Canadian Centre for Occupational Health and Safety

CHEMINFO Chemical Profiles Created by CCOHS

CCOHS Chemical Name: Ethanol

Record Contents

Format: All Sections

REFRESH RECORD

SECTION 1. CHEMICAL IDENTIFICATION

CHEMINFO Record Number: 423
CCOHS Chemical Name: Ethanol

Synonyms:

Absolute alcohol
Alcohol
Anhydrous ethanol
Ethanol denatured
Ethyl alcohol
Ethyl hydrate
Ethyl hydroxide
Fermentation alcohol
Grain alcohol
1-Hydroxyethane
Methyl carbinol
Ethyl alcohol anhydrous
Absolute ethanol
Alcohol, anhydrous
Denaturated ethanol

Chemical Name French: Éthanol

Chemical Name Spanish: Etanol

CAS Registry Number:	64-17-5
UN/NA Number(s):	1170 NA1987
RTECS Number(s):	KQ6300000
EU EINECS/ELINCS Number:	200-578-6
Chemical Family:	Saturated primary aliphatic alcohol / primary alkanol / primary alkyl alcohol / ethanol / ethyl alcohol
Molecular Formula:	C2-H6-O
Structural Formula:	CH3-CH2-OH

Status of Record:

The CHEMINFO record for this chemical is complete. The full format provides a detailed evaluation of health, fire and reactivity hazards, as well as recommendations on topics such as handling and storage, personal protective equipment, accidental release and first aid.

SECTION 2. DESCRIPTION

Appearance and Odour:

Colourless, clear, volatile liquid with a sweet, ethereal odour like wine or whiskey.(62,63,64) Denatured ethanol may have an unpleasant odour.(63) Anhydrous alcohol is hygroscopic (absorbs moisture from the air).(65,66)

Odour Threshold:

Reported values vary widely; 49-716 ppm. Geometric mean: 180 ppm (detection); 100 ppm (recognition) (67)

Warning Properties:

GOOD - TLV is 5 to 10 times the odour threshold.

Composition/Purity:

Commercial ethanol is manufactured either by fermentation or by chemical synthesis. Ethanol is available commercially in the anhydrous form (absolute alcohol or 100% ethanol) and as various proofs or percentages of ethanol-water, the most common being 190 proof or 95%.(62,68) The usual impurities in fermentation alcohol are fusel oil, aldehydes, ketones, esters, and water. Synthetic alcohol contains acids, aldehydes, ketones, other oxygenated compounds and possibly organic sulfur and some cyclic compounds and olefinic hydrocarbons. If ethanol is used for purposes other than as a beverage, it is denatured by addition of up to 1-5% of substances, such as methanol, 2-propanol, diethyl phthalate, ethyl acetate, formaldehyde, cyclohexane, methyl isobutyl ketone, methyl violet, pyridine, toluene, gasoline, heptane or kerosene, to make the product undesirable for human consumption.(21,65,66) References 21 and 65 provide a more complete list of denaturants. Completely denatured alcohol (CDA) and specially denatured alcohols (SDA) are available.(62,66)

Uses and Occurrences:

Ethanol is a component of alcoholic beverages, such as beer, wine and spirits. It is used as a solvent in inks and surface coatings, toiletries and cosmetic formulations, such as hair sprays and colourants, in household cleaning and detergent preparations, perfumes, tinctures and pharmaceutical preparations, insecticides and disinfectants, automotive deicing products and in food processing; as a raw material to produce various chemicals, such as acetaldehyde, butadiene, diethyl ether, ethyl acetate, ethyl acrylate, and other ethyl esters, ethylamine, ethylene, glycol ethers and vinegar; in the manufacture of drugs and medicinal chemicals, elastomers, plastics, perfumes, cosmetics, lacquers, dyes, polishes, plasticizers and explosives; and as a motor fuel additive to enhance octane and reduce emissions.(21,62,63,66) It can also be used as an antiseptic (germicide).(62,65)

SECTION 3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

Colourless, clear, volatile liquid with a sweet, ethereal odour like wine or whiskey. Denatured ethanol may have an unpleasant odour. Hygroscopic. FLAMMABLE LIQUID AND VAPOUR. Vapour is slightly heavier than air and may spread long distances. Distant ignition and flashback are possible. Mild central nervous system depressant following ingestion or exposure to very high vapour concentrations. May cause headache, nausea, dizziness, drowsiness, incoordination and confusion. EYE IRRITANT. Causes severe eye irritation. Aspiration hazard. Swallowing or vomiting of the liquid may result in aspiration into the lungs.

POTENTIAL HEALTH EFFECTS

Effects of Short-Term (Acute) Exposure

Inhalation:

Ethanol readily forms high vapour concentrations. However, harmful effects are unlikely to occur since it provides good warning of exposure. Aerosols and vapours are irritating to the nose and throat well above the odour threshold (approximately 100-180 ppm) and well below exposures expected to cause the effects typically associated with alcohol ingestion.
A 30-minute exposure to 1800-2000 ppm ethanol aerosol caused coughing, dry throat and temporary bronchial constriction.(58) Brief exposure to very high levels (5300-10600 ppm (cited as 10-20 mg/L)) produced temporary irritation of the nose and coughing. At 16000 ppm (cited as 30 mg/L), continuous irritation of nose, with coughing was observed and 21300 ppm

(cited as 40 mg/L) was considered to be intolerable for even a short period of time.(16) Forty volunteers exposed to 80-1900 ppm for 4 hours had a dose and time-related increase in feelings of annoyance, but no effects on tension, tiredness or other complaints.(116) Five male volunteers exposed to 0, 250, 500 or 1000 ppm for 6 hours experienced no changes in neuromotor function.(117)

Symptoms of alcohol intoxication, which develop following the ingestion of alcoholic beverages containing ethanol, have been well described in the literature (see "Ingestion" below). Similar effects are not expected to occur following inhalation of ethanol, unless the victim is knocked down or unable to remove themselves from exposure to high concentrations. Individuals with repeated exposure to ethanol can develop tolerance to its effects. In this case, higher exposure may be required to produce effects, which were previously observed at lower exposures.

One historical study has described symptoms such as headaches and slight numbness (approximately 1380 ppm for 30 minutes); sensations of warmth/cold (from 3340 ppm for 100 minutes); difficulty breathing, drowsiness and fatigue (from 8840 ppm for 60 minutes) in volunteers.(2,3) The validity of this study has been questioned, since subsequent studies have shown that it is unlikely that these effects would have been observed at the low concentrations cited.(3,16)

Skin Contact:

Ethanol is either not irritating or only very mildly irritating to the skin, based on human and animal information.

No irritation was produced in 16 volunteers following application of 0.5 mL of 95% ethanol, using a modified Draize test.(42) Application of 0.2 mL of ethanol (concentration not reported) for 4 hours caused irritation in only 1/31 volunteers.(118) Application of 60 microL of 60-99% ethanol, under a patch for 24 or 48 hours, to the skin of volunteers, caused drying of the skin but no redness.(119) Application of 0.1 mL, once/day for 10 days, to the skin of volunteers, caused no increase in skin thickness and no redness.(30) Application of 0.8 mL of 70% ethanol, twice daily for 4 days, caused almost no irritation in 20 volunteers.(120) Very mild irritation has been observed in animal tests.

Absorption of ethanol through the skin is minimal.(3) Harmful effects are not be expected by this route of exposure.

Eye Contact:

Depending upon concentration, direct contact with the liquid is expected to produce moderate to severe irritation, based on animal information.

Exposure to high vapour concentrations can produce mild irritation.

High vapour concentrations (7000-10000 ppm) have caused stinging and watering of the eyes in people. These effects increased in intensity with passing time and persisted throughout the exposure. There was no subsequent eye damage noted. Exposure to 2500 ppm had no effect on the eyes.(5,16)

Ingestion:

Due to the relatively low oral toxicity of ethanol, it is unlikely that harmful effects would result from accidental occupational ingestion. Evidence from animal studies and human consumption of alcoholic beverages demonstrates that ingestion of large amounts causes depression of the central nervous system (CNS), with symptoms such as lack of coordination, impaired vision, reduced reaction time, slurred speech, impaired judgement, nausea/vomiting and unconsciousness progressing to death from respiratory or circulatory failure.(2,49) For an average adult, the fatal ingested dose is approximately 1 L (approximately 2 pints) of 40-55% ethanol (the percentage found in whiskey, gin, rum, vodka, or brandy) consumed within a few minutes.(49) Based on animal evidence and its physical properties, ethanol can be

aspirated into the lungs during ingestion or vomiting. Aspiration can cause potentially fatal injury to the lungs. Ingestion is not a typical route of occupational exposure.

Effects of Long-Term (Chronic) Exposure

Occupational exposures, which principally occur by inhalation and skin contact, do not result in as high absorption of ethanol compared to the oral exposure that occurs from drinking alcoholic beverages.(2,3,21,32) Long-term ingestion of alcoholic beverages containing ethanol has been clearly associated with significant health problems, including cirrhosis of the liver and diseases of the gastrointestinal, cardiovascular, respiratory, and nervous systems. Mental problems include a wide range of neurological changes, depression and other mental disorders.(17,48,49) These effects are not reviewed here, since no reports of similar health effects from occupational exposures to ethanol were located.

Skin:

Long-term or repeated contact may result in dermatitis (dry, red, cracked skin). Repeated application of 10% ethanol, under cover, to 8 volunteers for 21 days, produced redness and hardening of the skin during the final 7 days of exposure.(42)

Skin Sensitization:

The information located is insufficient to conclude that ethanol is an occupational skin sensitizer.

Approximately 20 cases of ethanol allergic skin reactions confirmed by positive patch tests have been identified. In most cases, the exposure to ethanol was not occupational.(9,10,12,13,51-54,59,60,121) In some cases, a previous history of allergies was also identified.(53,54,59) One limited study suggests that contact sensitivity to ethanol may be related to an ethnic sensitivity, similar to the Oriental ethnic sensitivity, which results in skin flushing following ingestion of alcoholic beverages.(55) Another report suggests that some of the cases may actually be a non-allergic wheal reaction (non-allergic contact urticaria).(12)

In the three occupational exposure cases located, patch testing with ethanol proved positive. Prior history of allergies was not discussed for any of the cases.(9,10,61) Therefore, no firm conclusions can be drawn from these reports.

In one sensitization study, 6/93 volunteers developed delayed allergic skin reactions.(11) In another study, sensitization was not produced in any of 94 subjects tested.(8) These results indicate that ethanol may be a weak skin sensitizer.

Negative results have been obtained in animal tests.

No conclusions about the potential long-term health effects of ethanol can be drawn from a mortality study of ethanol production workers. Workers were exposed to strong sulfuric acid at the same time and it appears that this chemical is more likely to have caused the observed health effects.(15)

Carcinogenicity:

Occupational exposure to ethanol has not been associated with carcinogenicity. The International Agency for Research on Cancer (IARC) has classified alcoholic beverages as carcinogenic to humans (Group 1). The consumption of alcoholic beverages has caused an increase in cancer of the oral cavity, pharynx, larynx, esophagus, liver, colorectum, and female breast.(96,32,122) Because the positive associations were generally noted with different types of alcoholic beverages and because ethanol is carcinogenic to experimental animals, IARC has also classified ethanol in

alcoholic beverages as carcinogenic to humans (Group 1).(96) Oral exposure to alcoholic beverages containing ethanol is not relevant to occupational exposures.

The International Agency for Research on Cancer (IARC) has not evaluated the carcinogenicity of this chemical.

