Chemical identification Trichloroethylene
Synonyms TCE, Ethylene trichloride, Acetylene trichloride, Ethinyl trichloride, Trichloroethene
Composition > 99%
Chemical structure C2HCl3
CAS No. 79-01-6

SECTION 4 - FIRST AID MEASURES

Swallowed
If swallowed do NOT induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain open airway and prevent aspiration. Observe the patient carefully. Never give liquid to a person showing signs of being sleepy or with reduced awareness; i.e. becoming unconscious. Give water to rinse out mouth, then provide liquid slowly and as much as casualty can comfortably drink. Seek medical advice.
Eye
If this product comes in contact with the eyes: Wash out immediately with fresh running water. Ensure complete irrigation of the eye by keeping eyelids apart and away from eye and moving the eyelids by occasionally lifting the upper and lower lids. Seek medical attention without delay; if pain persists or recurs seek medical attention.
Skin
If skin contact occurs: Immediately remove all contaminated clothing, including footwear. Flush skin and hair with running water (and soap if available) Seek medical attention in event of irritation.
Inhaled
If fumes or combustion products are inhaled remove from contaminated area. Lay patient down. Keep warm and rested. Prostheses such as false teeth, which may block airway, should be removed, where possible, prior to initiating first aid procedures. Apply artificial respiration if not breathing, preferably with a demand valve resuscitator, bag-valve mask device, or pocket mask as trained. Perform CPR if necessary. Transport to hospital, or doctor.
Notes to Physician
Treat symptomatically. Following acute or short-term continued exposures to trichloroethylene: Trichloroethylene concentration in expired air correlates with exposure. 8 hours exposure to 100 ppm produces levels of 25 ppm immediately and 1 ppm 16 hours after exposure. Most mild exposures respond to removal from the source and supportive care. Serious toxicity most often results from hypoxemia or cardiac dysrhythmias so that oxygen, intubation, intravenous lines and cardiac monitoring should be started initially as the clinical situation dictates. Ipecac syrup should be given to alert patients who ingest more than a minor amount and present within 2 hours. The efficacy of activated charcoal and cathartics is unclear. The metabolites, trichloracetic acid, trichloroethanol and to a lesser degree, chloral hydrate, may be detected in the urine up to 16 days post exposure.

[Ellenhorn and Barceloux: Medical Toxicology]
BIOLOGICAL EXPOSURE INDEX – BEI

These represent the determinants observed in specimens collected from a healthy worker who has been exposed at the Exposure Standard (ES or TLV):

Determinant	Index	Sampling Time	Comments
1. Trichloroacetic acid in urine	10 mg/gm creatinine	End of work-week	NS
2. Trichloroacetic acid AND Trichloroethanol in urine	300mg/mg creatinine	End of shift at end of work-week	NS
3. Free Trichlorethanol in blood	4 mg/L	End of shift at end of work-week	NS
4. Trichloroethylene in end-exhaled air			SQ
5. Trichloroethylene in blood			SQ

NS: Non-specific determinant; also seen after exposure to other materials
SQ: Semi quantitative determinant - Interpretation may be ambiguous; should be used as a screening test or confirmatory test.

SECTION 5 - FIRE FIGHTING MEASURES

Extinguishing media
Water spray or fog. Foam. Dry chemical powder. BCF (where regulations permit). Carbon dioxide.
Fire fighting
Alert Fire Brigade and tell them location and nature of hazard. Wear breathing apparatus plus protective gloves. Prevent, by any means available, spillage from entering drains or water courses. Use firefighting procedures suitable for surrounding

area. DO NOT approach containers suspected to be hot. Cool fire exposed containers with water spray from a protected location. If safe to do so, remove containers from path of fire. Equipment should be thoroughly decontaminated after use.

Fire/Explosion hazard

Decomposes on heating and produces acrid and toxic fumes of: carbon dioxide (CO2), hydrogen chloride, phosgene and other pyrolysis products typical of burning organic material. May emit poisonous fumes. Non flammable liquid. However vapour will burn when in contact with high temperature flame. Ignition ceases on removal of flame. May form a flammable/explosive mixture in an oxygen enriched atmosphere. Heating may cause expansion/vapourisation with violent rupture of containers Decomposes on heating and produces corrosive fumes of hydrochloric acid, carbon monoxide and small amounts of toxic phosgene.

Fire incompatibility

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

Personal protective equipment

Breathing apparatus. Chemical splash suit. Chemical goggles. Safety glasses with side shields. Protective gloves. Safety gumboots.

SECTION 6 - ACCIDENTAL RELEASE MEASURES

Minor spills

Clean up all spills immediately. Avoid breathing vapours and contact with skin and eyes. Control personal contact with the substance, by using protective equipment. Contain and absorb spill with sand, earth, inert material or vermiculite. Wipe up. Place in a suitable, labelled container for waste disposal.

Major spills

Clear area of personnel and move upwind. Alert Fire Brigade and tell them location and nature of hazard. Wear full body protective clothing with breathing apparatus. Prevent, by all means available, spillage from entering drains or water courses. Consider evacuation (or protect in place). No smoking, naked lights or ignition sources. Increase ventilation. Stop leak if safe to do so. Water spray or fog may be used to disperse/absorb vapour. Contain or absorb spill with sand, earth or vermiculite. Collect recoverable product into labelled containers for recycling. Collect solid residues and seal in labelled drums for disposal. Wash area and prevent runoff into drains. After cleanup operations, decontaminate and launder all protective clothing and equipment before storing and re-using. If contamination of drains or waterways occurs, advise emergency services. Chemical Class: aliphatics, halogenated For release onto land: recommended sorbents listed in order of priority.

