic exposure to dioxanes may produce injury to the liver, kidney and brain. Repeated or prolonged exposures may result in the formation of tumors, typically of the liver and gall-bladder.
- Cyclic ethers can cause cancers, especially of the liver.

## Section 3 - COMPOSITION / INFORMATION ON INGREDIENTS

### HAZARD RATINGS

	Min	Max	
Flammability:	3		 
Toxicity:	2		
Body Contact:	2		
Reactivity:	2		
Chronic:	2		
			Min/Nil=0 Low=1 Moderate=2 High=3 Extreme=4
NAME	CAS RN		%
1,4-dioxane	123-91-1		> 99
inhibitors			< 1

## Section 4 - FIRST AID MEASURES

### SWALLOWED

- 
- If swallowed do NOT induce vomiting.
- If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain open airway and prevent aspiration.
- Observe the patient carefully.
- Never give liquid to a person showing signs of being sleepy or with reduced awareness; i.e. becoming unconscious.
- Give water to rinse out mouth, then provide liquid slowly and as much as casualty can comfortably drink.
- Seek medical advice.

### EYE

- If this product comes in contact with the eyes:
- Wash out immediately with fresh running water.
- Ensure complete irrigation of the eye by keeping eyelids apart and away from eye and moving the eyelids by occasionally lifting the upper and lower lids.
- If pain persists or recurs seek medical attention.
- Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

### SKIN

- If skin contact occurs:
- Immediately remove all contaminated clothing, including footwear
- Flush skin and hair with running water (and soap if available).
- Seek medical attention in event of irritation.

### INHALED

- 
- If fumes or combustion products are inhaled remove from contaminated area.
- Lay patient down. Keep warm and rested.
- Prostheses such as false teeth, which may block airway, should be removed, where possible, prior to initiating first aid procedures.
- Apply artificial respiration if not breathing, preferably with a demand valve resuscitator, bag-valve mask device, or pocket mask as trained. Perform CPR if necessary.
- Transport to hospital, or doctor, without delay.

## NOTES TO PHYSICIAN

- Treat symptomatically.  
Correct acidosis in the usual manner.

## Section 5 - FIRE FIGHTING MEASURES

Vapor Pressure (mmHg):	26.927 @ 20C
Upper Explosive Limit (%):	22.0
Specific Gravity (water=1):	1.03 @ 20C/4C
Lower Explosive Limit (%):	2.0

### EXTINGUISHING MEDIA

- 
- Water spray or fog.
- Alcohol stable foam.
- Dry chemical powder.
- Carbon dioxide.

### FIRE FIGHTING

- 
- Alert Emergency Responders and tell them location and nature of hazard.
- May be violently or explosively reactive.
- Wear breathing apparatus plus protective gloves.
- Prevent, by any means available, spillage from entering drains or water course.
- Consider evacuation (or protect in place).
- Fight fire from a safe distance, with adequate cover.
- If safe, switch off electrical equipment until vapor fire hazard removed.
- Use water delivered as a fine spray to control the fire and cool adjacent area.
- Avoid spraying water onto liquid pools.
- DO NOT approach containers suspected to be hot.
- Cool fire exposed containers with water spray from a protective location.
- If safe to do so, remove containers from path of fire.

### GENERAL FIRE HAZARDS/HAZARDOUS COMBUSTIBLE PRODUCTS

- 
- Liquid and vapor are highly flammable.
- Severe fire hazard when exposed to heat, flame and/or oxidizers.
- Vapor may travel a considerable distance to source of ignition.
- Heating may cause expansion or decomposition leading to violent rupture of containers.
- On combustion, may emit toxic fumes of carbon monoxide (CO).

Combustion products include: carbon dioxide (CO<sub>2</sub>), other pyrolysis products typical of burning organic material.

WARNING: Long standing in contact with air and light may result in the formation of potentially explosive peroxides.

### FIRE INCOMPATIBILITY

- Avoid contamination with oxidizing agents i.e. nitrates, oxidizing acids, chlorine bleaches, pool chlorine etc. as ignition may result.

### PERSONAL PROTECTION

Glasses:

Chemical goggles.

Gloves:

1. PE/EVAL/PE 2. PVA 3. TEFLON

Respirator:

Type A Filter of sufficient capacity

## Section 6 - ACCIDENTAL RELEASE MEASURES

### MINOR SPILLS

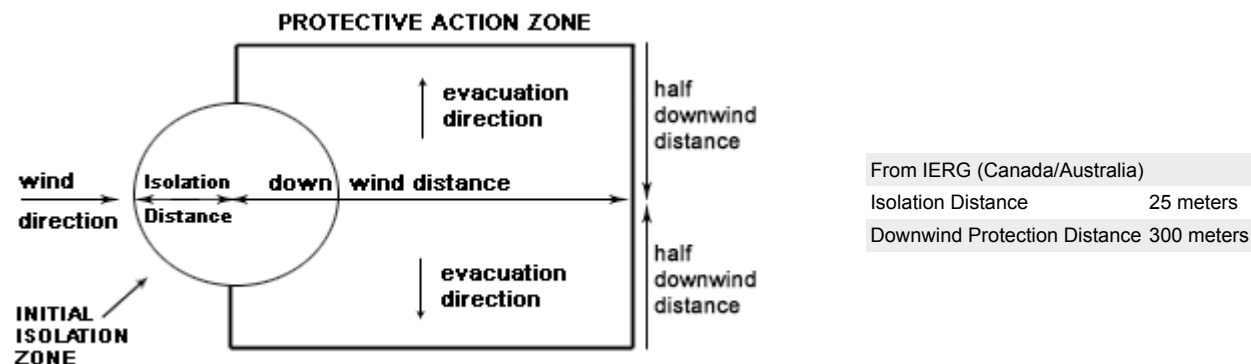
- 
- Remove all ignition sources.
- Clean up all spills immediately.
- Avoid breathing vapors and contact with skin and eyes.
- Control personal contact by using protective equipment.
- Contain and absorb small quantities with vermiculite or other absorbent material.
- Wipe up.
- Collect residues in a flammable waste container.

### MAJOR SPILLS

- 
- Clear area of personnel and move upwind.

- Alert Emergency Responders and tell them location and nature of hazard.
- May be violently or explosively reactive.
- Wear breathing apparatus plus protective gloves.
- Prevent, by any means available, spillage from entering drains or water course.
- Consider evacuation (or protect in place).
- No smoking, naked lights or ignition sources.
- Increase ventilation.
- Stop leak if safe to do so.
- Water spray or fog may be used to disperse / absorb vapor.
- Contain spill with sand, earth or vermiculite.
- Use only spark-free shovels and explosion proof equipment.
- Collect recoverable product into labeled containers for recycling.
- Absorb remaining product with sand, earth or vermiculite.
- Collect solid residues and seal in labeled drums for disposal.
- Wash area and prevent runoff into drains.
- If contamination of drains or waterways occurs, advise emergency services.