IARC has classified ethanol in alcoholic beverages as Group 1 (carcinogenic to humans). Ethanol alone has not been evaluated for carcinogenicity by IARC.

The American Conference of Governmental Industrial Hygienists (ACGIH) has designated this chemical as an animal carcinogen (A3).

The US National Toxicology Program (NTP) has not listed this chemical in its report on carcinogens.

NTP has listed consumption of alcoholic beverages as a known human carcinogen.

Teratogenicity and Embryotoxicity:

There is no evidence of developmental toxicity following occupational exposure to ethanol. Animal evidence clearly demonstrates that ingestion of ethanol can cause embryotoxicity, teratogenicity and fetotoxicity, but only in the presence of maternal toxicity. No effects were observed in one study with very high inhalation exposures, despite the observation of significant harmful effects in the mothers. Therefore, ethanol is not considered an occupational developmental hazard.

It is well documented that exposure to ethanol through the ingestion of alcoholic beverages during pregnancy can cause significant harmful effects in unborn children. Certain physical malformations, stillbirths, low birth weight, and neurological, behavioural and intelligence deficits have been observed in the children of mothers who have consumed alcohol during pregnancy. The various effects caused by alcohol ingestion are generally referred to as Fetal Alcohol Syndrome Disorder (FASD). The type and severity of effects on the fetus depend on the amount of alcohol consumed and the time during pregnancy when it is consumed. The full spectrum of FASD effects are associated with the consumption of large quantities of alcohol or with chronic alcoholism in the mother.(32,46,123) The lower limit of alcohol ingestion that causes adverse effects on the fetus has not been determined. These effects are not considered relevant to occupational exposures.

Reproductive Toxicity:

There is no evidence of reproductive toxicity following occupational exposure to ethanol. Effects on reproductive organs, including decreased testicular weight, decreased numbers of motile sperm, decreased ovarian function and irregular fertility cycles, have been observed in animals given very large oral doses of ethanol. However, no confirmed effects on fertility or reproductive capability have been observed. Therefore, ethanol is not considered an occupational reproductive toxin.

Reproductive effects have been observed in people who have consumed large amounts of alcoholic beverages. Human population studies have shown testicular atrophy and sperm effects in alcoholic men, but these effects are generally accompanied by cirrhosis of the liver. Some studies have shown early menopause in alcoholic women.(45) The effects from long-term high alcohol consumption cannot be related to people who are occupationally exposed to ethanol because the nature and degree of exposure is significantly different.

Mutagenicity:

There is insufficient information available to conclude that ethanol is mutagenic. Ethanol has caused mutagenic effects in tests using live animals. However, these effects have generally been observed at very high oral doses and the observations are not considered relevant to an occupational setting.(21,111)
There are no reports of mutagenic effects in people with occupational exposures. Mutagenic effects (such as increased frequencies of chromosomal aberrations, sister chromatid exchanges and aneuploidy) have been observed in the white blood cells of alcoholics.(17,31,125) However, it is not possible to conclude that these effects relate directly to ethanol exposure, because of other potential causes, such as smoking and exposure to other potentially harmful chemicals at the same time.

Toxicologically Synergistic Materials:

Most information about the interactions of ethanol with other chemicals results from studies involving alcohol consumption and exposure to chemicals. Occupational exposure to ethanol is much lower and any interactive effects would be substantially reduced or absent. Ethanol increases liver metabolism and thus increases the metabolism of some organic compounds. It may also compete for metabolic sites thus interfering with the metabolism of other compounds.(2,7)
Ethanol has been associated with an increase in the toxicity of many chemicals including other alcohols, ketones (e.g. acetone and methyl ethyl ketone), benzene, toluene, halogenated hydrocarbons (e.g. carbon tetrachloride, trichloroethylene, chloroform, and methylene chloride), aromatic amines and nitrosamines.(2,4,7,14,113) In particular, it enhances the activity of many chemicals that are harmful to the liver (hepatotoxic agents).(2) There is also a synergistic effect between ethanol and certain metals (e.g. chromium, cobalt, manganese and mercury) or compounds containing these metals.(7,114) Animal studies have shown that short- and long-term ingestion exposure to ethanol can result in enhanced dermal absorption of chemicals applied to the skin.
Some chemicals (e.g. thiuram disulfides or "antabuse" , dimethylformamide and cyanamide) can decrease or slow the metabolism of ethanol thereby increasing the toxic effects of ethanol.(7)

Potential for Accumulation:

Ethanol does not accumulate. It is readily absorbed by the oral or inhalation routes of exposure, but skin uptake is low. Human absorption of the vapour has been reported to be 33-62%, and independent of air concentration and ventilation rate. Most ethanol is metabolized before it is eliminated. It is metabolized primarily by the liver to acetaldehyde, which in turn is converted to acetic acid or acetate, which is oxidized to carbon dioxide, which is then exhaled. Only small amounts are eliminated unchanged in exhaled air, urine or perspiration. The rate of metabolism varies between individuals and, in the case of animals, between species.(2,3,17)

SECTION 4. FIRST AID MEASURES

Inhalation:

This chemical is flammable. Take proper precautions (e.g. remove any sources of ignition). If symptoms are experience, remove source of contamination or have victim move to fresh air. If symptoms persist, obtain medical advice.

Skin Contact:

Remove contaminated clothing, shoes and leather goods (e.g. watchbands, belts). Flush with lukewarm, gently flowing water for 5 minutes. Obtain medical advice. Completely decontaminate clothing, shoes and leather goods before re-use or

discard.

Eye Contact:

Immediately flush the contaminated eye(s) with lukewarm, gently flowing water for 15-20 minutes, while holding the eyelid(s) open. If a contact lens is present, DO NOT delay irrigation or attempt to remove the lens until flushing is done. Take care not to rinse contaminated water into the unaffected eye or onto the face. Immediately obtain medical attention.

Ingestion:

NEVER give anything by mouth if victim is rapidly losing consciousness, is unconscious or convulsing. Have victim rinse mouth thoroughly with water. DO NOT INDUCE VOMITING. If vomiting occurs naturally, have victim lean forward to reduce risk of aspiration. Have victim rinse mouth with water again. Immediately obtain medical attention.

First Aid Comments:

Consult a doctor and/or the nearest Poison Control Centre for all exposures except minor instances of inhalation or skin contact.
All first aid procedures should be periodically reviewed by a doctor familiar with the material and its conditions of use in the workplace.

NOTE: Denatured alcohol often contains other potentially toxic ingredients.

SECTION 5. FIRE FIGHTING MEASURES

Flash Point:

13 deg C (55.4 deg F) (closed cup) (100%) (67,69); 17 deg C (63 deg F) (closed cup) (96%) (69)

Lower Flammable (Explosive) Limit (LFL/LEL):

3.3% (69); 4.3% (62) (100%)

Upper Flammable (Explosive) Limit (UFL/UEL):

15% (66); 19% (62,69) (100%)

Autoignition (Ignition) Temperature:

363 deg C (685 deg F) (69); 423-425 deg C (793.4-797 deg F) (62,66) (100%)

Electrical Conductivity:

1.35 pS/m x 10(5) at 25 deg C (68,70,71)

Minimum Ignition Energy:

Not available.

Flammable Properties:

FLAMMABLE LIQUID. Can release vapours that form explosive mixtures with air at, or above 13 deg C (55.4 deg F). Vapour is slightly heavier than air and can travel a considerable distance to a source of ignition and flash back to a leak or open container. Mixtures of ethanol vapour and air at concentrations in the flammable range may be ignited by a static charge of sufficient energy.

Specific Hazards Arising from the Chemical:

During a fire, carbon monoxide, carbon dioxide, other irritant gases, which may include unburned alcohol, and other toxic constituents may be generated. Vapour can accumulate in confined spaces resulting in a toxicity and flammability hazard. Closed

containers may rupture violently and suddenly release large amounts of product when exposed to fire or excessive heat for a sufficient period of time.

Extinguishing Media:

Carbon dioxide, dry chemical powder, appropriate foam, water spray or fog. Water may be ineffective because it will not cool ethanol below its flash point.(69) Fire fighting foams, such as multipurpose alcohol-resistant foams, are recommended for most flammable liquid fires.(69) Foam manufacturers should be consulted for recommendations regarding types of foams and application rates.

Fire Fighting Instructions:

Evacuate area and fight fire from a safe distance. Approach fire from upwind to avoid hazardous vapours and toxic decomposition products.

Stop leak before attempting to stop the fire. If the leak cannot be stopped, and if there is no risk to the surrounding area, let the fire burn itself out. If the flames are extinguished without stopping the leak, vapours could form explosive mixtures with air and reignite. Water can extinguish the fire if used under favourable conditions and when hose streams are applied by experienced firefighters trained in fighting all types of flammable liquid fires.

Closed containers may rupture violently when exposed to the heat of fire and suddenly release large amounts of products. Always stay away from ends of tanks, but be aware that flying material (shrapnel) from ruptured tanks may travel in any direction. If possible, isolate materials not yet involved in the fire and move containers from fire area if this can be done without risk. Protect personnel. Otherwise, cool fire-exposed containers, tanks or equipment by applying hose streams. Cooling should begin as soon as possible (within several minutes) and should concentrate on any unwetted portions of the container. Apply water from the side and a safe distance. Cooling should continue until well after the fire is out. If this is not possible, use unmanned monitor nozzles and immediately evacuate the area.

If a leak or spill has not ignited, use water spray in large quantities to disperse the vapours and to protect personnel attempting to stop the leak. Water spray can be used to flush spills away from ignition sources and to dilute spills to non-flammable mixtures. Dike fire control water for appropriate disposal. Solid streams of water may be ineffective and spread material.

For an advanced or massive fire in a large area, use unmanned hose holders or monitor nozzles; if this is not possible withdraw from fire area and allow fire to burn. Withdraw immediately in case of rising sound from venting safety device or any discolouration of tank.

After the fire has been extinguished, toxic atmospheres may remain. Before entering such an area especially confined areas, check the atmosphere with an appropriate monitoring device.

Protection of Fire Fighters:

Ethanol is an eye irritant and a mild nervous system depressant. Firefighters may enter the area if positive pressure self-contained breathing apparatus (NIOSH approved or equivalent) and full Bunker Gear is worn.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) HAZARD IDENTIFICATION

NFPA - Health:	2 - Intense or continued (but not chronic) exposure could cause temporary incapacitation or possible residual injury. (100% and 95% ethanol).
NFPA - Flammability:	3 - Liquids and solids that can be ignited under almost all ambient temperature conditions. (100% and 95% ethanol).

NFPA - Instability: 0 - Normally stable, even under fire conditions, and not reactive with water. (100% and 95% ethanol).

SECTION 6. ACCIDENTAL RELEASE MEASURES

Spill Precautions:

Restrict access to area until completion of clean-up. Ensure clean-up is conducted by trained personnel only. Extinguish or remove all ignition sources. Wear adequate personal protective equipment. Ventilate area.

Clean-up:

Prevent material from entering sewers, waterways or confined spaces. Keep materials which can burn away from spilled material. Stop or reduce leak if safe to do so.

Contain spill with earth, sand, or absorbent material which does not react with spilled material. Remove liquid by explosion-proof pumps or vacuum equipment. Place in suitable, covered, labelled containers. Flush area with water. Contaminated absorbent material may pose the same hazards as the spilled product.

Large spills: Contact fire and emergency services and supplier for advice.

SECTION 7. HANDLING AND STORAGE

Handling:

This material is a FLAMMABLE LIQUID and VAPOUR and an EYE IRRITANT. Before handling, it is very important that engineering controls are operating and that protective equipment requirements are being followed. People working with this chemical should be properly trained regardings its hazards and its safe use.