SORBENT TYPE	RANK	APPLICATION	COLLECTION	LIMITATIONS
LAND SPILL - SMALL				
cross-linked polymer – particulate	1	shovel	shovel	R, W, SS
cross-linked polymer – pillow	1	throw	pitchfork	R, DGC, RT
wood fiber – pillow	2	throw	pitchfork	R, P, DGC, RT
treated wood fiber – particulate	2	shovel	shovel	R, W, DGC
sorbent clay – particulate	3	shovel	shovel	R, I, P
foamed glass – pillow	3	throw	pitchfork	R, P, DGC, RT
LAND SPILL - MEDIUM				
cross-linked polymer – particulate	1	blower	skiploader	R, W, SS
cross-linked polymer – pillow	2	throw	skiploader	R, DGC, RT
sorbent clay – particulate	3	blower	skiploader	R, I, P
polypropylene – particulate	3	blower	skiploader	W, SS, DGC
foamed glass – pillow	3	throw	skiploader	R, P, DGC, RT
expanded mineral – particulate	4	blower	skiploader	R, I, W, P, DGC

Legend
DGC: Not effective where ground cover is dense
R: Not reusable
I: Not incinerable
P: Effectiveness reduced when rainy
RT: Not effective where terrain is rugged
SS: Not for use within environmentally sensitive sites
W: Effectiveness reduced when windy
Reference: Sorbents for Liquid Hazardous Substance Cleanup and Control;

R.W Melvold et al: Pollution Technology Review No. 150: Noyes Data Corporation 1988
Personal Protective Equipment advice is contained in Section 8 of the MSDS.

SECTION 7 - HANDLING AND STORAGE

Procedure for handling
DO NOT allow clothing wet with material to stay in contact with skin. Avoid all personal contact, including inhalation. Wear protective clothing when risk of exposure occurs. Use in a well-ventilated area. Prevent concentration in hollows and sumps. DO NOT enter confined spaces until atmosphere has been checked. DO NOT allow material to contact humans, exposed food or food utensils. Avoid contact with incompatible materials. When handling, DO NOT eat, drink or smoke. Keep containers securely sealed when not in use. Avoid physical damage to containers. Always wash hands with soap and water after handling. Work clothes should be laundered separately. Launder contaminated clothing before re-use. Use good occupational work practice. Observe manufacturer's storage and handling recommendations contained within this SDS. Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
Suitable container
DO NOT use aluminium or galvanised containers. Lined metal can, lined metal pail/can. Plastic pail. Polyliner drum. Packing as recommended by manufacturer. Check all containers are clearly labelled and free from leaks. For low viscosity materials: Drums and jerricans must be of the non-removable head type. Where a can is to be used as an inner package, the can must have a screwed enclosure. For materials with a viscosity of at least 2680 cSt. (23 deg. C) and solids (between 15 C deg. And 40 deg C.): Removable head packaging; Cans with friction closures and low pressure tubes and cartridges may be used. Where combination packages are used, and the inner packages are of glass, there must be sufficient inert cushioning material in contact with inner and outer packages. In addition, where inner packagings are glass and contain liquids of packing group I and II there must be sufficient inert absorbent to absorb any spillage. Unless the outer packaging is a close fitting moulded plastic box and the substances are not incompatible with the plastic. Inhibited grades may be stored in metal drums.
Storage incompatibility
Haloalkenes are highly reactive. Some of the more lightly substituted lower members are highly flammable; many members of the group are peroxidisable and polymerisable. Avoid reaction or contact with potassium or its alloys - although apparently stable on contact with a wide range of halocarbons, reaction products may be shock-sensitive and may explode with great violence on light impact. Severity generally increases with the degree of halocarbon substitution and potassium-sodium alloys give extremely sensitive mixtures. BRETHERICK L.: Handbook of Reactive Chemical Hazards Avoid reaction with metal halides and active metals, e.g. sodium (Na), potassium (K), calcium (Ca), zinc (Zn), powdered aluminium (Al), magnesium (Mg) and magnesium alloys. Avoid contact with rubber, and plastics such as methacrylate polymers, polyethylene and polystyrene Haloacetylenes should be used with exceptional precautions. Explosions may occur during distillation when bath temperatures are too high or if air is admitted to a hot vacuum-distillation as evidenced by experience with bromoacetylenes. BRETHERICK L.: Handbook of Reactive Chemical Hazards Trichloroethylene: reacts violently with caustics (e.g. lye, potassium hydroxide, sodium hydroxide, etc.) produces spontaneously explosive dichloroacetylene in presence of caustics, epichlorohydrin, epoxides forms an explosive mixture with nitrogen tetroxide reacts violently with finely divided chemically active metals may undergo self-accelerating polymerisation in presence of magnesium, titanium, aluminium may ignite on contact with alkaline metal earths reacts explosively with sodium, potassium, lithium my decompose with formation of chlorine gas, hydrogen chloride gas and phosgene at high temperatures, in contact with hot metals, open flame and high intensity UV light slowly decomposes in light, in the presence of moisture, forming hydrochloric acid reacts, possibly violently, with aluminium tripropyl, antimony triethyl, antimony trimethyl, dimethylformamide, liquid oxygen, ozone, potassium nitrate, trimethylaluminium attacks metals, coatings, and plastics in presence of moisture attacks natural rubber may accumulate static charge and cause ignition of vapors Avoid storage with strong oxidisers (particularly oxygen in gas or liquid form and nitrogen dioxide), strong bases, acetone, sodium/sodium-potassium alloys, zinc. Avoid strong bases.