## PROTECTIVE ACTIONS FOR SPILL



## FOOTNOTES

- 1 PROTECTIVE ACTION ZONE is defined as the area in which people are at risk of harmful exposure. This zone assumes that random changes in wind direction confines the vapour plume to an area within 30 degrees on either side of the predominant wind direction, resulting in a crosswind protective action distance equal to the downwind protective action distance.
- 2 PROTECTIVE ACTIONS should be initiated to the extent possible, beginning with those closest to the spill and working away from the site in the downwind direction. Within the protective action zone a level of vapour concentration may exist resulting in nearly all unprotected persons becoming incapacitated and unable to take protective action and/or incurring serious or irreversible health effects.
- 3 INITIAL ISOLATION ZONE is determined as an area, including upwind of the incident, within which a high probability of localised wind reversal may expose nearly all persons without appropriate protection to life-threatening concentrations of the material.
- 4 SMALL SPILLS involve a leaking package of 200 litres (55 US gallons) or less, such as a drum (jerrican or box with inner containers). Larger packages leaking less than 200 litres and compressed gas leaking from a small cylinder are also considered "small spills". LARGE SPILLS involve many small leaking packages or a leaking package of greater than 200 litres, such as a cargo tank, portable tank or a "one-tonne" compressed gas cylinder.
- 5 Guide 127 is taken from the US DOT emergency response guide book.
- 6 IERG information is derived from CANUTEC - Transport Canada.

## ACUTE EXPOSURE GUIDELINE LEVELS (AEGL) (in ppm)

- AEGL 1: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
- AEGL 2: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- AEGL 3: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

## Section 7 - HANDLING AND STORAGE

### PROCEDURE FOR HANDLING

- Containers, even those that have been emptied, may contain explosive vapors.
- Do NOT cut, drill, grind, weld or perform similar operations on or near containers.
- DO NOT allow clothing wet with material to stay in contact with skin

The substance accumulates peroxides which may become hazardous only if it evaporates or is distilled or otherwise treated to concentrate the peroxides. The substance may concentrate around the container opening for example.

Purchases of peroxidizable chemicals should be restricted to ensure that the chemical is used completely before it can become peroxidized.

- A responsible person should maintain an inventory of peroxidizable chemicals or annotate the general chemical inventory to indicate which chemicals are subject to peroxidation. An expiration date should be determined. The chemical should either be treated to remove peroxides or disposed of before this date.
- The person or laboratory receiving the chemical should record a receipt date on the bottle. The individual opening the container should add an opening date.
- Unopened containers received from the supplier should be safe to store for 18 months.
- Opened containers should not be stored for more than 12 months.
- Avoid all personal contact, including inhalation.
- Wear protective clothing when risk of exposure occurs.
- Use in a well-ventilated area.
- Prevent concentration in hollows and sumps.
- DO NOT enter confined spaces until atmosphere has been checked.
- Avoid smoking, naked lights, heat or ignition sources.
- When handling, DO NOT eat, drink or smoke.
- Vapor may ignite on pumping or pouring due to static electricity.
- DO NOT use plastic buckets.
- Earth and secure metal containers when dispensing or pouring product.
- Use spark-free tools when handling.
- Avoid contact with incompatible materials.
- Keep containers securely sealed.
- Avoid physical damage to containers.
- Always wash hands with soap and water after handling.
- Work clothes should be laundered separately.
- Use good occupational work practice.
- Observe manufacturer's storing and handling recommendations.
- Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions.

#### RECOMMENDED STORAGE METHODS

• Packing as supplied by manufacturer. Plastic containers may only be used if approved for flammable liquid. Check that containers are clearly labeled and free from leaks.

- For low viscosity materials (i): Drums and jerricans must be of the non-removable head type. (ii): Where a can is to be used as an inner package, the can must have a screwed enclosure.
- For materials with a viscosity of at least 2680 cSt. (23 deg. C)
- For manufactured product having a viscosity of at least 250 cSt. (23 deg. C)
- Manufactured product that requires stirring before use and having a viscosity of at least 20 cSt (23 deg. C) - (i): Removable head packaging; (ii): Cans with friction closures and (iii): low pressure tubes and cartridges may be used.
- Where combination packages are used, and the inner packages are of glass, there must be sufficient inert cushioning material in contact with inner and outer packages
- In addition, where inner packagings are glass and contain liquids of packing group I there must be sufficient inert absorbent to absorb any spillage, unless the outer packaging is a close fitting molded plastic box and the substances are not incompatible with the plastic.

#### STORAGE REQUIREMENTS

• Easily peroxidizable. Products formed as a result of peroxidation are not only safety hazards but may chemically alter the chemical behavior of the parent compound. Should have a warning label affixed bearing the date of receipt in the laboratory and the date on which the label was first opened. Store-room items should have the label affixed by the Store-room whilst for non-storeroom items or materials synthesized in the laboratory, an individual chemist should be responsible for warning labels.

WARNING: This product may form peroxides to a hazardous level by concentration (by distillation, evaporation, etc.) Should be evaluated every twelve months after opening, redated if safe or else discarded. The oxidation of iodide to iodine or the conversion of colorless ferriothiocyanate to red ferrithiocyanate by peroxides are simple and convenient tests for most peroxides. Before distilling or evaporating test for peroxides. Leave at least 10% bottoms. Use a shield when evaporating or distilling mixtures which may contain peroxidizable compounds. Store away from heat and light. Particular attention should be paid to the adequacy of the closure on storage containers.

Peroxides may be removed by;

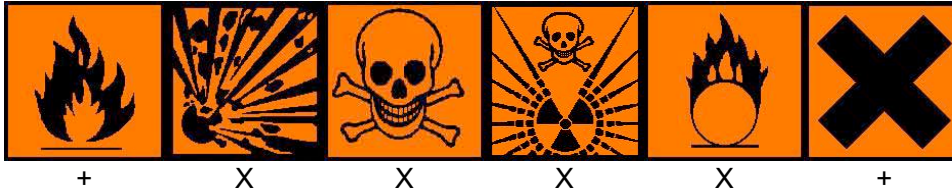
- passing the material over a column of ordinary activated alumina (care should be taken in disposal of the activated alumina);
- shaking with a concentrated solution of ferrous salt (provided the carrier solvent is water-insoluble);
- agitation with an approximately equimolar mixture of ferrous sulfate and sodium bisulfate;
- commercial quantities may be treated with a 5% solution of aqueous sodium carbonate.

Jackson et al: Control of Peroxidizable Compounds; Safety in the Chemical Laboratory, Journal of Chemical Education; Vol 47, 1970, pp A175-A188

When solvents have been freed from peroxides by percolation through a column of activated alumina, the adsorbed peroxides must promptly be desorbed by treatment with polar solvents, methanol or water, which must in turn be discarded safely.

- Material is hygroscopic, i.e. absorbs moisture from the air. Keep containers well sealed in storage.
- Store in original containers in approved flame-proof area.
- No smoking, naked lights, heat or ignition sources.
- DO NOT store in pits, depressions, basements or areas where vapors may be trapped.
- Keep containers securely sealed.
- Store away from incompatible materials in a cool, dry well ventilated area.
- Protect containers against physical damage and check regularly for leaks.
- Observe manufacturer's storing and handling recommendations.