Eliminate all ignition sources (e.g. sparks, open flames, hot surfaces). Keep away from heat. Post NO SMOKING signs. It is very important to keep areas where this material is used clear of other materials which can burn. Electrically ground all drums, transfer vessels, hoses and piping. Ground clips must contact bare metal. When dispensing in other than a closed system, ensure dispensing container is bonded to receiving transfer equipment and container. Never perform any welding, cutting, soldering, drilling or other hot work on an empty vessel.

For large scale operations, consider the installation of leak and fire detection equipment along with a suitable, automatic fire suppression system. Use non-sparking ventilation systems, approved explosion-proof equipment and intrinsically safe electrical systems in areas of use. Keep aisles and exits free of obstruction.

Avoid generating vapours or mists. Prevent the release of vapours and mists into the workplace air. Wear appropriate personal protective equipment, if necessary, to avoid eye contact with this chemical.

Use in smallest possible amounts in a well-ventilated area separate from the storage area. Do not use with incompatible materials such as oxidizers. See Incompatibilities - Materials to Avoid section for more information.

To avoid splashing, carefully dispense into sturdy containers made of compatible materials. Never transfer liquids by pressurizing the original shipping containers with air or inert gas. Do not dispense in storage area unless dispensing area is segregated by fire-resistant construction. Only use portable containers and dispensing equipment (faucet, pump, drip can) approved for flammable liquids.

Never return contaminated material to its original container. Label containers. Keep containers closed when not in use. Avoid damaging containers. Empty containers may contain hazardous residues.

Follow handling precautions on Material Safety Data Sheet. Have suitable emergency equipment for fires, spills and leaks readily available. Practice good housekeeping.

Maintain handling equipment. Comply with applicable regulations.

Storage:

Store in a cool, well-ventilated area out of direct sunlight and away from heat and ignition sources. Lighted cigarettes, matches or any other ignition sources should not be allowed around indoor or outdoor storage areas. Keep storage areas clear of burnable materials (e.g. old rags, cardboard).
Inspect all incoming containers to make sure they are properly labelled and not damaged. Keep quantity stored as small as possible.
Store in suitable, labelled containers (usually the shipping container). Keep containers closed. Bond and ground metal containers in storage area. Install pressure and vacuum- relief venting in all drums of flammable liquids. Make sure storage area is well ventilated. No stacking of containers. Protect from damage.
Use only approved "laboratory safe" explosion-proof refrigerator when storing small quantities.
Keep empty containers in separate storage area. Empty containers may contain hazardous residues. Keep closed.
Store away from ammonia and potassium tert-butoxide and other incompatible materials. See Incompatibilities - Materials to Avoid section for more information.
Storage area should be clearly identified, clear of obstruction and accessible only to trained and authorized personnel. Keep storage area separate from work areas.
Ground floor storage facilities are usually recommended. Store away from work process and production areas, elevators, building and room exits or main aisles leading to exits. Post warning signs. Inspect periodically for damage or leaks.
Avoid bulk storage indoors. Store in an isolated fireproof building, if possible. When storing large amounts, consider leak detection and automatic fire suppression system equipment for storage area. Storage facilities should be made of fire resistant materials. Use a grounded, non-sparking ventilation system, approved explosion-proof equipment and intrinsically safe electrical systems. Store within temperature range recommended by chemical manufacturer/supplier. Alarms that warn of temperatures higher than recommended may be necessary.
Equip storage tank vents with a flame arrestor. Storage tanks should be above ground, over an area sealed on the bottom and diked to hold entire contents. To reduce the fire/explosion hazard, consider the use of an inert gas in the container or storage vessel.
Store flammable materials according to occupational health and safety regulations and fire and building codes which will describe the kind of storage area and the type of storage containers for a specified amount of the material.
Have appropriate fire extinguishers and spill clean-up equipment in or near storage area. Contain spills or leaks by storing in trays made from compatible materials. Keep absorbents for leaks and spills readily available. Provide raised sills or ramps at doorways or create a trench which drains to a safe location.
Follow any special instructions for storage on Material Safety Data Sheet (e.g. maximum storage quantities).

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

NOTE: Exposure to this material can be controlled in many ways. The measures appropriate for a particular worksite depend on how this material is used and on the extent of exposure. This general information can be used to help develop specific control measures. Ensure that control systems are properly designed and maintained. Comply with occupational, environmental, fire, and other applicable regulations.

Sampling and Analysis:

Use appropriate instrumentation and sampling strategy (location, timing, duration, frequency, and number of samples). Interpretation of the sampling results is related to these variables and the analytical method. Sampling should be carried out by trained personnel.

OSHA Analytical Methods:

OSHA METHOD 100 - OSHA Analytical Methods Manual, 2nd ed. (90). Ethyl Alcohol. Validated method. Collection on two Anasorb 747 solid sorbent sampling tubes in series. Desorption with 60/40 N,N-dimethylformamide/carbon disulfide (CS2). Analysis by gas chromatography using flame ionization detector (FID). Detection limit: 15.52 ug per sample (0.68 ppm or 1.29 mg/m3) overall.

NIOSH Analytical Methods:

*NOTE: The method described below has been reported for alcohols including ethanol.
NIOSH METHOD 1400, Issue 2 - NIOSH Manual of Analytical Methods. 4th ed. (91). Alcohols I. Partially evaluated method. Collection on coconut shell activated charcoal sorbent tube. Desorption with 1% 2-butanol in carbon disulfide (CS2). Analysis by gas chromatography using flame ionization detector (FID). Estimated LOD: 0.01 mg per sample.
*NOTE: The method described below has been reported for volatile organic compounds including ethanol.
NIOSH METHOD 2549, Issue 1 - NIOSH Manual of Analytical Methods. 4th ed. (92). Volatile Organic Compounds (Screening). Partially evaluated method. Collection on thermal desorption tube. Analysis by thermal desorption followed by gas chromatography - mass spectrophotometry (GC-MS). Estimated LOD: 100 ng per sample or less.

Colorimetric Detector Tubes:

Commercially available.

Passive Sampling Devices:

Commercially available.

Engineering Controls:

Engineering methods to control hazardous conditions are preferred. Methods include mechanical ventilation (dilution and local exhaust), process or personnel enclosure, control of process conditions, and process modification (e.g. substitution of a less hazardous material). Administrative controls and personal protective equipment may also be required.
When there is large scale use of this material, local exhaust ventilation with or without process enclosure may be necessary. Use non-sparking, grounded ventilation systems, approved explosion-proof equipment and intrinsically safe electrical systems in areas of use. Exhaust directly to the outside. Supply sufficient replacement air to make up for air removed by exhaust systems.
For large-scale operations, consider the installation of leak and fire detection equipment along with a suitable, automatic fire suppression system.

Personal Protective Equipment:

If engineering controls and work practices are not effective in controlling exposure to this material, then wear suitable personal protection equipment including approved respiratory protection. Have appropriate equipment available for use in emergencies such as spills or fire.
If respiratory protection is required, institute a complete respiratory protection program including selection, fit testing, training, maintenance and inspection. Refer to the CSA Standard Z94.4-02 Selection, Care, and Use of Respirators", available from the Canadian Standards Association.

Respiratory Protection Guidelines:

NIOSH/OSHA RECOMMENDATIONS FOR ETHYL ALCOHOL CONCENTRATIONS IN AIR (77):
UP TO 3300 PPM: SAR; or full-facepiece 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.

NOTE: The IDLH concentration for ethyl alcohol is 3300 ppm (the Lower Explosive Limit).
The purpose of establishing an IDLH value is to ensure that the worker can escape from a given contaminated environment in the event of failure of the most protective respiratory protection equipment. In the event of failure of respiratory protective equipment every effort should be made to exit immediately.

The respirator use limitations specified by the approving agency and the manufacturer must be observed.
Recommendations apply only to NIOSH approved respirators.

ABBREVIATIONS: SAR = supplied-air respirator; SCBA = self-contained breathing apparatus; IDLH = immediately dangerous to life or health.

Eye/Face Protection:

Chemical safety goggles. A face shield may also be necessary.

Skin Protection:

Chemical protective gloves and other appropriate clothing to prevent repeated and/or prolonged skin contact.

Resistance of Materials for Protective Clothing:

Guidelines for ethanol (78):
RECOMMENDED (resistance to breakthrough longer than 8 hours): Butyl rubber, Viton(TM), Viton(TM)/Butyl rubber, Barrier (PE/PA/PE), Silver Shield/4H(TM) (polyethylene/ethylene vinyl alcohol), Tychem(TM) CPF 3.

RECOMMENDED (resistance to breakthrough longer than 4 hours): Neoprene rubber.

CAUTION, use for short periods only (resistance to breakthrough within 1 to 4 hours): Nitrile rubber, Polyethylene.

NOT RECOMMENDED for use (resistance to breakthrough less than 1 hour): Natural rubber, Polyvinyl alcohol, Polyvinyl chloride.

Recommendations are NOT valid for very thin Natural rubber, Neoprene, Nitrile and PVC gloves (0.3 mm or less).
Resistance of specific materials can vary from product to product. Breakthrough times are obtained under conditions of continuous contact, generally at room temperature. Evaluate resistance under conditions of use and maintain clothing carefully.

Personal Hygiene:

Have a eye-wash fountain readily available in the immediate work area. Do not smoke in work areas.

EXPOSURE GUIDELINES

THRESHOLD LIMIT VALUES (TLVs) / AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH) / 2010

Short-Term Exposure Limit (TLV-STEL):	1000 ppm Carcinogenicity Designation A3
TLV Basis - Critical Effect(s):	Upper respiratory tract irritation

TLV Definitions:

CARCINOGENICITY DESIGNATION A3 - Animal Carcinogen: Substance is carcinogenic in laboratory animals under conditions that are not considered relevant to worker exposure. Available human studies and evidence suggest that the substance is not likely to cause cancer in humans except under unusual or unlikely routes or levels of exposure. Worker exposure to an A3 carcinogen should be controlled to levels as low as reasonably achievable below the TLV.

TLV Comments:

NOTE: In many jurisdictions, exposure limits are similar to the ACGIH TLVs. Since the manner in which exposure limits are established, interpreted, and implemented can vary, obtain detailed information from the appropriate government agency in each jurisdiction.

PERMISSIBLE EXPOSURE LIMITS (PELs) / FINAL RULE LIMITS / US OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

Time-Weighted Average (PEL-TWA): Not established

NOTE: The OSHA PEL Final Rule Limits are currently non-enforceable due to a court decision. The OSHA PEL Transitional Limits are now in force.