SECTION 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION

Control parameters
OCCUPATIONAL EXPOSURE LIMITS (OEL)
INGREDIENT DATA

Source	Ingredient	Material name	TWA	STEL	Peak	Notes
Singapore Permissible Exposure Limits of Toxic Substances	trichloroethylene	trichloroethylene	269 mg/m3 / 50 ppm	537 mg/m3 / 100 ppm	Not Available	Not Available

EMERGENCY LIMITS

Ingredient	Material name	TEEL-1	TEEL-2	TEEL-3
trichloroethylene	trichloroethylene	Not Available	Not Available	Not Available

Ingredient	Original IDLH	Revised IDLH
trichloroethylene	1,000 ppm	1,000 (Unch) ppm

MATERIAL DATA

For trichloroethylene: Odour Threshold Value: 82 ppm (detection), 108 ppm (recognition) NOTE: Detector tubes for trichloroethylene, measuring in excess of 10 ppm, are commercially available. Long-term measurements (4 hrs) may be conducted to detect concentrations exceeding 2.5 ppm. Organs systems reported to be affected by excessive exposures of humans and animals to TCE are the central nervous system (CNS) (nausea, ataxia, headache, euphoria, analgesia, anaesthesia); liver (degeneration, hepatocellular carcinomas, mice only); kidney (degeneration); lung (oedema, tachypnea); heart (arrhythmias); skin (irritation, vesication) and paralysis of the fingers following immersion. Exposure at or below the recommended TLV-TWA is thought to minimise the potential for headache, fatigue and irritability. A STEL has been advised to protect against incoordination and other anaesthetic effects. Control of concentrations to these limits should also provide a substantial margin of safety in the prevention of liver and other systemic damage. The lower limit (REL-TWA) recommended by NIOSH is based on acute central nervous system (CNS) effects, headache and fatigue observed in health hazard evaluations at levels of 25 ppm to 50 ppm and upon the potential for cancer in humans (hepatocellular carcinomas in mice exposed by chronic gastric lavage is cited). - Notes on Trichloroethylene Toxicity: Concentration Clinical Effects: 100 ppm Odour Threshold barely perceptible to the unacclimated, 200 ppm Odour apparent, not unpleasant; slight eye irritation, 400 ppm (3 hours) Odour very definite, not unpleasant; slight eye irritation and minimal light- headedness, 1000-1200 ppm (6 min) Very strong odour, unpleasant; definite eye and nasal irritation with light- headedness and dizziness, 2000 ppm (5 min) Odour very strong, not tolerable; marked eye and respiratory irritation with drowsiness, dizziness and nausea.
Odour Safety Factor(OSF)
OSF=1.8 (TRICHLOROETHYLENE Established occupational exposure limits frequently do not take into consideration reproductive end points that are clearly below the thresholds for other toxic effects. Occupational reproductive guidelines (ORGs) have been suggested as an additional standard. These have been established after a literature search for reproductive no-observed-adverse effect-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL). In addition the US EPA's procedures for risk assessment for hazard identification and dose-response assessment as applied by NIOSH were used in the creation of such limits. Uncertainty factors (UFs) have also been incorporated. These exposure guidelines have been derived from a screening level of risk assessment and should not be construed as unequivocally safe limits. ORGS represent an 8-hour time-weighted average unless specified otherwise. CR = Cancer Risk/10000; UF = Uncertainty factor: TLV believed to be adequate to protect reproductive health: LOD: Limit of detection Toxic endpoints have also been identified as: D = Developmental; R = Reproductive; TC = Transplacental carcinogen Jankovic J., Drake F.: A Screening Method for Occupational Reproductive American Industrial Hygiene Association Journal 57: 641-649 (1996) Exposed individuals are NOT reasonably expected to be warned, by smell, that the Exposure Standard is being exceeded.
Odour Safety Factor (OSF) is determined to fall into either Class C, D or E.
The Odour Safety Factor (OSF) is defined as: OSF= Exposure Standard (TWA) ppm/ Odour Threshold Value (OTV) ppm.

Classification into classes follows:

Class	OSF	Description
A	550	Over 90% of exposed individuals are aware by smell that the Exposure Standard (TLV-TWA for example) is being reached, even when distracted by working activities
B	26-550	As "A" for 50-90% of persons being distracted
C	1-26	As "A" for less than 50% of persons being distracted
D	0.18-1	10-50% of persons aware of being tested perceive by smell that the Exposure Standard is being reached
E	<0.18	As "D" for less than 10% of persons aware of being tested

5.5 mg/m3 100 D NA

Respirator

Type A Filter of sufficient capacity. (AS/NZS 1716 & 1715, EN 143:2000 & 149:2001, ANSI Z88 or national equivalent). Where the concentration of gas/particulates in the breathing zone, approaches or exceeds the "Exposure Standard" (or ES), respiratory protection is required. Degree of protection varies with both face-piece and Class of filter; the nature of protection varies with Type of filter.

Required Minimum Protection Factor	Half-Face Respirator	Full-Face Respirator	Powered Air Respirator
up to 10 x ES	A-AUS / Class 1	-	A-PAPR-AUS / Class 1
up to 50 x ES	Air-line*	-	-

up to 100 x ES	-	A-3	-
100+ x ES	-	Air-line**	-

* - Continuous-flow; ** - Continuous-flow or positive pressure demand
A (All classes) = Organic vapours, B AUS or B1 = Acid gasses, B2 = Acid gas or hydrogen cyanide (HCN), B3 = Acid gas or hydrogen cyanide (HCN), E = Sulfur dioxide (SO2), G = Agricultural chemicals, K = Ammonia (NH3), Hg = Mercury, NO = Oxides of nitrogen, MB = Methyl bromide, AX = Low boiling point organic compounds (below 65 degC)

Eye

Safety glasses with side shields. Chemical goggles.