## SAFE STORAGE WITH OTHER CLASSIFIED CHEMICALS



X: Must not be stored together

O: May be stored together with specific preventions

+: May be stored together

## Section 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION

### EXPOSURE CONTROLS

Source	Material	TWA ppm	TWA mg/m <sup>3</sup>	STEL ppm	STEL mg/m <sup>3</sup>	Peak ppm	Peak mg/m <sup>3</sup>	TWA F/CC	Notes
US ATSDR Minimal Risk Levels for Hazardous Substances (MRLs)	1,4-dioxane (1,4-DIOXANE)	1							
US ATSDR Minimal Risk Levels for Hazardous Substances (MRLs)	1,4-dioxane (1,4-DIOXANE)	1							
Canada - Ontario Occupational Exposure Limits	1,4-dioxane (1,4-Dioxane)	20							Skin
US - Minnesota Permissible Exposure Limits (PELs)	1,4-dioxane (Dioxane (Diethylene dioxide))	25	90						
US ATSDR Minimal Risk Levels for Hazardous Substances (MRLs)	1,4-dioxane (1,4-DIOXANE)	2							
US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants	1,4-dioxane (Dioxane (Diethylene dioxide))	25	90						
US - Vermont Permissible Exposure Limits Table Z-1-A Transitional Limits for Air Contaminants	1,4-dioxane (Dioxane (Diethylene dioxide))	100	360						
US - Vermont Permissible Exposure Limits Table Z-1-A Final Rule Limits for Air Contaminants	1,4-dioxane (Dioxane (Diethylene dioxide))	25	90						
US - Idaho - Limits for Air Contaminants	1,4-dioxane (Dioxane (Diethylene dioxide))	100	360						
US - California Permissible Exposure Limits for Chemical Contaminants	1,4-dioxane (p-Dioxane, tech. grade; 1,4-dioxacyclohexane; 1,4-diethylene dioxide)	25	90						
US - Hawaii Air Contaminant Limits	1,4-dioxane (Dioxane (Diethylene dioxide))	25	90						
US - Michigan Exposure Limits for Air Contaminants	1,4-dioxane (Dioxane (Diethylene dioxide))	25	90						
US - Oregon Permissible Exposure Limits (Z1)	1,4-dioxane (Dioxane (Diethylene dioxide))	100	360						
Canada - Yukon Permissible Concentrations for Airborne Contaminant Substances	1,4-dioxane (Dioxane, tech. grade - Skin)	50	180	50	180				
US - Washington Permissible exposure limits of air contaminants	1,4-dioxane (Dioxane (Diethylene dioxide))	25		38					
Canada - Saskatchewan Occupational Health and Safety Regulations - Contamination Limits	1,4-dioxane (1,4-Dioxane)	20		30					Skin, T20

Canada - Nova Scotia Occupational Exposure Limits	1,4-dioxane (1,4-Dioxane)	20					TLV Basis: liver damage
US NIOSH Recommended Exposure Limits (RELs)	1,4-dioxane (Dioxane)		1	3.6			
Canada - Alberta Occupational Exposure Limits	1,4-dioxane (Diethylene dioxide (1,4-Dioxane))	20	72				
Canada - British Columbia Occupational Exposure Limits	1,4-dioxane (1,4-Dioxane)	20					Skin; 2B
US ACGIH Threshold Limit Values (TLV)	1,4-dioxane (1,4-Dioxane)	20					TLV Basis: liver damage
Canada - Prince Edward Island Occupational Exposure Limits	1,4-dioxane (1,4-Dioxane)	20					TLV Basis: liver damage
US - Wyoming Toxic and Hazardous Substances Table Z1 Limits for Air Contaminants	1,4-dioxane (Dioxane (Diethylene dioxide))	100	360				
US OSHA Permissible Exposure Levels (PELs) - Table Z1	1,4-dioxane (Dioxane (Diethylene dioxide))	100	360				
Canada - Quebec Permissible Exposure Values for Airborne Contaminants (English)	1,4-dioxane (Dioxane)	20	72				
Canada - Northwest Territories Occupational Exposure Limits (English)	1,4-dioxane (Dioxane - Tech. grade - Skin)	25	90	100	360		
US - Alaska Limits for Air Contaminants	1,4-dioxane (Dioxane (Diethylene dioxide))	25	90				

#### EMERGENCY EXPOSURE LIMITS

Material	Revised IDLH Value (mg/m3)	Revised IDLH Value (ppm)
1,4-dioxane		500

#### MATERIAL DATA

##### 1,4-DIOXANE:

- For 1,4-dioxane:

NIOSH Ceiling for dioxane: 1 ppm (30 minutes) - Potential Occupational Carcinogen

Odour Threshold Value: 0.80-172 ppm (detection), 1.8-278 ppm (recognition)

Because findings of both liver and lung tumours occur at high dietary levels of dioxane (approximately 10000 ppm) and are not seen at inhalation exposures slightly above 100 ppm for 2 years, dioxane is classed by ACGIH as an animal carcinogen of such low potential as to be of little significance as an occupational carcinogen at the recommended TLV-TWA. This is not the view of NIOSH who recommends a 1 ppm ceiling with the belief that the derivation of a safe exposure limit is not now available. The TLV-TWA has been derived from data on the hepatotoxic and nephrotoxic effects in workers and has been set the value to one-tenth of that which is required to produce a significant increase in the occurrence of cancer in animal experiments. Even though it appears that controls can be initiated in plants manufacturing dioxane to reflect the limits set by NIOSH industrial experience indicates that such controls may not be practicable where the solvent is in use.

Odour Safety Factor (OSF)

OSF=0.83 ("1,4-DIOXANE").

#### PERSONAL PROTECTION



Consult your EHS staff for recommendations

#### EYE

- Safety glasses with side shields.
- Chemical goggles.
- Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. DO NOT wear contact lenses.

#### HANDS/FEET

- Wear chemical protective gloves, eg. PVC.



Wear safety footwear or safety gumboots, eg. Rubber.

Suitability and durability of glove type is dependent on usage. Important factors in the selection of gloves include: such as:

- frequency and duration of contact,
- chemical resistance of glove material,
- glove thickness and
- dexterity

Select gloves tested to a relevant standard (e.g. Europe EN 374, US F739).

- When prolonged or frequently repeated contact may occur, a glove with a protection class of 5 or higher (breakthrough time greater than 240 minutes according to EN 374) is recommended.
- When only brief contact is expected, a glove with a protection class of 3 or higher (breakthrough time greater than 60 minutes according to EN 374) is recommended.
- Contaminated gloves should be replaced.

Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturiser is recommended.

- Aprotic solvents may greatly promote the toxic properties of solutes because of their unique ability to penetrate synthetic rubber protective gloves and the skin (butyl rubber gloves are reported to be more satisfactory than others

## OTHER

- 
- Overalls.
- PVC Apron.
- PVC protective suit may be required if exposure severe.
- Eyewash unit.
- Ensure there is ready access to a safety shower.
- Some plastic personal protective equipment (PPE) (e.g. gloves, aprons, overshoes) are not recommended as they may produce static electricity.
- For large scale or continuous use wear tight-weave non-static clothing (no metallic fasteners, cuffs or pockets), non sparking safety footwear.