PERMISSIBLE EXPOSURE LIMITS (PELs) / TRANSITIONAL LIMITS / US OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

Time-Weighted Average (PEL-TWA): 1000 ppm (1900 mg/m3)

Transitional Limit PEL Comments:

These Permissible Exposure Limits are taken from 29 CFR 1910.1000 Table Z - 1.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Molecular Weight: 46.07

Conversion Factor:

1 ppm = 1.88 mg/m3; 1 mg/m3 = 0.53 ppm at 25 deg C (calculated)

Physical State:	Liquid
Melting Point:	-114 deg C (-173.2 deg F) (100%) (Freezing point) (62,66,71)
Boiling Point:	78.3 deg C (172.9 deg F) (100%) (21,66,68); 78.15 deg C (172.7 deg F) (95%) (65,66)
Decomposition Temperature:	Not available.
Relative Density (Specific Gravity):	0.789 at 20 deg C (100%) (62,71,72); 0.785 at 25 deg C (100%) (68); 0.813 at 15.6 deg C (95%) (62) (water = 1)
Solubility in Water:	Soluble in all proportions at 20 deg C (21,62,66)
Solubility in Other Liquids:	Soluble in all proportions with diethyl ether, acetone, benzene, chloroform, methanol and some other organic solvents.(66,71,72)
Coefficient of Oil/Water Distribution	Log P(oct) = -0.31 (experimental) (73)

(Partition Coefficient):	
pH Value:	Not available.
Acidity:	Very weak acid and very weak base (127,128)
Dissociation Constant:	pKa = 15.9 at 25 deg C (68,128)
Viscosity-Dynamic:	1.17 mPa.s (1.17 centipoises) at 20 deg C (62); 1.074 mPa.s (1.074 centipoises at 25 deg C (71)
Viscosity-Kinematic:	1.48 mm2/s (1.48 centistokes) at 20 deg C; 1.37 mm2/s (1.37 centistokes) at 25 deg C (calculated)
Saybolt Universal Viscosity:	30.4-30.7 Saybolt Universal Seconds at 37.8 deg C (100 deg F) (calculated)
Surface Tension:	22.39 mN/m (22.39 dynes/cm) at 20 deg C; 21.97 mN/m (21.97 dynes/cm) at 25 deg C (74)
Vapour Density:	1.59 (air = 1) (calculated)
Vapour Pressure:	5.9 kPa (44.25 mm Hg) at 20 deg C (75); 7.87-7.90 kPa (59.03-59.26 mm Hg) at 25 deg C (68,76,79)
Saturation Vapour Concentration:	58200 ppm (5.82%) at 20 deg C; 77700-78000 ppm (7.77-7.80%) at 25 deg C (calculated)
Evaporation Rate:	2.4 (n-butyl acetate = 1); 8.3 (diethyl ether = 1) (75); also reported as 1.6 (100%) (n-butyl acetate = 1) (68)
Henry's Law Constant:	5.07 x 10(-1) Pa.m3/mol (cited as 5 x 10(-6) (atm.m3/mol) at 25 deg C (126); log H = -3.69 (dimensionless constant; calculated) ; 5.27 x 10(-1) Pa.m3/mol (cited as 5.2 x 10(-6) (atm.m3/mol) at 25 deg C (79); log H = -3.67 (dimensionless constant; calculated)

Other Physical Properties:

DIELECTRIC CONSTANT: 25.3 at 20 deg C (71); 25.44 at 25 deg C (68)

SECTION 10. STABILITY AND REACTIVITY

Stability:

Normally stable.

Possibility of Hazardous Reactions:

None known.

Flammable Gases Released Upon Contact with Water:

None.

Incompatibility - Materials to Avoid:

NOTE: Chemical reactions that could result in a hazardous situation (e.g. generation of flammable or toxic chemicals, fire or detonation) are listed here. Many of these reactions can be done safely if specific control measures (e.g. cooling of the reaction) are in place. Although not intended to be complete, an overview of important reactions involving common chemicals is provided to assist in the development of safe work practices.

STRONG OXIDIZING AGENTS (e.g. chromium trioxide, calcium hypochlorite, chlorine oxides, disulfuryl difluoride, nitrosyl perchlorate, nitric acid, permanganic acid, permanganates or potassium dioxide) - may react violently or explosively.(63,69,129)
HYDROGEN PEROXIDE - mixtures of concentrated peroxide and ethanol can be

detonated by shock or heat.(69,129)
PERCHLORIC ACID, METAL PERCHLORATES (e.g. silver perchlorate or magnesium perchlorate), MERCURIC NITRATE, SILVER NITRATE, SILVER and NITRIC ACID, or SILVER OXIDE and AQUEOUS AMMONIA - may form shock-sensitive or explosive compounds.(69,129)
ALKALI METALS (e.g. sodium or potassium) - reaction may be explosive due to the formation of hydrogen-air mixtures, unless air is excluded.(129)
BROMINE PENTAFLUORIDE or BROMIDES - reaction may be vigorous or violent with risk of fire and explosion.(69,129)
SODIUM HYDRAZIDE - can explode.(63,69,129)
ZIRCONIUM TETRACHLORIDE- interaction is violent.(129)
PHOSPHORUS (III) OXIDE - ignites readily at normal temperatures.(129)
POTASSIUM TERT-BUTOXIDE - contact of solid butoxide with ethanol vapour caused ignition.(69,129)
ACIDS, ACID ANHYDRIDES, or ACID CHLORIDES (e.g. acetyl chloride) - reaction may be vigorous or violent, with the evolution of heat.(69,129)
CALCIUM OXIDE or CESIUM OXIDE - may ignite on contact.(129)
PLATINUM BLACK CATALYST - ignites.(129)
BROMINE and PHOSPHORUS or IODINE AND PHOSPHORUS - the vigorous interaction.(129)

Hazardous Decomposition Products:

During a fire, carbon monoxide, carbon dioxide, other irritant gases, which may include unburned alcohol, and other toxic constituents may be generated.

Conditions to Avoid:

Open flames, sparks, static charge, heat and other ignition sources.

Corrosivity to Metals:

Anhydrous (absolute) ethanol corrodes aluminum alloys. However, type 3003 aluminum alloy resists corrosion from aqueous solutions of ethanol up to 95%.(130) Ethanol is not corrosive at room temperature to the common metals, such as stainless steel (e.g. types 301, 303, 304, 316, 321, 347, 17-4 pH, 400 series), carbon steel (types 1010, 1020, 1075, 1095), gray cast iron, high nickel cast iron (Ni-resist), high silicon cast iron (Duriron), nickel and nickel-base alloys, such as Monel, Hastelloy B/B-2, Hastelloy C/C-276, Inconel 600, and Incoloy 825, Carpenter 20Cb-3, copper and its alloys, 70-30 copper-nickel, 90-10 copper-nickel, silicon copper, brass, admiralty brass, aluminum brass, cartridge brass, naval brass, bronze, aluminum bronze, silicon bronze, tantalum, titanium and zirconium.(130,131,132) May react with hot aluminum.(63)

Corrosivity to Non-Metals:

Ethanol (up to 100%) attacks plastics, such as acrylics, styrene-acrylonitrile (SAN), polyurethane (rigid), polystyrene and polymethacylate acrylic (132,133); and elastomers, such as polyacrylate, polyurethane, nylon 11, nylon 12, flexible polyvinyl chloride (PVC) and low-density polyethylene (LDPE) at room temperature.(132,134) 90% Ethanol attacks nylon 12 plastic.(133) At room temperature, ethanol (up to 100%) does not attack plastics, such as Teflon and other fluorocarbons like ethylene tetrafluoroethylene (EFTE; Tefzel), fluoroethylene (ECTFE; Halar) and polyvinylidene fluoride (PVDF; Kynar), polyvinylidene chloride (Saran), chlorinated polyvinyl chloride (CPVC), polyvinyl chloride (PVC), polypropylene (PP), nylon, acrylonitrile-butadiene-styrene (ABS), polyetherether ketone(PEEK), chlorinated polyether (Penton), high density polyethylene (HDPE), ultra high molecular weight polyethylene (UHMPE), crosslinked polyethylene (XPE), polybutylene terephthalate (PBT), polyethylene terephthalate (PET), polyphenylene oxide (Noryl), thermoset polyesters (bisphenol-A fumarate, halogenated and general purpose), thermoset vinyl ester, thermoset epoxy and ethylene vinyl acetate (EVA) (132,133); elastomers, such as nitrile Buna N (NBR), ethylene propylene (EP), ethylene propylene diene (EPDM), Viton A, Teflon and other fluorocarbons, Chemraz, Kalrez and Fluoraz, chloroprene (neoprene), styrene butadiene (SBR), butyl rubber (IIR; isobutylene isoprene), isoprene, natural rubber,

hard rubber, soft rubber, chlorosulfonated polyethylene (CSM; Hypalon), silicone and fluorosilicone (132,134); and coatings, such as coal tar epoxy, epoxy (chemical resistant and polyamide), phenolic, polyester, urethanes and vinyls.(132)

SECTION 11. TOXICOLOGICAL INFORMATION

LC50 (male rat): greater than 32380 ppm (4-hour exposure); 2/6 rats died during exposure; 18-hour post-exposure observation period (19)
LC50 (male mouse): greater than 30000 ppm (4-hour exposure); cited as greater than 60000 ppm (1-hour exposure); at 60000 ppm for 1 hour, 0/12 mice died; 3-day observation period (20)
LC50 (mouse): 21000 ppm (4-hour exposure); cited as 39 g/m3 (4-hour exposure) (1, unconfirmed)

LD50 (oral, mature male rat): 7060 mg/kg (cited as 7.06 g/kg) (41)
LD50 (oral, mouse): 3450 mg/kg (1, unconfirmed)
LD50 (oral, guinea pig): 5560 mg/kg (cited as 5.56 g/kg) (37)

LD50 (dermal, rabbit): greater than 15800 mg/kg (cited as greater than 20 mL/kg); at 20 mL/kg, 1/4 rabbits died; evaluated as reliability not assignable (21, unconfirmed)

Eye Irritation:

Ethanol is a moderate to severe eye irritant.

Application of 0.1 mL of 100% ethanol caused moderate irritation in rabbits, which completely reversed by 14 days. Average scores at 24, 48 and 72 hours for 3 rabbits were: corneal opacity: 1.67/4, 1.33/4, 0.33/4; iris injury: 1/2, 0.33/2, 0/1: redness: 2.67/3, 2.33/3, 1.33/3; chemosis: 2/4, 1.67/4, 0.33/4.(95) Application of 0.1 mL of undiluted ethanol produced moderate eye irritation (average scores at 24, 48 and 72 hours: redness: 2.39/3; chemosis: 1.22/4; iris injury: 0.27/2; corneal opacity: 1.17/4).(93) The time for changes to reverse was not reported. Application of 0.1 mL of undiluted ethanol caused moderate injury in rabbits (scored up to 5 where 5 is severe injury; graded 3/10).(38) In other studies, application of 0.1 mL of 90% ethanol produced severe irritation in rabbits and 95% ethanol produced mild to moderate irritation in rabbits.(39,40) There have been extensive studies of the visual and ocular effects produced with short-term and long-term intoxication with alcoholic beverages.(5) These effects are not reported here as they are not relevant to occupational exposure.

Skin Irritation:

Ethanol is a very mild irritant.

Application of 0.5 mL ethanol to intact skin for 4 hours caused very mild irritation in rabbits (average scores at 24, 48 and 72 hours: erythema: 0.33/4; edema: 0/4).(94) In a modified Draize test, application of 0.2 mL of 95% ethanol for 2 hours produced no irritation to intact skin and only very mild irritation to abraded (damaged) skin of rabbits.(39) Application of 0.5 mL of 95% ethanol, under a cover for 24 hours, produced very mild irritation in rabbits.(42) In one unconfirmed study, application of 20 mg for 24 hours in a standard Draize test produced moderate irritation in rabbits.(1, unconfirmed) Application of 0.1 mL, once/day for 10 days, caused no redness and swelling in rabbits or guinea pigs. A slight increase in skin thickness was measured.(30)

Effects of Short-Term (Acute) Exposure:

Ethanol has produced central nervous system (CNS) depression following ingestion and inhalation exposure to high concentrations in studies using rats, mice and guinea pigs. Observations have included drowsiness, incoordination, respiratory depression, unconsciousness, and death.