Hands/feet

Wear chemical protective gloves, e.g. PVC. Wear safety footwear or safety gumboots, e.g. Rubber. The selection of suitable gloves does not only depend on the material, but also on further marks of quality which vary from manufacturer to manufacturer. Where the chemical is a preparation of several substances, the resistance of the glove material cannot be calculated in advance and has therefore to be checked prior to the application. The exact break through time for substances has to be obtained from the manufacturer of the protective gloves and has to be observed when making a final choice. Suitability and durability of glove type is dependent on usage. Important factors in the selection of gloves include: frequency and duration of contact, chemical resistance of glove material, glove thickness and dexterity Select gloves tested to a relevant standard (e.g. Europe EN 374, US F739, AS/NZS 2161.1 or national equivalent). When prolonged or frequently repeated contact may occur, a glove with a protection class of 5 or higher (breakthrough time greater than 240 minutes according to EN 374, AS/NZS 2161.10.1 or national equivalent) is recommended. When only brief contact is expected, a glove with a protection class of 3 or higher (breakthrough time greater than 60 minutes according to EN 374, AS/NZS 2161.10.1 or national equivalent) is recommended. Some glove polymer types are less affected by movement and this should be taken into account when considering gloves for long-term use. Contaminated gloves should be replaced. Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturiser is recommended. Polyethylene gloves.

Recommended material(s)

GLOVE SELECTION INDEX

Glove selection is based on a modified presentation of the: "Forsberg Clothing Performance Index". The effect(s) of the following substance(s) are taken into account in the computer generated selection: TRICHLOROETHYLENE

Material	PI
PE/EVAL/PE	A
PVA	A
TEFLON	A
VITON	B
HYPALON	C
NEOPRENE	C
NITRILE	C
PVC	C
VITON/NEOPRENE	C
VITON/NITRILE	C

* PI – Performance Index
A: Best Selection
B: Satisfactory; may degrade after 4 hours continuous immersion
C: Poor to Dangerous Choice for other than short term immersion
NOTE: As a series of factors will influence the actual performance of the glove, a final selection must be based on detailed observation. - * Where the glove is to be used on a short term, casual or infrequent basis, factors such as "feel" or convenience (e.g. disposability), may dictate a choice of gloves which might otherwise be unsuitable following long-term or frequent use. A qualified practitioner should be consulted.

Other

Employees working with confirmed human carcinogens should be provided with, and be required to wear, clean, full body protective clothing (smocks, coveralls, or long-sleeved shirt and pants), shoe covers and gloves prior to entering the regulated area. [AS/NZS ISO 6529:2006 or national equivalent] Employees engaged in handling operations involving carcinogens should be provided with, and required to wear and use half-face filter-type respirators with filters for dusts, mists and fumes, or air purifying canisters or cartridges. A respirator affording higher levels of protection may be substituted. [AS/NZS 1715 or national equivalent] Emergency deluge showers and eyewash fountains, supplied with potable water, should be located near, within sight of, and on the same level with locations where direct exposure is likely. Prior to each exit from an area containing confirmed human carcinogens, employees should be required to remove and leave protective clothing and

equipment at the point of exit and at the last exit of the day, to place used clothing and equipment in impervious containers at the point of exit for purposes of decontamination or disposal. The contents of such impervious containers must be identified with suitable labels. For maintenance and decontamination activities, authorized employees entering the area should be provided with and required to wear clean, impervious garments, including gloves, boots and continuous-air supplied hood. Prior to removing protective garments the employee should undergo decontamination and be required to shower upon removal of the garments and hood.

Engineering controls

Engineering controls are used to remove a hazard or place a barrier between the worker and the hazard. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions to provide this high level of protection. The basic types of engineering controls are: Process controls which involve changing the way a job activity or process is done to reduce the risk. Enclosure and/or isolation of emission source which keeps a selected hazard "physically" away from the worker and ventilation that strategically "adds" and "removes" air in the work environment. Ventilation can remove or dilute an air contaminant if designed properly. The design of a ventilation system must match the particular process and chemical or contaminant in use. Employers may need to use multiple types of controls to prevent employee overexposure. Employees exposed to confirm human carcinogens should be authorized to do so by the employer, and work in a regulated area. Work should be undertaken in an isolated system such as a "glove-box". Employees should wash their hands and arms upon completion of the assigned task and before engaging in other activities not associated with the isolated system. Within regulated areas, the carcinogen should be stored in sealed containers, or enclosed in a closed system, including piping systems, with any sample ports or openings closed while the carcinogens are contained within. Open vessel systems are prohibited. Each operation should be provided with continuous local exhaust ventilation so that air movement is always from ordinary work areas to the operation. Exhaust air should not be discharged to regulated areas, non-regulated areas or the external environment unless decontaminated. Clean make-up air should be introduced in sufficient volume to maintain correct operation of the local exhaust system. For maintenance and decontamination activities, authorized employees entering the area should be provided with and required to wear clean, impervious garments, including gloves, boots and continuous-air supplied hood. Prior to removing protective garments the employee should undergo decontamination and be required to shower upon removal of the garments and hood. Except for outdoor systems, regulated areas should be maintained under negative pressure (with respect to non-regulated areas). Local exhaust ventilation requires make-up air be supplied in equal volumes to replaced air. Laboratory hoods must be designed and maintained so as to draw air inward at an average linear face velocity of 0.76 m/sec with a minimum of 0.64 m/sec. Design and construction of the fume hood requires that insertion of any portion of the employees body, other than hands and arms, be disallowed.

SECTION 9 - PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Colourless liquid with a sweetish, chloroform-like odour.