## GLOVE SELECTION INDEX

• Glove selection is based on a modified presentation of the:

"Forsberg Clothing Performance Index".

The effect(s) of the following substance(s) are taken into account in the computer-generated selection: 1,4-dioxane

• Protective Material CPI \*

PE/EVAL/PE	A
PVA	A
TEFLON	A
BUTYL	B
SARANEX-23	C
NATURAL RUBBER	C
NATURAL+NEOPRENE	C
NITRILE	C
NEOPRENE	C
VITON	C
VITON/NEOPRENE	C
PVC	C

• \* CPI - Chemwatch Performance Index

A: Best Selection

B: Satisfactory; may degrade after 4 hours continuous immersion

C: Poor to Dangerous Choice for other than short term immersion

NOTE: As a series of factors will influence the actual performance of the glove, a final selection must be based on detailed observation. -

\* Where the glove is to be used on a short term, casual or infrequent basis, factors such as "feel" or convenience (e.g. disposability), may dictate a choice of gloves which might otherwise be unsuitable following long-term or frequent use. A qualified practitioner should be consulted.

## RESPIRATOR

• Selection of the Class and Type of respirator will depend upon the level of breathing zone contaminant and the chemical nature of the contaminant. Protection Factors (defined as the ratio of contaminant outside and inside the mask) may also be important.

Breathing Zone Level ppm (volume)	Maximum Protection Factor	Half-face Respirator	Full-Face Respirator
1000	10	A-1	-
1000	50	-	A-1
5000	50	Airline*	-
5000	100	-	A-2

10000	100	-	A-3
	100+		Airline* *

\* - Continuous Flow \*\* - Continuous-flow or positive pressure demand.

The local concentration of material, quantity and conditions of use determine the type of personal protective equipment required.

Use appropriate NIOSH-certified respirator based on informed professional judgement. In conditions where no reasonable estimate of exposure can be made, assume the exposure is in a concentration IDLH and use NIOSH-certified full face pressure demand SCBA with a minimum service life of 30 minutes, or a combination full facepiece pressure demand SAR with auxiliary self-contained air supply. Respirators provided only for escape from IDLH atmospheres shall be NIOSH-certified for escape from the atmosphere in which they will be used.

### ENGINEERING CONTROLS

• For flammable liquids and flammable gases, local exhaust ventilation or a process enclosure ventilation system may be required. Ventilation equipment should be explosion-resistant. Air contaminants generated in the workplace possess varying "escape" velocities which, in turn, determine the "capture velocities" of fresh circulating air required to effectively remove the contaminant.

Type of Contaminant:	Air Speed:
solvent, vapors, degreasing etc., evaporating from tank (in still air).	0.25-0.5 m/s (50-100 f/min.)
aerosols, fumes from pouring operations, intermittent container filling, low speed conveyer transfers, welding, spray drift, plating acid fumes, pickling (released at low velocity into zone of active generation)	0.5-1 m/s (100-200 f/min.)
direct spray, spray painting in shallow booths, drum filling, conveyer loading, crusher dusts, gas discharge (active generation into zone of rapid air motion)	1-2.5 m/s (200-500 f/min.)

Within each range the appropriate value depends on:

Lower end of the range	Upper end of the range
1: Room air currents minimal or favorable to capture	1: Disturbing room air currents
2: Contaminants of low toxicity or of nuisance value only.	2: Contaminants of high toxicity
3: Intermittent, low production.	3: High production, heavy use
4: Large hood or large air mass in motion	4: Small hood-local control only

Simple theory shows that air velocity falls rapidly with distance away from the opening of a simple extraction pipe. Velocity generally decreases with the square of distance from the extraction point (in simple cases). Therefore the air speed at the extraction point should be adjusted, accordingly, after reference to distance from the contaminating source. The air velocity at the extraction fan, for example, should be a minimum of 1-2 m/s (200-400 f/min.) for extraction of solvents generated in a tank 2 meters distant from the extraction point. Other mechanical considerations, producing performance deficits within the extraction apparatus, make it essential that theoretical air velocities are multiplied by factors of 10 or more when extraction systems are installed or used.

## Section 9 - PHYSICAL AND CHEMICAL PROPERTIES

### PHYSICAL PROPERTIES

Liquid.

Mixes with water.

State	Liquid	Molecular Weight	88.12
Melting Range (°F)	53.24	Viscosity	Not Available
Boiling Range (°F)	214.34	Solubility in water (g/L)	Miscible
Flash Point (°F)	53.96 (TCC)	pH (1% solution)	Not available
Decomposition Temp (°F)	Not Available	pH (as supplied)	Not applicable
Autoignition Temp (°F)	356	Vapor Pressure (mmHg)	26.927 @ 20C
Upper Explosive Limit (%)	22.0	Specific Gravity (water=1)	1.03 @ 20C/4C
Lower Explosive Limit (%)	2.0	Relative Vapor Density (air=1)	3
Volatile Component (%vol)	100	Evaporation Rate	Not available
Gas group	IIB		

### APPEARANCE

• Material is hygroscopic, absorbs moisture from surrounding air. Clear colourless, highly flammable liquid; soluble in water. Faint ethereal odour. Unstabilised material may form explosive peroxides in the presence of air.

## Section 10 - CHEMICAL STABILITY

### CONDITIONS CONTRIBUTING TO INSTABILITY

- 
- Presence of incompatible materials.
- Product is considered stable.

- Hazardous polymerization will not occur.

## STORAGE INCOMPATIBILITY

• Dioxane:

- can form unstable peroxides when exposed to air, moisture; peroxides can be detonated by heat, friction, impact
- reacts explosively with hydrogen and hot Raney nickel
- reacts violently with silver perchlorate, sulfur trioxide, strong oxidisers, strong acids, nitromethane, boron trifluoride, decaborane
- is incompatible with aliphatic amines, amides, caustics, isocyanates, triethynylaluminium
- flow or agitation may generate electrostatic charges due to low conductivity
- attacks many plastics
- The unhindered oxygen atom found on cyclic ethers such as the epoxides, oxetanes, furans, dioxanes and pyrans, carries two unshared pairs of electrons - a structure which favors the formation of coordination complexes and the solvation of cations.
- Cyclic ethers are used as important solvents, as chemical intermediate and as monomers for ring-opening polymerization.
- They are unstable at room temperature due to possibility of peroxide formation; stabiliser is sometimes needed for storage and transportation.

NOTE: Ethers lacking non-methyl hydrogen atoms adjacent to the ether link are thought to be relatively safe.

Avoid reaction with oxidizing agents.

- Many aprotic (non-hydroxylic) solvents are not inert towards other reagents and care must be taken when using untried combinations of solvents and reagents for the first time.
- Some aprotic solvents have a dramatic effect on reaction rates

For incompatible materials - refer to Section 7 - Handling and Storage.