Inhalation:

The concentration of ethanol that reduced the respiratory rate of male mice by 50% (RD50) was 27300 ppm for a 10-minute exposure.(47) The RD50 is a measure of sensory irritation (nose, throat and respiratory irritation). These results indicate that ethanol is a relatively weak sensory irritant. Numerous studies have shown that ethanol causes depression of the central nervous system (CNS). Drowsiness, incoordination, loss of reflexes, unconsciousness, respiratory failure and death have been observed following exposure. The effects depend on both the concentration and length of exposure.(2,21,32) Mild intoxication was seen in rats exposed to 30324 ppm (cited as 57 mg/L) for 3 hours. After 9 hours exposure, lethargy and incoordination were severe and at 12 hours there was a loss of reflexes.(33) Male mice were exposed to 0, 40000, 50000 or 60000 for 10, 30 and 60 minutes. Calculated concentrations for a 50% decrease in a motor performance test were 49746 ppm for 10 minutes, 32415 ppm for 30 minutes or 30297 ppm for 60 minutes.(20) Male rats were exposed to 0, 4090, 8140, 14900 or 32380 ppm for 4 hours. Exposure to 8140 ppm and higher resulted in changes in behavioural tests. Exposure to 4090 ppm had no effects.(19) In a study that examined the effects of ethanol on blood composition, female mice exposed to 17710-20210 ppm (cited as 20-38 mg/L) for 24 hours had a significant decrease in the number of white blood cells and platelets.(56) In continuous exposure studies, where rats were exposed to high levels (8000-13300 ppm), for 4-26 days, liver changes (increased weight, increased fats) were noted, as well as reduced numbers of cells in the spleen, thymus and bone marrow.(3,29)

Ingestion:

Numerous studies have shown that ethanol causes dose-related depression of the central nervous system (CNS). Drowsiness, incoordination, loss of reflexes, unconsciousness, respiratory failure and death have been observed following exposure.(2,21,32) In a study designed to test aspiration risk, aspiration of 0.2 mL of 100% ethanol produced death in 5/10 rats. Aspiration of 0.2 mL of 70% ethanol in water on produced death in 1/10 rats.(35)

Effects of Long-Term (Chronic) Exposure:

Long-term studies show liver damage following exposure to high oral doses.

Inhalation:

No harmful effects were observed in rats, guinea pigs, rabbits, monkeys and dogs exposed continuously by inhalation for 90 days to 46 ppm ethanol.(36) Guinea pigs also showed no harmful effects following intermittent inhalation exposure to 3000 ppm of a product largely composed of ethanol for 10.5 weeks.(43) In a study that examined the effects of ethanol on blood composition, female mice exposed continuously to 5320-13300 ppm (cited as 10-25 mg/L) for 20-43 days had a significant decrease in the number of platelets. No effects were seen on hemoglobin or red or white blood cells.(56) In a historical study, exposure of rabbits to saturated vapours (approximately 58000 ppm) for 25-365 days caused liver damage (cirrhosis of the liver).(2, unconfirmed)

Ingestion:

Long-term oral dosing studies using rats have consistently shown liver damage (fatty infiltration, focal necrosis, inflammation and/or fibrosis).(2,21,32)

Macaca monkeys given 6200 mg/kg/day in the diet for up to 48 months also developed varying degrees of fatty changes in the liver.(97) Baboons fed high dietary levels (amount not reported) of ethanol developed fatty livers, liver fibrosis and, in some cases, hepatitis after 9-12 months exposure.(57) In an unpublished study, which was evaluated as valid with restrictions, mice were given 0, 1, 2, 3, 4, 5 or 10% ethanol in a liquid diet for 90 days. The reported approximate dose at 2% was 2400 mg/kg/day (i.e. estimated approximate doses of 0, 1200, 2400, 3600, 4800, 6000 or 12000 mg/kg/day). Dose-related liver effects (yellowing, fatty changes to the central lobe) were seen at 3600 mg/kg/day and higher.(21, unconfirmed) Effects on the heart were studied in rats given 0 or 3% ethanol in their drinking water for 8 weeks (approximate reported doses were 0 or 4050 mg/kg/day). Ethanol ingestion resulted in the development of fibrosis of the heart in 4/20 animals and in statistically significant biochemical changes indicative of heart damage.(98) Rats and mice were given 0 or 5% ethanol in the drinking water for 90 days. Approximate daily doses were 5000 mg/kg for rats and 10000 mg/kg for mice. No significant harmful effects were observed.(99) No significant harmful effects were seen in a related 2-year study where mice were given 0, 2.5 or 5% ethanol in drinking water (approximate doses were 0, 5000 and 10000 mg/kg/day).(100) These studies were designed to determine harmful effects from urethane administered either in drinking water or in 2.5 or 5% ethanol and no direct comparison was done between animals exposed only to ethanol and unexposed controls. Immune system effects were observed in one strain of rats exposed to high dietary levels of ethanol (ethanol supplied 35% of calories) for 6 weeks, while another strain showed no significant effects. The authors conclude that susceptibility to the immune system effects may be genetically linked.(18) This study is limited by small numbers (5-6/group).

Skin Sensitization:

Ethanol is not a skin sensitizer.

Ethanol had no effect in the mouse ear sensitization assay (6) and failed to produce sensitization in five different tests using guinea pigs (8).

Carcinogenicity:

The International Agency for Research on Cancer (IARC) has determined that there is sufficient evidence for the carcinogenicity of ethanol in experimental animals.(96) Administration of ethanol in drinking-water caused a dose-related increase in the incidence of hepatocellular adenomas and carcinomas in male mice, an increased incidence of head and neck carcinomas in male and female rats, an increased incidence of forestomach carcinomas, testicular interstitial-cell adenomas, and osteosarcomas of the head, neck, and other sites in male rats, and of mammary adenocarcinomas in female rats. In most of the studies where it was co-administered with known carcinogens, ethanol enhanced the carcinogenic effect.(96)

Teratogenicity, Embryotoxicity and/or Fetotoxicity:

There is insufficient information available to conclude that ethanol is an occupational teratogen, embryotoxin or fetotoxin. The harmful effects of oral administration of ethanol to pregnant animals are well documented. Effects have included fetotoxicity (e.g. delayed growth), embryotoxicity (e.g. increased prenatal mortality), and teratogenicity (e.g. malformations of the central nervous system, facial structures, heart, limbs and urogenital system). However, most studies involving oral ethanol exposure have involved very large doses which have also produced or are expected to produce significant maternal toxicity.(17,27,28,34,32)

The lowest reported dose which caused teratogenicity in rats is approximately 316 mg/kg (cited as 0.4 mL/kg).(44) No firm conclusions can be drawn from this study because it is limited by small numbers (12-14/group) and because the authors did not conduct a full evaluation of maternal toxicity. Several recent studies have shown effects on behaviour, brain growth, brain chemistry, learning, or tooth development in offspring of rats, mice or guinea pigs exposed prenatally to

ethanol.(22,101,,102,103,104,105,106) In most cases the exposures were high and would be expected to cause maternal toxicity, although maternal effects were not usually reported. An important consideration in the interpretation of all oral developmental toxicity studies of ethanol is that pregnant animals exposed to ethanol in drinking water or food or by intubation consume less food than unexposed animals. Therefore a reduction in nutrients during a critical period of development is a confounding factor.(21,107) Inhalation exposure of rats to levels as high as 20000 ppm did not produce any statistically significant teratogenic effects despite severe maternal toxicity (unconsciousness).(26) In a related study, male and female rats were exposed to 16000 or 10000 ppm for 6 weeks before mating with untreated rats. Pregnant rats were exposed throughout pregnancy. Measurable neurochemical effects but no behavioural effects were observed in the offspring of exposed male or female rats.(24)

Reproductive Toxicity:

Effects on reproductive organs, including decreased testicular weight, decreased numbers of motile sperm, decreased ovarian function and irregular fertility cycles, have been observed in animals given large oral doses of ethanol. However, no confirmed effects on fertility or reproductive capability have been observed.(2,17)
In a well-conducted continuous breeding study, mice were exposed to 5, 10 or 15% ethanol in water (approximate reported doses were 8500, 16000 and 20000 mg/kg/day). No effects on fertility and only minor reproductive effects were observed (reduced sperm motility and increased time between litters).(23) In two other studies, no effects on fertility were seen in male rats given 2000, 3000 or 5000 mg/kg/day orally for 9 weeks prior to mating. Effects on the offspring such as increased fetal weight, change in sex ratio, and dose-related increased adrenal weight were seen at 3000 and/or 5000 mg/kg/day. Toxicity to the males was not assessed, however deaths were reported at 3000 mg/kg/day and higher.(108,109) Male and female rats with inhalation exposure to 10000 or 16000 ppm ethanol for 6 weeks prior to mating showed no effects on fertility.(24) Male rats given 3% ethanol in their drinking water (reported approximate dose was 4050 mg/kg/day) for 8 weeks had biochemical changes in the testes indicating increased protein and lipid oxidation. No changes in body weight or testicular weight were observed.(110) In a poorly designed study, 10 male rats dosed with 20% ethanol in drinking water for 60 days showed statistically significant testicular effects and an increased rate of fetal death in all 3 post-exposure matings. Observations of reduced fertility were not statistically significant.(25) In another poorly designed study, 10 female rabbits administered 5 mL/100 g of 10% ethanol and then mated, were determined to be infertile.(50) No conclusions can be drawn from these studies due to the small number of animals used and the fact that only a single dosing group was used.

Mutagenicity:

The mutagenicity of ethanol has been extensively studied and reviewed.(17,21,31,32,111) Ethanol has caused mutagenic effects in tests using live animals. However, these effects have generally been observed at very high oral doses or in poorly conducted studies. The observations are not considered relevant to an occupational setting.(21,111) Positive and negative results have been obtained in cultured mammalian cells while results for bacteria, yeast and fruit flies (Drosophila) have been mostly negative.
Statistically significant dominant lethal mutations were observed when male mice were orally exposed to 0.1 mL of 40 or 60% ethanol (reported doses of 1240 or 1860 mg/kg/day) for 3 days and then mated. The response was dose-related.(81) The results of this study are considered invalid and unreliable.(21,111) A well-conducted inter-laboratory study also showed some positive results, but the overall conclusion was that ethanol is unlikely to produce a dominant lethal effect at doses up to the maximum tolerated dose.(89) A dose-related, statistically significant increase in aneuploidy was observed in the germ cells of male mice following a single oral dose of 0.8 mL of 12.5% or 15% ethanol (approximately 4000 or 4800 mg/kg).(84) Positive results were also obtained for aneuploidy in the germ cells of mice and hamsters in two other studies.(83,86) Male rats were exposed to 12000-16000 mg/kg (cited as 12-16 g/kg) ethanol in their diets for 6 weeks. Significantly increased numbers of

micronucleated bone marrow cells were observed in the ethanol fed rats.(85)
Statistically significant sister chromatid exchanges were observed in the peripheral lymphocytes, but not the bone marrow, of rats exposed to 10 or 20% ethanol (approximately 10000 or 20000 mg/kg/day) as their only liquid supply for 3 or 6 weeks.(88) A statistically significant increase in sister chromatid exchanges was observed in the bone marrow of male mice when 10 or 20% ethanol (approximately 20000 or 40000 mg/kg/day) was given as the only liquid supply for 3-16 weeks.(87)
Rats given a single oral dose of 5000 mg/kg or fed a liquid diet containing 5% ethanol for 1 week had a significant increase in DNA adducts in the liver.(112)
Positive and negative results (chromosome aberrations, sister chromatid exchanges, micronucleus, point mutations) have been obtained in tests using cultured mammalian cells, with and without metabolic activation.(17,21,32) Negative results (point mutation, DNA damage, DNA repair) have been obtained in most tests using bacteria, with and without metabolic activation.(17,21,32) A positive result (aneuploidy) was obtained in a test using yeast.(17)
Negative results (point mutation, sex-linked recessive lethal, recombination) have been obtained in fruit flies (Drosophila).(17)

Toxicological Synergisms:

Animal studies have shown that ethanol increases the toxicity of many chemicals including other alcohols, ketones (e.g. acetone and methyl ethyl ketone), benzene, toluene, halogenated hydrocarbons (e.g. carbon tetrachloride, trichloroethylene, chloroform, and methylene chloride), aromatic amines and nitrosamines.(2,4,7,14,113) In particular, ethanol enhances the activity of many chemicals that are harmful to the liver (hepatotoxic agents).(2) There is also a synergistic effect between ethanol and certain metals (e.g. chromium, cobalt, manganese and mercury) or compounds containing these metals.(7,114) Studies in rats have shown that short- and long-term ingestion exposure to ethanol can result in enhanced dermal absorption of chemicals applied to the skin.(115)

SECTION 12. ECOLOGICAL INFORMATION

NOTE : Inclusion of Ecological Information on an MSDS is optional under the US Hazard Communication Standard and the Canadian Controlled Products Regulations (WHMIS). In other jurisdictions, inclusion of Ecological Information may be a requirement. For specific requirements, contact the relevant regulatory authorities in the jurisdiction where the MSDS is intended to be used.