Physical properties

State	Liquid	Molecular Weight (g/mol)	131.38
Melting Range (°C)	> 73	Viscosity	Not Available
Boiling Range (°C)	86 – 88	Solubility in water (g/L)	Immiscible
Flash Point (°C)	Not Applicable	pH (1% solution)	Not Applicable
Decomposition Temp (°C)	Not Available	pH (as supplied)	Not Applicable
Auto ignition Temp (°C)	410	Vapour Pressure (kPa)	7.87 @ 20 °C
Upper Explosive Limit (%)	90	Specific Gravity (water=1)	1.47
Lower Explosive Limit (%)	12.5	Relative Vapour density (air=1)	4.54
Volatile Component (%vol)	100	Evaporation Rate	Not Available

SECTION 10 - CHEMICAL STABILITY AND REACTIVITY INFORMATION

Conditions contributing to instability

Unstable in the presence of incompatible materials. Product is considered stable. Hazardous polymerisation will not occur.

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

SECTION 11 - TOXICOLOGICAL INFORMATION

Acute toxicity

Trichloroethylene

TOXICITY **IRRITATION**

LD50 – Dermal – (rabbit) – 29400 mg/kg
LC50 – Inhalation – (rat) – 140.7 mg/L/1 Hour
LD50 – Oral – (rat) – 4920 mg/kg

Eye – (rabbit) – 20 mg/24 hours – SEVERE
Skin – (rabbit) – 500 mg/24 hours – SEVERE

Skin corrosion or irritation

The material produces severe skin irritation; evidence exists, or practical experience predicts, that the material either: produces severe inflammation of the skin in a substantial number of individuals following direct contact, and/or produces significant and severe inflammation when applied to the healthy intact skin of animals (for up to four hours), such inflammation being present twenty-four hours or more after the end of the exposure period. Skin irritation may also be present after prolonged or repeated exposure; this may result in a form of contact dermatitis (nonallergic). The dermatitis is often characterised by skin redness (erythema) and swelling (oedema) which may progress to blistering (vesiculation), scaling and thickening of the epidermis. At the microscopic level there may be intercellular oedema of the spongy layer of the skin (spongiosis) and intracellular oedema of the epidermis. NOTE: Prolonged contact is unlikely, given the severity of response, but repeated exposures may produce severe ulceration. Skin contact with the material may damage the health of the individual; systemic effects may result following absorption. Open cuts, abraded or irritated skin should not be exposed to this material Entry into the blood-stream through, for example, cuts, abrasions, puncture wounds or lesions, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

Serious eye damage or irritation

Evidence exists, or practical experience predicts, that the material may cause eye irritation in a substantial number of individuals and/or may produce significant ocular lesions which are present twenty-four hours or more after instillation into the eye(s) of experimental animals. Repeated or prolonged eye contact may cause inflammation characterised by a temporary redness (similar to windburn) of the conjunctiva (conjunctivitis); temporary impairment of vision and/or other transient eye damage/ulceration may occur.

Respiratory or skin sensitization

Inhalation of vapours may cause drowsiness and dizziness. This may be accompanied by narcosis, reduced alertness, loss of reflexes, lack of coordination and vertigo. Limited evidence or practical experience suggests that the material may produce irritation of the respiratory system, in a significant number of individuals, following inhalation. In contrast to most organs, the lung is able to respond to a chemical insult by first removing or neutralising the irritant and then repairing the damage. The repair process, which initially evolved to protect mammalian lungs from foreign matter and antigens, may however, produce further lung damage resulting in the impairment of gas exchange, the primary function of the lungs. Respiratory tract irritation often results in an inflammatory response involving the recruitment and activation of many cell types, mainly derived from the vascular system. Inhalation hazard is increased at higher temperatures. Acute effects from inhalation of high concentrations of vapour are pulmonary irritation, including coughing, with nausea; central nervous system depression - characterised by headache and dizziness, increased reaction time, fatigue and loss of co-ordination Inhalation of aerosols (mists, fumes), generated by the material during the course of normal handling, may be damaging to the health of the individual. Anaesthetics and narcotic effects (with dulling of senses and odour fatigue) are a consequence of exposure to chlorinated solvents. Individual response varies widely; odour may not be considered objectionable at levels which quickly induce central nervous system effects. High vapour concentrations may give a feeling of euphoria. This may result in reduced responses, followed by rapid onset of unconsciousness, possible respiratory arrest and death. Systemic effects of trichloroethylene (TCE) exposure involve the central nervous system and produce headache, light-headedness, dizziness, ataxia, euphoria, confusion, drowsiness, and coma. Other adverse findings include nausea, vomiting, hypotension, bradycardia or tachycardia and hepatitis. Deaths may occur from ventricular arrhythmias as a result of sensitisation of the myocardium to adrenaline or other catecholamines. Recovery from narcotic effects is usually rapid following cessation of exposure. Trigeminal nerve impairment and peripheral neuropathy have been reported following TCE exposure. Evidence of acute human toxicity comes mainly from the use of TCE as an anaesthetic. Tachypnea and ventricular arrhythmias are experienced at inhaled concentrations exceeding 15000 ppm. Systemic toxicity is low following anaesthesia. Occasional hepatotoxicity (liver dysfunction) has been reported; this is probably due to the breakdown of TCE to dichloroacetylene and phosgene by soda-lime present in some anaesthetic devices. The effects of TCE appear to be enhanced in some individuals by simultaneous exposure to caffeine, ethanol and other drugs. "Degreaser's Flush" describes a reddening of facial, neck and back skin and is seen by certain individuals after exposure to TCE.