## Section 11 - TOXICOLOGICAL INFORMATION

1,4-dioxane

### TOXICITY AND IRRITATION

• unless otherwise specified data extracted from RTECS - Register of Toxic Effects of Chemical Substances.

TOXICITY	IRRITATION
Oral (rat) LD50: 4200 mg/kg	Skin(rabbit): 515 mg (open)-Mild
Inhalation (human) TCLo: 470 ppm.	Eye(human): 300 ppm/15m
Inhalation (human) LCLo: 470 ppm/3 d	Eye(rabbit): 21 mg (int)-Irritant
Dermal (rabbit) LD50: 7600 mg/kg	

• Asthma-like symptoms may continue for months or even years after exposure to the material ceases. This may be due to a non-allergenic condition known as reactive airways dysfunction syndrome (RADS) which can occur following exposure to high levels of highly irritating compound. Key criteria for the diagnosis of RADS include the absence of preceding respiratory disease, in a non-atopic individual, with abrupt onset of persistent asthma-like symptoms within minutes to hours of a documented exposure to the irritant. A reversible airflow pattern, on spirometry, with the presence of moderate to severe bronchial hyperreactivity on methacholine challenge testing and the lack of minimal lymphocytic inflammation, without eosinophilia, have also been included in the criteria for diagnosis of RADS. RADS (or asthma) following an irritating inhalation is an infrequent disorder with rates related to the concentration of and duration of exposure to the irritating substance. Industrial bronchitis, on the other hand, is a disorder that occurs as result of exposure due to high concentrations of irritating substance (often particulate in nature) and is completely reversible after exposure ceases. The disorder is characterised by dyspnea, cough and mucus production.

#### For 1,4-dioxane:

Acute toxic effects reported in animals are mainly CNS depression, kidney and liver damage. Overt CNS effects (including convulsions) have been reported in rabbits administered (i.v.) 5 ml (2060 mg/kg) of 1,4-dioxane in solution. Subtle effects on CNS function, as assessed by perturbations of certain neurotransmitters in male rats (Sprague-Dawley) have been reported following an oral dose of 1050 mg/kg 1,4-dioxane. A study of the effects of 1,4-dioxane on electrically evoked seizure discharge, considered to be a sensitive indicator of neurotropic effects, revealed that a 30% depression in response following

inhalation of 1860 ppm (4 hr) in rats and 2400 ppm (2 hr) in mice

Slight dermal erythema and severe scale formation were reported in rabbits up to 8 days after dermal application of 1,4-dioxane (dose not reported). Mild irritation was also observed in rabbit skin following an application of 515 mg 1,4-dioxane in an open Draize Test. However, skin irritation was not seen in rats exposed (unoccluded) to 8,300 mg/kg 1,4-dioxane. Evidence of skin irritation was not seen in guinea pigs, rabbits or mice following repeated (studies ranging from 50-100 days) dermal exposure to 1,4-dioxane (above 50 mg) applied two or three times per day

1,4-Dioxane has been reported to have a miotic effect in rabbits at concentrations below that causing alterations in the conjunctiva or cornea, with pupils returning to normal 10 to 15 minutes after administration. Liquid 1,4-dioxane has been reported to cause eye irritation in rabbits. Irritation of the nose and lung has been reported following inhalation of 1,4-dioxane (>2000 ppm) in guinea pigs, mice and cats

An inhalation study has been carried out in human volunteers exposed to 50 ppm (180 mg/m<sup>3</sup>) 1,4-dioxane for 6 hr. In this study absorption of 1,4-dioxane was estimated at around 80% of dose. The maximum uptake (10.9 mg/kg) was around 50% of that measured in rats following similar exposure. Because of its rapid biotransformation to b-hydroxyethoxyacetic acid (HEAA), the body burden of 1,4-dioxane was estimated to be no more than 1.2 mg/kg at steady state.

No data were available for dermal uptake for 1,4-dioxane in humans (in vivo), although skin absorption was considered a potential route of exposure in case reports of human fatalities from short term exposures.

Significant differences exist for dermal penetration (in diffusion cell studies on human skin) of 1,4-dioxane under occluded and non-occluded conditions. Up to 3.2% of applied 1,4-dioxane (dissolved in lotion) was absorbed under occlusion for 3.5 hr, whereas only 0.3% absorption occurred under non-occluded conditions. Differences in the amount of absorption were accounted for by the high volatility of 1,4-dioxane. A permeability constant (Kp) of 2.7 x 10<sup>-4</sup> cm/hr was determined for the occluded test system which is similar to that calculated for undiluted 1,4-dioxane. The absorption rate for 1,4-dioxane (under occlusion) was calculated to be approximately 0.3 mg/cm<sup>2</sup>/hr which compares with

other solvents reported as being readily absorbed in in vitro skin (human) tests.

From the solubility characteristics alone, it is predicted that 'considerable uptake' by the skin could be expected for 1,4-dioxane, but that oxidation and evaporation from the skin surface would limit the total amount absorbed. Almost 90% (as a percentage of applied dose) evaporation of 1,4-dioxane in a lotion was demonstrated within 15 minutes of application (to a non-absorbent test material), with the remainder evaporating over the next 24 hr.

Sub-acute and sub-chronic studies for 1,4-dioxane have been carried out in rats, mice, guinea pigs, rabbits, dogs and cats. Effects reported include narcosis, behavioural changes, haematological effects, cardiac effects and histopathological lesions of the kidneys, liver and brain. In general, the doses used in these studies are very high and as such provide little useful information on critical effects (i.e., most sensitive effects) and no observed adverse effect levels (NOAELs).

#### Metabolism and elimination

The major metabolite of 1,4-dioxane in humans is beta-hydroxyethanoxyacetic acid (HEAA). Four volunteers were exposed to 50 ppm 1,4-dioxane for 6 hr. A steady state plasma level of 10 ug/ml 1,4-dioxane was reached after 3 hr inhalation exposure, with a steady state plasma

concentration of 8 mg/ml HEAA reached 1 hr after cessation of exposure (i.e., after 7 hr). The plasma half-lives for 1,4-dioxane and HEAA were around 1 and 2.5 hr respectively. HEAA accounted for around 99% of recovered 1,4-dioxane in urine. Clearance of 1,4-dioxane from kidneys was around 400 times slower than HEAA.

1,4-Dioxane may inhibit the oxidative metabolism of other substances as it has been shown to inhibit human CYP2A6 activity in liver microsomes in vitro.

The material may cause skin irritation after prolonged or repeated exposure and may produce on contact skin redness, swelling, the production of vesicles, scaling and thickening of the skin.

WARNING: This substance has been classified by the IARC as Group 2B: Possibly Carcinogenic to Humans.

Brain degenerative changes, kidney tubule changes, urine volume changes, lymphoma including Hodgkin's disease recorded.