The American National Standard for Hazardous Industrial Chemicals - Material Safety Data Sheets - Preparation (ANSI Z400.1-2004) provides advice on data that could be included in this section.

Databases in CCOHS's CD-ROM and Web collection which contain useful Ecological Information include CESARS, HSDB® (Hazardous Substances Data Bank) and CHRIS (Chemical Hazards Response Information System).

SECTION 13. DISPOSAL CONSIDERATIONS

Review federal, provincial and local government requirements prior to disposal. Store material for disposal as indicated in Storage Conditions. Disposal by controlled incineration or secure landfill may be acceptable.

SECTION 14. TRANSPORT INFORMATION

CANADIAN TRANSPORTATION OF DANGEROUS GOODS (TDG) SHIPPING INFORMATION

Shipping Name and Description: ETHANOL more than 24 per cent ethanol, by volume; ETHANOL SOLUTION more than 24 per cent ethanol, by volume; ETHYL ALCOHOL more than 24 per cent ethanol, by volume; or ETHYL ALCOHOL SOLUTION more than 24 per cent ethanol, by volume

UN Number: UN1170

Class: 3

Packing Group/Category: II

Special Provisions: ---

Passenger Carrying Road/Railway Vehicle Index: 5 kg or L

Marine Pollutant: ---

Packing Group/Category: III

Special Provisions: ---

Passenger Carrying Road/Railway Vehicle Index: 60 kg or L

Marine Pollutant: ---

NOTE: This information incorporates the Transportation of Dangerous Goods Regulations SOR/2001-286, effective October 14, 2009.

US DEPARTMENT OF TRANSPORT (DOT) HAZARDOUS MATERIALS SHIPPING INFORMATION (49 CFR)

Shipping Name and Description: ETHANOL or ETHYL ALCOHOL or ETHANOL SOLUTIONS or ETHYL ALCOHOL SOLUTIONS

Hazard Class or Division: 3

Identification Number: UN1170

Packing Group: II III

Shipping Name and Description: DENATURED ALCOHOL

Hazard Class or Division: 3

Identification Number: NA1987

Packing Group: II III

NOTE: This information was taken from the US Code of Federal Regulations Title 49 - Transportation and is effective July 1, 2009.

SECTION 15. REGULATORY INFORMATION

CANADIAN WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)

CCOHS WHMIS Classification:

B2 - Flammable and combustible material - Flammable liquid
D2B - Poisonous and infectious material - Other effects - Toxic

WHMIS Health Effects Criteria Met by this Chemical:
D2B - Eye irritation - toxic - other

WHMIS Ingredient Disclosure List:
Included for disclosure at 0.1% or greater.

Detailed WHMIS Classification According to Criteria:

Class A - Compressed Gas:
Does not meet criteria.

Class B - Flammable and Combustible Material:
Meets criteria for "Flammable liquid".
Closed cup flash point: 13 deg C (55.4 deg C) (100%); 17 deg C (63 deg F) (96%).

Class C - Oxidizing Material:
Does not meet criteria.

Class D - Poisonous and Infectious Material. Division 1 - Immediate and Serious Toxic Effects:
Does not meet criteria.

Acute Lethality:
Does not meet criteria.
LC50 (male rat): greater than 32380 ppm (4-hour exposure); LC50 (mouse): 21000 ppm (4-hour exposure); cited as 39 g/m3 (4-hour exposure) (unconfirmed) ; LD50 (oral, mature male rat): 7060 mg/kg (cited as 7.06 g/kg); LD50 (oral, mouse): 3450 mg/kg (unconfirmed); LD50 (dermal, rabbit): greater than 15800 mg/kg (cited as greater than 20 mL/kg) (unconfirmed)

Class D - Poisonous and Infectious Material. Division 2 - Other Toxic Effects:
Meets criteria for "Toxic material".
See detailed evaluation below.

Chronic Health Effects:
Does not meet criteria.
Adverse effects only observed at high doses.

Carcinogenicity:
Does not meet criteria.
Not listed by IARC.
ACGIH A3.
Occupational exposure to ethanol has not been associated with carcinogenicity. IARC has classified ethanol in alcoholic beverages as carcinogenic to humans (Group 1).

Teratogenicity and Embryotoxicity:
Insufficient information.
There is no evidence of developmental toxicity following occupational exposure to ethanol. Animal evidence clearly demonstrates that ingestion of ethanol can cause embryotoxicity, teratogenicity and fetotoxicity, but

only in the presence of maternal toxicity. It is well documented that exposure to ethanol through the ingestion of alcoholic beverages during pregnancy can cause significant harmful effects in unborn children. These effects are not considered relevant to occupational exposure.

Reproductive Toxicity:

Insufficient information.

There is no evidence of reproductive toxicity following occupational exposure to ethanol. Effects on reproductive organs, including decreased testicular weight, decreased numbers of motile sperm, decreased ovarian function and irregular fertility cycles, have been observed in animals given very large oral doses of ethanol. However, no confirmed effects on fertility or reproductive capability have been observed. Reproductive effects have been observed in people who have consumed large amounts of alcoholic beverages. These effects are not considered relevant to occupational exposures.

Mutagenicity:

Insufficient information.

Ethanol has caused mutagenic effects in tests using live animals. However, these effects have generally been observed at very high oral doses and the observations are not considered relevant to an occupational setting. There are no reports of mutagenic effects in people with occupational exposures. Reports of mutagenic effects in people who abuse alcoholic beverages are not considered relevant to occupational exposures.

Respiratory Tract Sensitization:

Does not meet criteria.

Not reported as a human respiratory sensitizer.

Skin Irritation:

Does not meet criteria.

Not irritating or only very mildly irritating to the skin, based on human and animal information.

Eye Irritation:

"Toxic".

Moderate to severe irritation, based on animal information.

Skin Sensitization:

Does not meet criteria.

No firm conclusions can be drawn based on the 3 occupational case reports located. Negative results have been obtained in animal tests.

Class E - Corrosive Material:

Does not meet criteria.

One source reports that anhydrous (absolute) ethanol corrodes aluminum alloys. No corrosion rate is given. However, aqueous solutions of ethanol up to 95% are not corrosive to type 3003 aluminum.

Class F - Dangerously Reactive Material:

Does not meet criteria.

US OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200)

OSHA Hazard Communication Evaluation:

Meets criteria for hazardous material, as defined by 29 CFR 1910.1200.

EUROPEAN UNION (EU) CLASSIFICATION AND LABELLING INFORMATION

This EU classification information reflects the 29th Adaptation to Technical Progress (ATP) of Council Directive 67/548/EEC. The EU has adopted the 30th ATP (2008/58/EC of 21 August 2008) and 31st ATP (2009/2/EC of 15 January 2009) of this Council Directive. See: http://ecb.jrc.ec.europa.eu/esis for current information.

EU Classification:

Highly flammable. Highly flammable. [F;R11] (135)

EU Risk Phrases:

Highly flammable. [R:11]

EU Safety Phrases:

Keep out of reach of children.* Keep container tightly closed. Keep away from sources of ignition - No smoking. [S:(2-)*7-16]
*This safety phrase can be omitted from the label when the substance or preparation is sold for industrial use only.

SECTION 16. OTHER INFORMATION

Selected Bibliography:

(1) MDL Information Systems, Inc. Ethyl alcohol. Last updated: 2007-08. In: Registry of Toxic Effects of Chemical Substances (RTECS(R)). Available from: Canadian Centre for Occupational Health and Safety (CCOHS)
(2) Bevan, C. Monohydric alcohols C1-C6. In: Patty's toxicology. 5th ed. Edited by E. Bingham, et al. Chpt. 77, Vol. 2. John Wiley and Sons, 2001. Article online posting date: Apr. 16, 2001
(3) Criteria Group for Occupational Standards, National Institute of Occupational Health. Consensus report for ethanol vapors. In: Scientific basis for Swedish occupational standards XI. Edited by P. Lundberg. Arbete och Halsa. No. 8 (1991). p. 120-125
(4) Youssef, A., et al. Comparative lethality of methanol, ethanol and mixtures in female rats. Journal of Applied Toxicology. Vol. 12, no. 3 (June 1992). p. 193-197
(5) Grant, W.M., et al. Toxicology of the Eye. 4th ed. Charles C. Thomas, 1993. p. 71-81
(6) Descotes, J. Identification of contact allergens: the mouse ear sensitization assay. Journal of Toxicology - Cutaneous and Ocular Toxicology. Vol. 7, no. 4 (Dec. 1988). p. 263-272
(7) Hills, B.W., et al. The interaction of ethyl alcohol and industrial chemicals. American Journal of Industrial Medicine. Vol. 3 (1982). p. 321- 333
(8) Marzulli, F., et al. Validation of guinea pig tests for skin hypersensitivity. In: Dermatotoxicology. 2nd ed. Edited by F.N. Marzulli, et al. Hemisphere Publishing Corporation, 1983. p. 237-250
(9) Patruno, C., et al. Allergic contact dermatitis due to ethyl alcohol. Contact Dermatitis. Vol. 31, no. 2 (Aug. 1994). p. 124
(10) Fregert, S., et al. Alcohol dermatitis. Acta Dermato-Venereologica. Vol. 49, no. 5 (1969). p. 493-497
(11) Stotts, J., et al. Induction of human skin sensitization to ethanol. The Journal of Investigative Dermatology. Vol. 69, no. 2 (Aug. 1977). p. 219-222
(12) Ophaswongse, S., et al. Alcohol dermatitis: allergic contact dermatitis and contact urticaria syndrome: a review. Contact Dermatitis. Vol. 30, no. 1 (Jan. 1994). p. 1-6
(13) Fregert, S., et al. Dermatitis from alcohols. Journal of Allergy. Vol. 34, no. 5 (Sept.-Oct. 1963). p. 404-408