Germ cell mutagenicity

Strong evidence exists that the substance may cause irreversible but non-lethal mutagenic effects following a single exposure. Symmetrically substituted oxiranes such as 1,2-dichloroethylene and 1,1,2-2-tetrachloroethylene are more stable and less mutagenic than unsymmetrical chlorinated oxiranes such as 1,1-dichloroethylene, 1,1,2-trichloroethylene and monochloroethylene (vinyl chloride).

Carcinogenicity

Strong evidence exists that the substance may cause irreversible but non-lethal mutagenic effects following a single exposure. On the basis, primarily, of animal experiments, the material may be regarded as carcinogenic to humans. There is sufficient evidence to provide a strong presumption that human exposure to the material may result in cancer on the basis of:

appropriate long-term animal studies, other relevant information. There is some evidence that human exposure to the material may result in developmental toxicity. This evidence is based on animal studies where effects have been observed in the absence of marked maternal toxicity, or at around the same dose levels as other toxic effects but which are not secondary non-specific consequences of the other toxic effects. Halogenated oxiranes may arise following epoxidation of haloalkenes. The metabolism of haloethylenes by microsomal oxidation leading to epoxide formation across the double bond has been proposed. The resulting oxiranes are highly reactive and may covalently bind to nucleic acids leading to mutations and possible cancers. A measure of such potential carcinogenicity is the development of significant preneoplastic foci in livers of treated rats. The carcinogenicity of halogenated oxiranes may lie in the reactivity of an epoxide intermediate. It is reported that 1,1-dichloroethylene, vinyl chloride, trichloroethylene, tetrachloroethylene and chloroprene, for example, are carcinogens in vivo - this may be a consequence of oxirane formation. Symmetrically substituted oxiranes such as 1,2-dichloroethylene and 1,1,2-2-tetrachloroethylene are more stable and less mutagenic than unsymmetrical chlorinated oxiranes such as 1,1 dichloroethylene, 1,1,2-trichloroethylene and monochloroethylene (vinyl chloride). The carcinogenicity of 1,1-dichloroethylene has primarily been associated with inhalation exposure while that of vinyl chloride, trichloroethylene and tetrachloroethylene occurs following exposure by both inhalation and oral routes. National Toxicology Program Toxicity Report Series Number 55; April 2002. Various studies report an association between cancer and industrial exposure to tetrachloroethylene; IARC concluded that this evidence is sufficient to assign appropriate warnings. Similar warnings have been issued by IARC for vinyl fluoride. Similarly vinyl bromide exhibited neoplastic and tumourigenic activity in rats exposed by inhalation and is classified by various bodies as potentially carcinogenic. Substances such as chloroprene (2-chloro-1,3-butadiene), are reported to produce an increased frequency of chromosomal aberrations in the lymphocytes of Russian workers. Russian epidemiological studies also suggest an increased incidence of skin and lung cancer following exposure to chloroprene, a result which is not supported by other studies. Generally speaking, the monohalogenated substances exhibit higher carcinogenic potential than their dihalogenated counterparts. Whether additional substitution lessens such hazard is conjectural. Tetrafluoroethylene, for example, produced clear evidence of carcinogenic activity in a two-year inhalation study in rats and mice. National Toxicology Program Technical Report Series 450, April 1997.

TRICHLOROETHYLENE: Three European studies have found slight but statistically significant increases in cancer in workers exposed to trichloroethylene. A survey of Finnish workers exposed to primarily trichloroethylene found an association of limited statistical significance between exposure and incidence of stomach, liver, prostate, and lymphohematopoietic cancers. A significant association between workplace exposure to trichloroethylene and kidney cancer was found in a retrospective cohort study of German cardboard factory workers. In a study of Swedish workers, a statistically significant increase in non Hodgkin's lymphoma was observed. These workers were exposed to solvents in addition to trichloroethylene, and exposures were self-reported. A study of dry cleaners found a significant increase in the incidence of all malignant neoplasms combined as well as increased incidences of cancer at several sites (lung/bronchus/trachea, cervix, and skin). Some laboratory studies with rats and mice have linked trichloroethylene exposure to various types of cancers. Several of these studies, however, should be viewed cautiously, since the tumorigenic activity might be influenced by the presence of direct-acting compounds, namely the epoxides (e.g., epichlorohydrin) added as stabilizers in trichloroethylene. Epoxides are known to be very reactive, and some, such as epichlorohydrin, are potent carcinogens themselves.

Reproductive toxicity

Increases in miscarriages have been reported among nurses exposed to unspecified concentrations of trichloroethylene and other chemicals in operating rooms. The occurrence of miscarriages could not conclusively be attributed to trichloroethylene because there was concomitant exposure to other chemicals. A retrospective case-control study conducted in humans compared spontaneous abortion rates among women who had been exposed occupationally or non-occupationally to trichloroethylene and other solvents to rates among women without solvent exposure. The authors observed approximately three times the risk of spontaneous abortion with exposure to trichloroethylene. This risk increased further when women with less than a half hour of exposure to trichloroethylene each week were excluded from the analysis. However, a consistent dose response relationship was not observed, and most of the women were exposed to a variety of solvents, not just trichloroethylene. No increase in malformed babies was observed among approximately 2,000 fathers and mothers exposed to unspecified concentrations of trichloroethylene in the workplace. A retrospective case-control study conducted in humans compared spontaneous abortion rates among women who had been exposed occupationally or nonoccupationally to trichloroethylene and other solvents to rates among women without solvent exposure. The authors observed about a 3-fold increase in risk of spontaneous abortion associated with exposure to trichloroethylene (TCE). This risk increased further when women with less than l/2 hour of exposure to TCE per week were excluded from the analysis. However, a consistent dose response relationship was not observed and most of the women were exposed to a variety of solvents other than TCE.In this same study, the relationship between exposure to halogenated solvents during the first 20 weeks of pregnancy and fetal growth were examined. No association between exposure to solvents and decreased fetal growth was observed. However, the number of small infants was too low to specifically analyze TCE exposures and most fetal growth would occur after the first 20 weeks of pregnancy. Pregnant laboratory animals have been exposed to trichloroethylene vapors, but no conclusive studies have been encountered that clearly indicate teratogenic effects. Available data from animals suggest that the conceptus is not uniquely susceptible to trichloroethylene.