### CARCINOGEN

1,4-Dioxane	International Agency for Research on Cancer (IARC) - Agents Reviewed by the IARC Monographs	Group	2B
1,4-Dioxane	ND	Carcinogenicity	B2
1,4-Dioxane	ND	Carcinogen Category	B2
1,4-Dioxane	ND	Carcinogen Category	A3
1,4-DIOXANE	US Environmental Defense Scorecard Recognized Carcinogens	Reference(s)	P65
1,4-DIOXANE	US Environmental Defense Scorecard Suspected Carcinogens	Reference(s)	P65
1,4-Dioxane	US Air Toxics Hot Spots TSD for Describing Available Cancer Potency Factors	IARC Class	2B

### SKIN

1,4-dioxane	ND	Notes	Skin
1,4-dioxane	US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants - Skin	Skin Designation	X
1,4-dioxane	US - Vermont Permissible Exposure Limits Table Z-1-A Transitional Limits for Air Contaminants - Skin	Skin Designation	X
1,4-dioxane	US - Vermont Permissible Exposure Limits Table Z-1-A Final Rule Limits for Air Contaminants - Skin	Skin Designation	X
1,4-dioxane	US - Washington Permissible exposure limits of air contaminants - Skin	Skin	X
1,4-dioxane	ND	Skin Designation	Yes
1,4-dioxane	ND	Notation	Skin; 2B
1,4-dioxane	US - Minnesota Permissible Exposure Limits (PELs) - Skin	Skin Designation	X
1,4-dioxane	US - Hawaii Air Contaminant Limits - Skin Designation	Skin Designation	X
1,4-dioxane	ND	Skin Designation	X
1,4-dioxane	US OSHA Permissible Exposure Levels (PELs) - Skin	Skin Designation	X
1,4-dioxane	US - California Permissible Exposure Limits for Chemical Contaminants - Skin	Skin	X
1,4-dioxane	US - California Permissible Exposure Limits for Chemical Contaminants - Skin	Skin	S
1,4-dioxane	Canada - Alberta Occupational Exposure Limits - Skin	Substance Interaction	1

## Section 12 - ECOLOGICAL INFORMATION

Refer to data for ingredients, which follows:

1,4-DIOXANE:

• Hazardous Air Pollutant:	Yes
• Fish LC50 (96hr.) (mg/l):	1000- 6700

• Algae IC50 (72hr.) (mg/l):	575
• log Kow (Prager 1995):	- 0.27
• log Kow (Sangster 1997):	- 0.27
• log Pow (Verschueren 1983):	- 0.42
• Half- life Soil - High (hours):	4320
• Half- life Soil - Low (hours):	672
• Half- life Air - High (hours):	81
• Half- life Air - Low (hours):	8.1
• Half- life Surface water - High (hours):	4320
• Half- life Surface water - Low (hours):	672
• Half- life Ground water - High (hours):	8640
• Half- life Ground water - Low (hours):	1344
• Aqueous biodegradation - Aerobic - High (hours):	4320
• Aqueous biodegradation - Aerobic - Low (hours):	672
• Aqueous biodegradation - Anaerobic - High (hours):	17280
• Aqueous biodegradation - Anaerobic - Low (hours):	2688
• Photooxidation half- life water - High (hours):	8.00E+04
• Photooxidation half- life water - Low (hours):	1608
• Photooxidation half- life air - High (hours):	81
• Photooxidation half- life air - Low (hours):	8.1

• For 1,4-dioxane:

log Kow : -0.27- -0.42

Koc : 1.23

Half-life (hr) air : 6.69-9.6

Henry's atm m3 /mol: 4.88E-06

BOD 5 : 10 nil

Environmental fate:

There are no data needs regarding the environmental fate of 1,4-dioxane. 1,4-Dioxane is miscible in water and partitions primarily to the aqueous media in the environment. 1,4-Dioxane has high mobility in soil and has the potential to migrate into groundwater. In air, 1,4-dioxane will degrade by reaction with OH radicals with a half-life of <1 day. 1,4-Dioxane has been found to be resistant to biodegradation in the environment, 1,4-Dioxane is expected to persist in both water and soil. Because 1,4-dioxane is miscible in water, it is not bioconcentrated in plants, aquatic organisms, or animals. However, bioaccumulation in plants may occur by transpiration. 1,4-Dioxane is not biomagnified to any extent in prey organisms.

1,4-Dioxane is expected to volatilise at a moderate rate from water and soil surfaces. In air, it is subject to photooxidation with an estimated half-life of 1-3 days. 1,4-Dioxane is relatively resistant to biodegradation in water and soils. It binds weakly to soils and will therefore move readily into groundwater. Bioconcentration, bioaccumulation, and biomagnification are not significant for 1,4-dioxane.

Transport and Partitioning: The Henry's law constant for 1,4-dioxane is  $4.8 \times 10^{-6}$  atm m<sup>3</sup>/mole which indicates that 1,4-dioxane is expected to volatilize from water surfaces. Based on this Henry's law constant, the volatilisation half-life from a model river (1 m deep, flowing 1 m/second, wind velocity of 3 m/second) is estimated as 7 days. The volatilisation half-life from a model lake (1 m deep, flowing 0.05 m/second, wind velocity of 0.5 m/sec) is estimated as 56 days. The Henry's law constant for 1,4-dioxane also indicates that volatilisation from moist soil surfaces may occur. The potential for volatilisation of 1,4-dioxane from dry soil surfaces may exist based upon a vapor pressure of 38.1 mm Hg. According to a classification scheme, an estimated Koc value of 17 suggests that 1,4-dioxane is expected to have very high mobility in soil. This estimated Koc value was calculated using a log Kow of -0.27 and a regression-derived equation. In the absence of significant degradation processes for 1,4-dioxane, 1,4-dioxane is susceptible to leaching from soil into groundwater. In clay soils, 1,4-dioxane will not be adsorbed because of any specific interaction with the surface of clay minerals. However, 1,4-dioxane can get trapped in the interfacial region of clay soils due to its strong interaction with water molecules. This may result in a lower than expected mobility for 1,4-dioxane in clay soils. Groundwater retardation factors (Rt) for 1,4-dioxane range from 1.0 to 1.6. These values indicate that 1,4-dioxane is expected to be a mobile compound (e.g., Rf for chloride=1.0, which is indicative of no retardation) in groundwater experimental bioconcentration study also reported very low BCF values (e.g., 0.2–0.7) for 1,4-dioxane (EC 2002). Therefore, bioconcentration, bioaccumulation, and biomagnification are unlikely to be significant for 1,4-dioxane.