(14) Hartmann, R.J., et al. Effect of exposure to toluene and ethanol alone or in combination on a match-to-sample discrimination task in the juvenile baboon. Proceedings of the Western Pharmacology Society. Vol. 27 (Jan. 1984). p. 251-253
(15) Teta, M.J., et al. Mortality study of ethanol and isopropanol production workers at two facilities. Scandinavian Journal of Work, Environmental and Health. Vol. 18, no. 2 (Apr. 1992). p. 90-96
(16) Lester, D., et al. The inhalation of ethyl alcohol by man. I. Industrial hygiene and medicolegal aspects. II. Individuals treated with tetraethylthiuram disulfide. Quarterly Journal of Studies on Alcohol. Vol. 12 (1951). p. 167-178
(17) International Agency for Research on Cancer. IARC monographs on the evaluation of carcinogenic risks to humans. Vol. 44. Alcohol drinking. World Health Organization, 1988
(18) Razani-Boroujerdi, S., et al. Alcohol-induced changes in the immune response: immunological effects of chronic ethanol intake are genetically regulated. Toxicology and Applied Pharmacology. Vol. 127, no. 1 (July 1994). p. 37-43
(19) Mullin, L.S., et al. Comparison of unconditioned reflex and conditioned avoidance tests in rats exposed by inhalation to carbon monoxide, 1,1,1-trichloroethane, toluene or ethanol. Neurotoxicology. Vol. 3, no. 1 (July 1982). p. 126-137
(20) Moser, V., et al. Acute motor and lethal effects of inhaled toluene, 1,1,1-trichloroethane, halothane and ethanol in mice: effects of exposure duration. Toxicology and Applied Pharmacology. Vol. 77 (1985). p. 285-291
(21) Ethanol; CAS No. 64-17-5. SIDS initial assessment report for SIAM 19. UNEP Publications, Oct. 2004
(22) Carneiro, L.M., et al. Behavioral and neurochemical effects on rat offspring after prenatal exposure to ethanol. Neurotoxicology and Teratology. Vol. 27, no. 4 (July 2005). p. 585-592
(23) Lamb, J. IV Ethanol. Environmental Health Perspectives. Vol. 105, suppl. 1 (Feb. 1997). p. 199-205, 309-310
(24) Nelson, B.K., et al. Neurochemical, but not behavioral, deviations in the offspring of rats following prenatal or paternal inhalation exposure to ethanol. Neurotoxicology and Teratology. Vol. 10, no. 1 (1988). p. 15-22
(25) Mankes, R.F., et al. Paternal effects of ethanol in the Long-Evans rat. Journal of Toxicology and Environmental Health. Vol. 10, no. 6 (Dec. 1982). p. 871-878
(26) Nelson, B.K., et al. Teratological assessment of methanol and ethanol at high inhalation levels in rats. Fundamental and Applied Toxicology. Vol. 5, no. 4 (Aug. 1985). p. 727-736
(27) Mankes, R.F., et al. Acute embryopathic effects of ethanol in the Long- Evans rat. Journal of Toxicology and Environmental Health. Vol. 11, no. 4 (Apr. 1983). p. 583-590
(28) Chernoff, G.F. The fetal alcohol syndrome in mice: an animal model. Teratology. Vol. 15, no. 3 (1977). p. 223-230
(29) Marietta, C.A., et al. Effects of long term ethanol inhalation on the immune and hematopoetic systems of the rat. Alcoholism. Vol. 12, no. 2 (1988). p. 211-214
(30) Wahlberg, J.E. Edema-inducing effect of solvents following topical administration. Dermatosen. Vol. 32, no. 3 (1984). p. 91-94
(31) Obe, G., et al. Genetic effects of alcohol. International Commission for Protection Against Environmental Mutagens and Carcinogens. ICPEMC Working Paper No. 15/1. Mutation Research. Vol. 186, no. 3 (1987). p. 177-200
(32) Health Council of the Netherlands. Ethanol (ethyl alcohol): Evaluation of the health effects from occupational exposure. The Hague: Health Council of the Netherlands, 2006; publication no. 2006/06OS
(33) Dong, Q.S., et al. Inhibition of platelet aggregation in whole blood after exposure of rats to alcohol by inhalation. Alcohol. Vol. 14, no. 1 (Jan.-Feb. 1997). p. 49-54
(34) Blakley, P.M. Experimental teratology of ethanol. Issues and Reviews in Teratology. Vol. 4 (1988). p. 237-282
(35) Gerarde, H.W., et al. The aspiration hazard and toxicity of a homologous series of alcohols. Archives of Environmental Health. Vol. 13 (Oct. 1966). p. 457-461
(36) Coon, R.A., et al. Animal inhalation studies on ammonia, ethylene glycol, formaldehyde, dimethylamine and ethanol. Toxicology and Applied Pharmacology. Vol. 16, no. 3 (May 1970). p. 646-655
(37) Smyth, Jr., H.F., et al. The single dose toxicity of some glycols and derivatives.

Journal of Industrial Hygiene and Toxicology. Vol. 23, no. 6 (June 1941). p. 259-268
(38) Carpenter, C.P., et al. Chemical burns of the rabbit cornea. American Journal of Ophthalmology. Vol. 29 (1946). p. 1363-1372
(39) Guess, W.L. Tissue reactions to 2-chloroethanol in rabbits. Toxicology and Applied Pharmacology. Vol. 16, no. 2 (Mar. 1970). p. 382-390
(40) Guillot, J.P., et al. Evaluation of the ocular-irritation potential of 56 compounds. Food and Chemical Toxicology. Vol. 20, no. 5 (1982). p. 573- 582
(41) Wiberg, G.S., et al. Increased ethanol toxicity in old rats: changes in LD50, in vivo and in vitro metabolism, and liver alcohol dehydrogenase activity. Toxicology and Applied Pharmacology. Vol. 16, no. 3 (May 1970). p. 718-727
(42) Phillips, II, L., et al. A comparison of rabbit and human skin response to certain irritants. Toxicology and Applied Pharmacology. Vol. 21 (1972). p. 369-382
(43) Smyth, Jr., H.F., et al. Inhalation experiments with certain lacquer solvents. The Journal of Industrial Hygiene. Vol. 10, no. 8 (Oct. 1928). p. 261-271
(44) Mankes, R.F., et al. Teratogenic and reproductive effects of ethanol in Long-Evans rat. Journal of Toxicology and Environmental Health. Vol. 10, no. 2 (1982). p. 267-276
(45) Gavaler, J.S., et al. Reproductive consequences of alcohol abuse: males and females compared and contrasted. International Commission for Protection Against Environmental Mutagens and Carcinogens. ICPEMC Working Paper No. 15/7. Mutation Research. Vol. 186, no. 3 (1987). p. 269-277
(46) Streissguth, A.P., et al. Alcohol and pregnancy: an overview and an update. Substance and Alcohol Actions/Misuse. Vol. 4, nos. 2-3 (1983). p. 149-173
(47) Kane, L.E., et al. Evaluation of sensory irritation from some common industrial solvents. American Industrial Hygiene Association Journal. Vol. 41, no. 6 (June 1980). p. 451-454
(48) Ahmed, F.E. Toxicological effects of ethanol on human health. Critical Reviews in Toxicology. Vol. 25, issue 4 (July 1995). p. 347-367
(49) Ethyl alcohol. In: Clinical toxicology of commercial products. 5th ed. Edited by R.E. Gosselin, et al. Williams and Wilkins, 1984. p. III- 166 to III-171
(50) Chaudhury, R.R., et al. Effect of alcohol on the fertility of female rabbits. Journal of Endocrinology. Vol. 34 (1966). p. 275-276
(51) Van Ketel, W.G., et al. Contact dermatitis from ethanol. Contact Dermatitis. Vol. 1 (1975). p. 7-10
(52) Kanzaki, T., et al. Late phase allergic reaction of the skin to ethyl alcohol. Contact Dermatitis. Vol. 25, no. 4 (1991). p. 252-253
(53) Rilliet, A., et al. Alcohol contact urticaria syndrome (immediate-type hypersensitivity): case report. Dermatologica. Vol. 161 (1980). p. 361-364
(54) Melli, M.C., et al. Sensitization from contact with ethyl alcohol. Contact Dermatitis. Vol. 14, no. 5 (May 1986). p. 315
(55) Wilkin, J.K., et al. Ethnic contact urticaria to alcohol. Contact Dermatitis. Vol. 12, no. 2 (Feb. 1985). p. 118-120
(56) Malik, F., et al. Haematological abnormalities in mice continuously exposed to ethanol vapour. British Journal of Experimental Pathology. Vol. 67 (1986). p. 831-8
(57) Lieber, C.S., et al. Experimental production of fatty liver, hepatitis, and cirrhosis in sub-human primates fed ethanol with adequate diets. Proceedings of the National Academy of Science, USA. Vol. 72, no. 2 (Feb. 1975). p. 437-441
(58) Zuskin, E., et al. Lung function changes by ethanol intoxication. Clinical Allergy. Vol. 11, no. 3 (May 1981). p. 243-248
(59) Drevets, C.C., et al. Dermatitis from alcohol. The Journal of Allergy. Vol. 32, no. 4 (July-Aug. 1961). p. 277-282
(60) Martin-Scott, I. Contact dermatitis from alcohol. British Journal of Dermatology. Vol. 72 (1960). p. 372-373
(61) Haxthausen, H. Allergic eczema caused by ethyl alcohol: elicited both by epicutaneous and by internal application. Acta Dermato-Venereologica. Vol. 25 (1944). p. 527-528
(62) Logsdon, J.E. Ethanol. In: Kirk-Othmer encyclopedia of chemical technology. John Wiley and Sons, 2005
(63) Emergency action guide for ethyl alcohol. Association of American Railroads, Mar. 1995
(64) Ethyl alcohol. Hawley's condensed chemical dictionary. [CD-ROM]. 15th ed.