Specific target organ toxicity -single exposure

May cause lung/liver/kidney damage.
Specific target organ toxicity - repeated exposure
No data available
Aspiration hazard
Accidental ingestion of the material may be damaging to the health of the individual. When tetrachloroethylene (perchloroethylene) is used in the treatment of hookworm (4.5 to 6.5 gm orally) the only adverse effect is inebriation. Transient hepatotoxicity in patients given single oral doses of up to 5 ml have been recorded.
Potential health effects
Inhalation May be harmful if inhaled. Vapours may cause drowsiness and dizziness.
Ingestion May be harmful if swallowed.
Skin May cause severe skin irritation.
Eyes May cause eye irritation.
Signs and Symptoms of Exposure
No data available
TRICHLOROETHYLENE: The material may produce moderate eye irritation leading to inflammation. Repeated or prolonged exposure to irritants may produce conjunctivitis. The material may produce severe skin irritation after prolonged or repeated exposure, and may produce a contact dermatitis (nonallergic). This form of dermatitis is often characterised by skin redness (erythema) thickening of the epidermis. Histologically there may be intercellular oedema of the spongy layer (spongiosis) and intracellular oedema of the epidermis. Prolonged contact is unlikely, given the severity of response, but repeated exposures may produce severe ulceration. For trichloroethylene: **Inhalation effects:** Humans have died from breathing high concentrations of trichloroethylene fumes. Most of the reported deaths have been associated with accidental breathing of unusually high levels of trichloroethylene vapors in the workplace, often during its use in degreasing operations. These studies usually attributed death to ventricular fibrillation or central nervous system depression, since gross post-mortem abnormalities were not apparent. A number of the deaths occurred after the trichloroethylene exposure ended and involved physical exertion that may have contributed to the sudden deaths. Death associated with liver damage has also been reported in persons occupationally exposed to trichloroethylene for intermediate and chronic durations, followed by a high acuteduration exposure. Animal experimentation has revealed inhaled concentrations that result in death following acute, intermediate, and chronic exposure. Death was often caused by the central nervous system depression that occurs with very high exposure levels. **Cardiovascular effects:** High doses of hydrocarbons such as trichloroethylene could act upon the heart to cause cardiac sensitization to catecholamines. This is supported by animal studies. For example, dogs and rabbits exposed to very high concentrations of trichloroethylene (5,000 or 10,000 ppm, and 3,000 ppm, respectively) for .1 hour showed increased arrhythmias when injected intravenously with epinephrine (adrenaline). In animals, trichloroethylene itself, rather than its metabolites, is apparently responsible for the cardiac sensitization because chemicals that inhibit the metabolism of trichloroethylene increase its potency, while chemicals that enhance the metabolism of trichloroethylene decrease its potency. **Gastrointestinal Effects:** Case reports indicate that acute inhalation exposure to trichloroethylene results in nausea and vomiting Anorexia, nausea, and vomiting have also been reported as chronic effects of occupational exposure to trichloroethylene. The exposure levels were not measured. Anorexia and vomiting were reported in a woman chronically exposed to occupational levels between 40 and 800 ppm. Trichloroethylene-induced effects on the autonomic nervous system may contribute to these effects Cases of pneumatosis cystoides intestinalis (a rare condition characterised by gas-filled cysts in the submucosa of the small intestine) seen in Japanese lens cleaners and polishers were attributed to trichloroethylene exposure in the workplace. **Hepatic Effects.** There is some evidence for trichloroethylene-induced hepatotoxic effects in humans. However, much of this information is limited by the fact that the exposure levels associated with these effects were usually not reported, and the individuals may have been exposed to other substances as well. **Renal Effects:** Trichloroethylene may have effects in the kidney; however, studies in humans are limited by having poor or no exposure data and by concomitant exposure to other chemicals. There was no evidence of kidney damage in 250 neurosurgery patients who underwent prolonged trichloroethylene anaesthesia nor in 405 women who had caesarean sections and were exposed to trichloroethylene anaesthesia. There are few reports of renal dysfunction in workers exposed to trichloroethylene. Exposure of rats to extremely high levels (1,000 ppm or higher) for periods of less than 1 day led to the dysfunction of the tubular and glomerular regions of the nephron, as indicated by increases in urinary glucose, proteins, glucosaminidase, gamma glutamyl transpeptidase, and serum urea nitrogen. **Dermal Effects:** Stevens-Johnson syndrome, a severe erythema, was seen in five people occupationally exposed to trichloroethylene for 2-5 weeks at levels ranging from 19 to 164 ppm. The study authors suggested that the erythema was caused by a hypersensitivity reaction to trichloroethylene. An exfoliative dermatitis and scleroderma, also thought to have an immune component, have been reported in persons occupationally exposed to trichloroethylene. **Neurological Effects:** Trichloroethylene has been used as a surgical anesthetic (Hewer 1943). Some patients were reported to have experienced trigeminal neuropathy following anesthesia using trichloroethylene in association with soda-lime. The reaction of trichloroethylene with the soda-lime was thought to have produced dichloroacetylene which triggered neuropathies in 13 patients over a 4-month period in a county hospital. No new cases were discovered for 3 months after the discontinuation of the use of soda-lime. Acute exposure to trichloroethylene and its decomposition products (e.g., dichloroacetylene) has also led to residual neuropathy, characterized by nerve damage. This neuropathy is characterized