Transformation and Degradation

Air: The primary loss mechanism for 1,4-dioxane in the atmosphere is photooxidation with OH radicals, while photolysis, reaction with ozone molecules, and reaction with nitrate radicals are insignificant in comparison. The second-order rate constant for OH radical photooxidation of 1,4-dioxane is  $1.09 \times 10^{-11}$  cm

Using OH radical concentrations of  $0.5 \times 10^6$ - $1.5 \times 10^6$  OH radicals/cm<sup>3</sup> and a 12-hour day, the atmospheric half-lives for 1,4-dioxane are 2.9 and 1.0 days, respectively. Reaction products from OH radical photooxidation are 2-oxodioxane (or c-C<sub>4</sub>H<sub>7</sub>O<sub>2</sub>). The lifetime of this alkyl radical, 2-oxodioxane in air at 1 atm is 0.02 microseconds with respect to the addition of O<sub>2</sub> to give the corresponding peroxy radical (c-C<sub>4</sub>H<sub>7</sub>O<sub>2</sub>)O<sub>2</sub>. These radicals react rapidly ( $t_{1/2}$ =6 minutes based on NO concentration of  $2.5 \times 10^8$  molecules/cm<sup>3</sup>) with NO to produce NO<sub>2</sub> and by inference (c-C<sub>4</sub>H<sub>7</sub>O<sub>2</sub>)O alkoxy radicals. The sole atmospheric fate of this alkoxy radical is decomposition via C-C bond scission leading to the formation of ethylene glycol diformate. There are no known reactions for the in situ formation of 1,4-dioxane in the atmosphere.

Water : Since 1,4-dioxane does not have functional groups that are susceptible to hydrolysis, hydrolysis of 1,4-dioxane is not expected to occur in the environment. Since 1,4-dioxane does not adsorb light in the environmental spectrum (i.e., >290 nm), 1,4-dioxane is not expected to undergo direct photolysis in aqueous media. 1,4-Dioxane may undergo indirect photolysis by aqueous hydroxyl radicals near the water surface. The half-life for this reaction is 336 days at pH 7. However, the extent of this reaction of OH radicals with 1,4-dioxane is unknown in the environment.

1,4-Dioxane has been found to be resistant to biodegradation. Results of a biological oxygen demand (BOD) test for 1,4-dioxane indicate that negligible oxygen was consumed over a 20-day test period. Degradation of 1,4-dioxane was not observed in cultures of sewage microorganisms exposed for 1 year to waste water treatment plant effluents adjusted to contain 1,4-dioxane at concentrations ranging from 100 to 900 mg/L. In a different study, microorganisms present in either municipal or industrial activated sludge were unable to degrade 1,4-dioxane during 2 days of continuous exposure to concentrations ranging from 10 to 100 mg/L. Accordingly, it appears that 1,4-dioxane will not undergo significant degradation in conventional biological treatment systems. Thus, 1,4-dioxane has been classified as not readily biodegradable and it is not expected to rapidly biodegrade in the environment.

Acclimated microbial cultures may be capable of degrading 1,4-dioxane under certain conditions. A mixed microbial culture enriched from a 1,4-dioxane contaminated soil was capable of aerobically degrading 1,4-dioxane in the presence of tetrahydrofuran (THF).

**Sediment and soil:** Limited information was located on the transformation and degradation of 1,4-dioxane in soils and sediment. The potential to enhance 1,4-dioxane biodegradation in both planted and unplanted soil, was investigated by adding the 1,4-dioxane-degrading actinomycete, *Amycolata* sp. CB1190. 1,4-Dioxane was not removed within 120 days in sterile controls or in viable microcosms not amended with CB1190. Popular root extract (40 mg/L as chemical oxygen demand [COD]) stimulated 1,4-dioxane degradation in bioaugmented soil, and 100 mg/L of 1,4-dioxane was removed within 45 days. Other cosubstrates that enhanced 1,4-dioxane degradation by CB1190 included THF and 1-butanol, while glucose and soil extract did not affect 1,4-dioxane degradation. While long-term enrichments eventually yield cultures of CB1190 that are capable of growth on 1,4-dioxane alone, THF appears to be the preferred growth substrate for CB1190.

**Other media:** Pure 1,4-dioxane is known to react with molecular oxygen at ambient temperatures to form peroxides and hydroperoxides in the course of long-term storage and handling. Peroxides are formed primarily with exposure to air and UV light. Formate esters are formed from subsequent transformations of peroxides and hydroperoxides by way of free-radical mechanisms.

**Comment:** Pure or nearly pure 1,4-dioxane is disposed of by incineration. It is expected that 1,4-dioxane is completely destroyed by this method. Aqueous solutions of 1,4-dioxane are disposed in waste water treatment facilities. Because 1,4-dioxane is resistant to biodegradation, complete mineralisation of this chemical is not efficient. Thus, there may be need to develop effective methods of disposal for aqueous solutions of 1,4-dioxane.

**Ecotoxicity:**

1,4-Dioxane can be classified as practically non-toxic to aquatic micro-organisms, plants, invertebrates and fish.

Fish LC50 (96 h): bluegill sunfish (*Lepomis macrochirus*) >10,000 mg/l; channel catfish (*Ictalurus punctatus*) 6,155 mg/l; fathead minnow (*Pimephales promelas*) 9,850 mg/l; rainbow trout (*Oncorhynchus mykiss*) 7,981 mg/l

Fish NOEC (32 d): fathead minnow (*Pimephales promelas*) 145 mg/l

Daphnia magna EC50 (48 h): 5500 mg/l

Algal EC50 (8 d): *Scenedesmus quadricauda* 5600 mg/l

Bacterial IC50 (16 h): 2700 mg/l.

• DO NOT discharge into sewer or waterways.

### Ecotoxicity

Ingredient	Persistence: Water/Soil	Persistence: Air	Bioaccumulation	Mobility
1,4-dioxane	HIGH	MED	LOW	HIGH

## Section 13 - DISPOSAL CONSIDERATIONS

### US EPA Waste Number & Descriptions

A. General Product Information

Ignitability characteristic: use EPA hazardous waste number D001 (waste code I)

B. Component Waste Numbers

When 1,4-dioxane is present as a solid waste as a discarded commercial chemical product, off-specification species, as a container residue, or a spill residue, use EPA waste number U108 (waste code T).

### Disposal Instructions

All waste must be handled in accordance with local, state and federal regulations.

• Puncture containers to prevent re-use and bury at an authorized landfill.

Legislation addressing waste disposal requirements may differ by country, state and/ or territory. Each user must refer to laws operating in their area. In some areas, certain wastes must be tracked.

A Hierarchy of Controls seems to be common - the user should investigate:

- Reduction
- Reuse
- Recycling
- Disposal (if all else fails)

This material may be recycled if unused, or if it has not been contaminated so as to make it unsuitable for its intended use. If it has been contaminated, it may be possible to reclaim the product by filtration, distillation or some other means. Shelf life considerations should also be applied in making decisions of this type. Note that properties of a material may change in use, and recycling or reuse may not always be appropriate.

DO NOT allow wash water from cleaning equipment to enter drains. Collect all wash water for treatment before disposal.

- Recycle wherever possible.
- Consult manufacturer for recycling options or consult Waste Management Authority for disposal if no suitable treatment or disposal facility can be identified.
- Dispose of by: Burial in a licensed land-fill or Incineration in a licensed apparatus (after admixture with suitable combustible material)
- Decontaminate empty containers. Observe all label safeguards until containers are cleaned and destroyed.