Edited by R.J. Lewis, Sr. John Wiley and Sons, Inc., 2007
(65) Ethyl alcohol. The Merck index: an encyclopedia of chemicals, drugs and biologicals. Edited by M.J. O'Neil, et al. 14th ed. Merck and Company, 2006. p. 645
(66) Kosaric, N., et al. Ethanol. In: Ullmann's encyclopedia of industrial chemistry. 7th ed. John Wiley and Sons, 2005
(67) Odor thresholds for chemicals with established occupational health standards. American Industrial Hygiene Association, 1989. p. 18, 57-58
(68) Riddick, J.A., et al. Ethanol. In: Organic solvents: physical properties and methods of purification. 4th ed. Techniques of organic chemistry. Vol. II. John Wiley and Sons, 1986. p. 192-193, 871-876
(69) Fire protection guide to hazardous materials. 13th ed. Edited by A.B. Spencer, et al. National Fire Protection Association, 2002. NFPA 325; NFPA 491
(70) Britton, L.G. Using material data in static hazard assessment. Plant/Operations Progress. Vol. 11, no. 2 (Apr. 1992). p. 56-70
(71) Speight, J.G. Lange's handbook of chemistry. 16th ed. McGraw-Hill, Inc., 2005. p. 2.164, 2.227, 2.382, 2.429, 2.435, 2.480, 2.698
(72) CRC Handbook of chemistry and physics. 86th ed. Edited by D.R. Lide. CRC Press, 2005. p. 3-232, 15-17
(73) Syracuse Research Corporation. Interactive LogKow (KowWin) Database Demo. Date unknown
(74) Jasper, J.J. Surface tension of pure liquid compounds. In: Compilation of data of some 2200 pure liquid compounds. Journal of Physical and Chemical Reference Data. Vol. 1, no. 4 (1972). p. 852, 965
(75) Stoye, D, et al. Solvents. In: Ullmann's encyclopedia of industrial chemistry. 7th ed. John Wiley and Sons, 2005
(76) Ambrose, D., et al. Thermodynamic properties of organic oxygen compounds. XXV. Vapour pressures and normal boiling temperatures of aliphatic alcohols. Journal of Chemical Thermodynamics. Vol 2 (1970). p. 631-645
(77) Ethyl alcohol. In: NIOSH pocket guide to chemical hazards. National Institute for Occupational Safety and Health
(78) Forsberg, K., et al. Quick selection guide to chemical protective clothing. 5th ed. Wiley Interscience, John Wiley and Sons, 2007
(79) Syracuse Research Corporation. Environmental Fate Database: CHEMFATE Chemical Search. Last updated: 2008-07-16
(80) Report on Carcinogens. 11th ed. US Department of Health and Human Services, Public Health Service, National Toxicology Program
(81) Badr, F.M., et al. Evaluation of the mutagenic effects of ethyl alcohol by different techniques. Adv. Exper. Med. Biol. Vol. 85A (1977). p. 25-26
(82) Washington, W.J., et al. Ethanol-induced late fetal death in mice exposed around the time of fertilization. Mutation Research. Vol. 147 (1985). p. 205-210
(83) Kaufman, M.H. Ethanol-induced chromosomal abnormalities at conception. Nature. Vol. 302. p. 258-260
(84) Hunt, P.A. Ethanol-induced aneuploidy in male germ cells of the mouse. Cytogenetics and cell genetics. Vol. 44 (1987). p. 7-10
(85) Baraona, E., et al. Cytogenetic damage of bone marrow cells produced by chronic alcohol consumption. Life Sciences. Vol. 19 (1981). p. 1797-1802
(86) Daniel, A. and Roane, D. Aneuploidy induced by ethanol during spermatogenesis in the Chinese hamster. [Abstract]. Mutation Research. Vol. 164 (1986). p. 193
(87) Obe, G., et al. Induction of chromosomal aberrations in peripheral lymphocytes of human blood in vitro, and of SCEs in bone-marrow cells of mice in vivo by ethanol and its metabolite acetaldehyde. Mutation Research. Vol. 68 (1979). p. 291-294
(88) Tates, A.D., et al. Cytogenetic effects in hepatocytes, bone-marrow cells and blood lymphocytes of rates exposed to ethanol in drinking water. Mutation Research. Vol. 29 (1980). p. 285-288
(89) James, D.A., et al. Analysis of results from a collaborative study of the dominant lethal assay. Mutation Research. Vol. 97 (1982). p. 303-314
(90) Occupational Safety and Health Administration (OSHA). Ethyl Alcohol. In: OSHA Analytical Methods Manual. Revision Date: Oct. 31, 2001
(91) National Institute for Occupational Safety and Health (NIOSH). Alcohols I. In: NIOSH Manual of Analytical Methods (NMAM(R)). 4th ed. Edited by M.E. Cassinelli, et al. DHHS (NIOSH) Publication 94-113. Aug. 1994

(92) National Institute for Occupational Safety and Health (NIOSH). Volatile Organic Compounds (Screening). In: NIOSH Manual of Analytical Methods (NMAM(R)). 4th ed. Edited by M.E. Cassinelli, et al. DHHS (NIOSH) Publication 94-113. Aug. 1994
(93) Jacobs, G.A. OECD eye irritation tests on three alcohols: acute toxicity data. Journal of the American College of Toxicology. Part B. Vol. 1 (1990). p. 56-57
(94) Jacobs, G.A., et al. OECD skin irritation tests on three alcohols. Journal of the American College of Toxicology. Vol. 11 (1992). p. 733
(95) European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC). Eye irritation reference chemicals data bank. 2nd ed. Technical Report No. 48 (2). ECETOC, June 1998. p. 62
(96) International Agency for Research on Cancer (IARC). Alcoholic beverage consumption. IARC, Feb 6-13, 2007. Accessed: July 2007
(97) Mezey, E. et al. Effect of chronic ethanol feeding on hepatic collagen in the monkey. Hepatology. Vol. 3 (1983). p. 41 - 44
(98) Vendemiale, G., et al. Mitochondrial oxidative damage and myocardial fibrosis in rats chronically intoxicated with moderate doses of ethanol. Toxicology Letters. Vol. 123, no. 2-3 (Sept. 2001). p. 209-216
(99) NTP Technical report on toxicity studies on urethane in drinking water and urethane in 5% ethanol administered to F344 Rats and B6C3F1 mice. NIH Publication No. 96-3937. US Department of Health and Human Services, National Institutes of Health, Mar. 1996
(100) NTP technical report on the toxicology and carcinogenesis studies of urethane, ethanol, and urethane/ethanol in B6C3F1 Mice (drinking water studies). No. 510. NIH Publication No. 04-4444. US Department of Health and Human Services, National Institutes of Health, Aug. 2004
(101) Gass, J.T., et al. Alcohol exposure during development: analysis of effects on female sexual behavior. Alcoholism: Clinical and Experimental Research. Vol. 31, no. 12 (Dec. 2007). p. 2065-2072
(102) Jimenez-Farfan, D., et al. EGF-R and erbB-2 in murine tooth development after ethanol exposure. Birth Defects Research (Part A): Clinical and Molecular Teratology. Vol. 73, no. 2 (Feb. 2005). p. 65-71
(103) Bailey, C.D., et al. Chronic prenatal ethanol exposure alters the proportion of GABAergic neurons in layers II/III of the adult guinea pig somatosensory cortex. Neurotoxicology and Teratology. Vol. 26, no. 1 (Jan. 2004). p. 59-63
(104) Mihalick, S.M., et al. Prenatal ethanol exposure, generalized learning impairment, and medial prefrontal cortical deficits in rats. Neurotoxicology and Teratology. Vol. 23, no. 5 (Sept. 2001). p. 453-462
(105) Byrnes, M.L., et al. Effect of prenatal ethanol exposure during the brain growth spurt of the guinea pig. Neurotoxicology and Teratology. Vol. 23, no. 4 (July 2001). p. 355-364
(106) Vaglenova, J., et al. Fetal alcohol effects in rats exposed pre- and postnatally to a low dose of alcohol. Alcoholism: Clinical and Experimental Research. Vol. 22, no. 3 (May 1998). p. 697-703
(107) Irvine, L.H. Relevance of the developmental toxicity of ethanol in the occupational setting. Journal of Applied Toxicology. Vol. 23 (2003). p. 289-299
(108) Abel E.L. Rat offspring sired by males treated with alcohol. Alcohol. Vol. 10, no. 3 (1993). p. 237-242
(109) Abel E.L. A surprising effect of paternal alcohol treatment on rat fetuses. Alcohol. Vol. 12, no. 1 (1995). p. 1-6
(110) Grattagliano, I., et al. Chronic ethanol intake induces oxidative alterations in rat testis. Journal of Applied Toxicology. Vol. 17, no. 5 (1997). p. 307-311
(111) Phillips, B.J., et al. Is ethanol genotoxic? A review of the published data. Mutagenesis. Vol. 16, no. 2 (Mar. 2001). p. 91-101
(112) Navasumrit, P., et al. Ethanol enhances the formation of endogenously and exogenously derived adducts in rat hepatic DNA. Mutation Research. Vol. 479, no. 1-2 (Aug. 2001). p. 81-94
(113) Marrubini, G., et al. Prolonged ethanol ingestion enhances benzene myelotoxicity and lowers urinary concentrations of benzene metabolite levels in CD-1 male mice. Toxicological Sciences. Vol. 75, no. 1 (Sept. 2003). p. 16-24
(114) Acharya, S., et al. A subtoxic interactive toxicity study of ethanol and chromium in male Wistar rats. Alcohol. Vol. 23, no. 2 (Feb. 2001). p. 99-108

(115) Brand, R.M., et al. A single oral dose of ethanol can alter transdermal absorption of topically applied chemicals in rats. Toxicological Sciences. Vol. 92, no. 2 (Aug. 2006). p. 349-355
(116) Seeber, A., et al. Solvent exposure and ratings of well-being: dose-effect relationships and consistency of data. Environmental Research. Vol. 73, no. 1-2 (1997). p. 81-91
(117) Nadeau, V., et al. Neuromotor effects of acute ethanol inhalation exposure in humans: a preliminary study. Journal of Occupational Health (Japan). Vol. 45, no. 4 (July 2003). p. 215-222
(118) Basketter, D.A., et al. Determination of skin irritation potential in the human 4-hour patch test. Contact Dermatitis. Vol. 51 (2004). p. 1-4
(119) Loffler, H., et al. How irritant is alcohol? British Journal of Dermatology. Vol. 157, no. 1 (July 2007). p. 74-81
(120) Tupker, R.A., et al. Irritancy of antiseptics tested by repeated open exposures on the human skin, evaluated by non-invasive methods. Contact Dermatitis. Vol. 37, no. 5 (Nov. 1997). p. 213-217
(121) Okazawa, H., et al. Allergic contact dermatitis due to ethyl alcohol. Contact dermatitis. Vol. 38 (1998). p. 233
(122) Boffetta P., et al. Alcohol and cancer. Lancet Oncology. Vol. 7, no. 2 (Feb. 2006). p. 149-156
(123) Health Council of the Netherlands. Risks of alcohol consumption related to conception, pregnancy and breastfeeding. The Hague: Health Council of the Netherlands, 2005; publication no. 2004/22
(124) Gohlke, J.M., et al. Computational models of ethanol-induced neurodevelopmental toxicity across species: implications for risk assessment. Birth Defects Research (Part B). Vol. 83 (2008). p. 1-11
(125) Maffei, F., et al. Increased cytogenetic damage detected by FISH analysis on micronuclei in peripheral lymphocytes from alcoholics. Mutagenesis. Vol. 15, no. 6 (2000). p. 517-523
(126) Syracuse Research Corporation. The Physical Properties Database (PHYSPROP). Interactive PhysProp Database Demo. Date unknown
(127) Morrison, R.T., et al. Organic chemistry. 4th ed. Allyn and Bacon, 1983. p. 201-202, 500-501
(128) Pine, S.H., et al. Organic chemistry. 4th ed. McGraw-Hill Book Company, 1980. p. 200
(129) Urben, P.G., ed. Bretherick's handbook of reactive chemical hazards. 5th ed. Vol. 1. Butterworth-Heinemann Ltd., 1995. p. 343-345
(130) Ethyl alcohol. In: Handbook of corrosion data. 2nd ed. Edited by B.D. Craig, et al. ASM International, 1995. p. 331-334
(131) Pruett, K.M. Chemical resistance guide to metals and alloys: a guide to chemical resistance of metals and alloys. Compass Publications, 1995. p. 122-133
(132) Schweitzer, P.A. Corrosion resistance tables: metals, nonmetals, coatings, mortars, plastics, elastomers and linings, and fabrics. 4th ed. Part B, E-O. Marcel Dekker, Inc., 1995. p. 1145-1148
(133) Pruett, K.M. Chemical resistance guide for plastics: a guide to chemical resistance of engineering thermoplastics, fluoroplastics, fibers and thermoset resins. Compass Publications, 2000. p. 170-181
(134) Pruett, K.M. Chemical resistance guide for elastomers II: a guide to chemical resistance of rubber and elastomeric compounds. Compass Publications, 1994. p. C-134 to C-145
(135) European Economic Community. Commission Directive 93/72/EEC. Sept. 1, 1993

Information on chemicals reviewed in the CHEMINFO database is drawn from a number of publicly available sources. A list of general references used to compile CHEMINFO records is available in the database Help.

Review/Preparation Date: 2009-01-15

Revision Indicators:

TLV-TWA	2009-03-17
TLV-STEL	2009-03-17
TLV basis	2009-03-17
TLV proposed changes	2009-03-17
Carcinogenicity	2009-03-23
WHMIS detailed classification	2009-03-23

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