by facial numbness, jaw weakness, and facial discomfort (indicating damage to cranial nerves V and VII) which can persist for several months. Chronic exposure in the workplace has also been associated with damage to the cranial nerves in several cases Persons who have died from overexposure have shown degeneration of cranial nuclei in the brain stem). Some of these effects may be attributed to dichloroacetylene, a decomposition product of trichloroethylene, which may form under nonbiological conditions of heat or alkalinity. Intermediate and chronic exposures of workers to trichloroethylene have produced neurological effects similar to those found in acute exposure situations. Workers chronically exposed to levels between 38 and 172 ppm reported symptoms of sleepiness, dizziness, headache, and nausea, but no apparent trigeminal nerve disorders. Other reported neurological effects of chronic occupational exposure to unquantified trichloroethylene levels include memory loss mood swings, trigeminal neuropathy. Genotoxic Effects: Investigations into the genotoxicity of trichloroethylene in humans have not been conclusive but are suggestive of clastogenic effects. A study of chromosomal aberrations among trichloroethylene-exposed workers detected an increase in hypodiploid cells but found no evidence of chromosomal breaks in lymphocytes. Men using trichloroethylene as a degreasing agent were tested for lymphocyte chromosomal abnormalities- specifically, breaks, gaps, deletions, inversions, translocations, and hyperdiploidy. The same study also investigated the rate of nondisjunction for the Y chromosome in sperm. Positive results were observed for chromosomal aberrations and hyperdiploid cells, but the results were negative for chromosomal nondisjunction. Some authors suggest that smoking and trichloroethylene exposure may act together to produce increased sister chromatid exchange frequencies.

SECTION 12 - ECOLOGICAL INFORMATION

Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
Do NOT allow product to come in contact with surface waters or to intertidal areas below the mean high water mark. Do not contaminate water when cleaning equipment or disposing of equipment wash-waters.
Wastes resulting from use of the product must be disposed of on site or at approved waste sites.
DO NOT discharge into sewer or waterways.

Toxicity

Toxicity to fish

LC50 – Fish – 1.345 mg/L – 96 hours

Toxicity to daphnia and other aquatic invertebrates

EC50 – Algae or other aquatic plants – 11.596 mg/L – 96 hours
EC50 – Crustacea – 0.00775142 mg/L – 48 hours

Ecotoxicity

Ingredient	Persistence: Water/Soil	Persistence: Air	Bioaccumulation	Mobility
Trichloroethylene	HIGH	LOW	HIGH	LOW

SECTION 13 - DISPOSAL CONSIDERATIONS

Consult manufacturer for recycling options and recycle where possible. Consult State Land Waste Management Authority for disposal. Incinerate residue at an approved site. Recycle containers if possible, or dispose of in an authorized landfill.

SECTION 14 - TRANSPORTATION INFORMATION

Labels Required: TOXIC LIQUID

Hazchem:
No data available

Land Transport UNDG:

Class or division:	6.1	Subsidiary risk:	Not Applicable
UN No.:	1710	UN packing group:	III
Limited quantity:	5 L	Special provisions:	Not Applicable

Shipping Name: TRICHLOROETHYLENE

Air Transport IATA:

ICAO/IATA Class:	6.1	ICAO/IATA Subrisk:	Not Applicable

UN/ID Number:	1710	Packing Group:	III
Special provisions:	Not Applicable	ERG Code:	6A
Cargo Only		Cargo Only	
Packing Instructions:	663	Maximum Qty / Pack:	220 L
Passenger and Cargo		Passenger and Cargo	
Packing Instructions:	655	Maximum Qty / Pack:	60 L
Passenger and Cargo Limited		Passenger and Cargo Limited	
Quantity Packing Instructions:	Y642	Maximum Qty / Pack:	2 L

Shipping Name: TRICHLOROETHYLENE

Maritime Transport IMDG:

IMDG Class:	6.1	IMDG Subrisk:	Not Applicable
UN Number:	1710	Packing Group:	III
EMS Number:	F-A, S-A	Special provisions:	Not Applicable
Limited Quantities:	5 L		

Shipping Name: TRICHLOROETHYLENE

Transport in bulk according to Annex II of MARPOL 73 / 78 and the IBC code

Source	Ingredient	Pollution Category
IMO MARPOL 73/78 (AnnexII) - List of Noxious Liquid Substances Carried in Bulk	Trichloroethylene	Y

SECTION 15 - REGULATORY INFORMATION

REGULATIONS

PERCHLOROETHYLENE (127-18-4) IS FOUND ON THE FOLLOWING REGULATORY LISTS; International Agency for Research on Cancer (IARC) - Agents Classified by the IARC Monographs. Singapore Permissible Exposure Limits of Toxic Substances.

National Inventory	Status
Australia – AICS	Y
Canada – DSL	Y
Canada – NDSL	N (trichloroethylene)
China – IECSC	Y
Europe – EINEC / ELINCS / NLP	Y
Japan – ENCS	Y
Korea – KECI	Y
New Zealand – NZIoC	Y
Philippines – PICCS	Y
USA – TSCA	Y
Legend:	Y = All ingredients are on the inventory N = Not determined or one or more ingredients are not on the inventory and are not exempt from listing(see specific ingredients in brackets)

SECTION 16 - OTHER INFORMATION

Reason for the revision: General update.

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the products. Best Chemical Co (S) Pte Ltd shall not be held liable for any damage resulting from handling or from contact with the above product.