## Section 14 - TRANSPORTATION INFORMATION



DOT:

Symbols:	None	Hazard class or Division:	3
Identification Numbers:	UN1165	PG:	II
Label Codes:	3	Special provisions:	IB2, T4, TP1
Packaging: Exceptions:	150	Packaging: Non-bulk:	202
Packaging: Exceptions:	150	Quantity limitations: Passenger aircraft/rail:	5 L
Quantity Limitations: Cargo aircraft only:	60 L	Vessel stowage: Location:	B
Vessel stowage: Other:	None		

Hazardous materials descriptions and proper shipping names:

Dioxane

#### Air Transport IATA:

ICAO/IATA Class:	3	ICAO/IATA Subrisk:	None
UN/ID Number:	1165	Packing Group:	II
Special provisions:	None		

Shipping Name: DIOXANE

#### Maritime Transport IMDG:

IMDG Class:	3	IMDG Subrisk:	None
UN Number:	1165	Packing Group:	II
EMS Number:	F-E,S-D	Special provisions:	None

Limited Quantities: 1 L

Shipping Name: DIOXANE

## Section 15 - REGULATORY INFORMATION

### 1,4-dioxane (CAS: 123-91-1) is found on the following regulatory lists;

"Canada - Alberta Occupational Exposure Limits", "Canada - British Columbia Occupational Exposure Limits", "Canada - Nova Scotia Occupational Exposure Limits", "Canada - Ontario Occupational Exposure Limits", "Canada - Prince Edward Island Occupational Exposure Limits", "Canada - Saskatchewan Industrial Hazardous Substances", "Canada - Saskatchewan Occupational Health and Safety Regulations - Contamination Limits", "Canada - Saskatchewan Occupational Health and Safety Regulations - Designated Chemical Substances", "Canada - Yukon Permissible Concentrations for Airborne Contaminant Substances", "Canada ARET (Accelerated Reduction / Elimination of Toxics) Substance List", "Canada Ingredient Disclosure List (SOR/88-64)", "Canada National Pollutant Release Inventory (NPRI)", "Canada Toxicological Index Service - Workplace Hazardous Materials Information System - WHMIS (English)", "GESAMP/EHS Composite List - GESAMP Hazard Profiles", "IMO IBC Code Chapter 17: Summary of minimum requirements", "IMO MARPOL 73/78 (Annex II) - List of Noxious Liquid Substances Carried in Bulk", "International Agency for Research on Cancer (IARC) - Agents Reviewed by the IARC Monographs", "OECD Representative List of High Production Volume (HPV) Chemicals", "US - California Air Toxics ""Hot Spots"" List (Assembly Bill 2588) Substances for which emissions must be quantified", "US - California Occupational Safety and Health Regulations (CAL/OSHA) - Hazardous Substances List", "US - California OEHHA/ARB - Acute Reference Exposure Levels and Target Organs (RELs)", "US - California OEHHA/ARB - Chronic Reference Exposure Levels and Target Organs (CRELs)", "US - California Permissible Exposure Limits for Chemical Contaminants", "US - California Proposition 65 - Carcinogens", "US - California Proposition 65 - No Significant Risk Levels (NSRLs) for Carcinogens", "US - California Toxic Air Contaminant List Category II", "US - Connecticut Hazardous Air Pollutants", "US - Hawaii Air Contaminant Limits", "US - Idaho - Limits for Air Contaminants", "US - Maine Chemicals of High Concern List", "US - Massachusetts Oil & Hazardous Material List", "US - Michigan Exposure Limits for Air Contaminants", "US - Minnesota Hazardous Substance List", "US - Minnesota Permissible Exposure Limits (PELs)", "US - New Jersey Right to Know Hazardous Substances", "US - Oregon Permissible Exposure Limits (Z1)", "US - Pennsylvania - Hazardous Substance List", "US - Rhode Island Hazardous Substance List", "US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants", "US - Vermont Hazardous Constituents", "US - Vermont Hazardous wastes which are Discarded Commercial Chemical Products or Off-Specification Batches of Commercial Chemical Products or Spill Residues of Either", "US - Vermont Permissible Exposure Limits Table Z-1-A Final Rule Limits for Air Contaminants", "US - Vermont Permissible Exposure Limits Table Z-1-A Transitional Limits for Air Contaminants", "US - Washington Class A toxic air pollutants: Known and Probable Carcinogens", "US - Washington Dangerous waste constituents list", "US - Washington Discarded Chemical Products List - ""U"" Chemical Products", "US - Washington Permissible exposure limits of air contaminants", "US - Wyoming Toxic and Hazardous Substances Table Z1 Limits for Air Contaminants", "US ACGIH Threshold Limit Values (TLV)", "US ACGIH Threshold Limit Values (TLV) - Carcinogens", "US ATSDR Minimal Risk Levels for Hazardous Substances (MRLs)", "US CAA (Clean Air Act) - HON Rule - Organic HAPs (Hazardous Air Pollutants)", "US Clean Air Act - Hazardous Air Pollutants", "US Department of Transportation (DOT) List of Hazardous Substances and Reportable Quantities - Hazardous Substances Other Than Radionuclides", "US DOE Temporary Emergency Exposure Limits (TEELs)", "US EPA Acute Exposure Guideline Levels (AEGs) - Interim", "US EPA Carcinogens Listing", "US EPA High Production Volume Program Chemical List", "US EPA Master Testing List - Index I Chemicals Listed", "US EPA Voluntary Children's Chemical Evaluation

Program (VCCEP),"US EPCRA Section 313 Chemical List","US List of Lists - Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-to-Know Act (EPCRA) and Section 112(r) of the Clean Air Act","US National Toxicology Program (NTP) 11th Report Part B. Reasonably Anticipated to be a Human Carcinogen","US NIOSH Recommended Exposure Limits (RELs)","US OSHA Permissible Exposure Levels (PELs) - Table Z1","US RCRA (Resource Conservation & Recovery Act) - Appendix IX to Part 264 Ground-Water Monitoring List 1","US RCRA (Resource Conservation & Recovery Act) - Hazardous Constituents - Appendix VIII to 40 CFR 261","US RCRA (Resource Conservation & Recovery Act) - List of Hazardous Wastes","US RCRA (Resource Conservation & Recovery Act) - Phase 4 LDR Rule - Universal Treatment Standards","US Toxic Substances Control Act (TSCA) - Inventory"

## Section 16 - OTHER INFORMATION

### LIMITED EVIDENCE

- Inhalation skin contact and/or ingestion may produce health damage\*.
  - Cumulative effects may result following exposure\*.
  - May produce skin discomfort\*.
- \* (limited evidence).

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- Classification of the mixture and its individual components has drawn on official and authoritative sources as well as independent review by the Chemwatch Classification committee using available literature references.

A list of reference resources used to assist the committee may be found at:  
[www.chemwatch.net/references](http://www.chemwatch.net/references).

- The (M)SDS is a Hazard Communication tool and should be used to assist in the Risk Assessment. Many factors determine whether the reported Hazards are Risks in the workplace or other settings. Risks may be determined by reference to Exposures Scenarios. Scale of use, frequency of use and current or available engineering controls must be considered.

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Issue Date: Jan-9-2009

Print Date:Jul-1-2010