Chemical Safety Data Sheet SD-14

PROPERTIES AND ESSENTIAL INFORMATION

FOR

SAFE HANDLING AND USE

OF

TRICHLOROETHYLENE

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ADOPTED 1947
FIRST REVISION 1948
SECOND REVISION 1956

Chemicals in any form can be safely stored, handled or used if the physical, chemical and hazardous properties are fully understood and the necessary precautions, including the use of proper safeguards and personal protective equipment, are observed.

Manufacturing Chemists' Association, Inc.

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TRICHLOROETHYLENE

PREFACE

Trichloroethylene may be harmful by inhalation, by prolonged or repeated contact with the skin or mucous membranes, or when taken by mouth.

The Interstate Commerce Commission does not classify it as a dangerous article requiring special packaging but the Manufacturing Chemists' Association recommends the use of a warning label on containers.

Suggestions for the safe handling of trichloroethylene are given in the body of the data sheet.

FIRST AID — SEE PAGE 15

Chemical Safety Data Sheet

TRICHLOROETHYLENE

Adopted 1947
Revised 1948
Revised 1956

1. NAMES

Chemical Name: Trichloroethylene
Common Names: Trichlorethylene, Ethylene Trichloride
Formula: $CHCl.CCl_2$

2. PROPERTIES

2.1 GRADES

Technical or Dry Cleaning, Degreasing and Extraction

2.2 PROPERTIES AND CHARACTERISTICS

Physical State.....Liquid
Explosive Limits.....Not flammable or explosive at ordinary room temperatures but moderately flammable at higher temperatures.
Flash Point.....Practically nonflammable.
Boiling Point (760 mm.).....87.0°C. (188°F.) Lange.
Color.....Clear and colorless unless marked with an identifying dye, e.g., degreasing grade.
Corrosivity.....Stabilized trichloroethylene may be used in the presence of air, water and light with any of the common construction metals at temperatures up to 120°C. (248°F.).
Hygroscopic.....No.
Ignition Temperature.....410°C. (770°F.).
Light Sensitivity.....See "Corrosivity" above.
Melting Point.....−73°C. (−99°F.) Lange.
Odor.....Somewhat similar to odor of chloroform.
Reactivity.....Not dangerously reactive except that strong alkalies, such as caustic soda, may react with trichloroethylene to form explosive mixtures (dichloracetylene). Weaker alkalies, such as trisodium phosphate, may be used with safety.
Solubility in Water.....0.1 grams per 100 ml.
Specific Gravity at 20°/4°C. (68°/39°F.) (Water = 1).....1.464
Vapor Density (Air = 1).....4.54

VAPOR PRESSURE OF TRICHLOROETHYLENE

Temperature °C	Temperature °F	Vapor Pressure mm. Mercury
0	32	19.9
10	50	35.7
20	68	57.8
30.5	87	93.7
40	104	146.8
50	122	212
60	140	305.7
86.9	188	760

Threshold Limit..... 200 ppm. by volume in air.

3. HAZARDS

3.1 HEALTH HAZARDS (See 10.)

Trichloroethylene may be harmful by inhalation, by prolonged or repeated contact with the skin or mucous membranes, or when taken by mouth. However, if proper precautions are constantly observed, this compound can be handled with safety.

3.2 FIRE HAZARD

3.2.1 The fire hazard is very small, trichloroethylene being classified by the Underwriters' Laboratories as nonflammable at ordinary temperatures, and only slightly flammable at higher temperatures.

The fire hazard is rated 3, as determined by the U.L. Standard for Classification, in which ethyl ether rates 100, ethyl alcohol 60-70, and paraffin oil 10-20. In practical applications, such as cleaning fluids and vapor degreasing, the formation of combustible mixtures is extremely unlikely.

3.2.2 At very high temperatures, such as occur in open flames, trichloroethylene may decompose to give hydrochloric acid and other toxic products.

4. ENGINEERING CONTROL OF HAZARDS

4.1 BUILDING DESIGN

Processes should not be located near open flames, open electric heaters or high temperature operations, since trichloroethylene vapor exposed to such high temperatures may be decomposed to toxic and corrosive substances (See 3.2.2).

4.2 EQUIPMENT DESIGN

Processes should be designed so that the operator is not exposed to direct contact with trichloroethylene or its vapor. The technical problems of designing equipment, providing adequate ventilation and formulating operational procedures which promise maximum security and economy, can be handled best by engineers and safety specialists. Manufacturers of trichloroethylene, and of the equipment in which it is to be used, are always prepared to help with these problems, and to assist in maintaining safe working conditions. In most States, authoritative advice and assistance may also be obtained from the industrial hygiene division of the State health department, or from the labor department.

4.2.1 System Types

Depending upon the application, trichloroethylene may be used in any one of the three systems described below:

4.2.1.1 For the vapor degreasing of metals, equipment manufacturers have designed special open type machines in which the solvent liquid and vapor are controlled by balanced heat input and cooling capacity of condensing coils, which establish a "vapor ceiling." Such vapor degreasing units should always be installed in locations free from draft conditions.

4.2.1.2 Partially closed equipment has been designed for the use of trichloroethylene in the dry cleaning industry. Such equipment, however, exhausts the greater part of the solvent vapor to the outside atmosphere, thereby minimizing exposure of the worker. Proper design of the machine ensures against seepage of solvent liquid and vapor during the cleaning operation. Partially closed systems are likewise adapted to metal degreasing operations in some conveyorized vapor units.

4.2.1.3 Extraction equipment designed for trichloroethylene is an example of a closed system design.

4.3 VENTILATION

4.3.1 General ventilation should be adequate for processes conducted in closed or partially closed equipment, but mechanical exhaust ventilation, preferably of the downdraft type, may be provided for clean-out and other special operations. Open top vapor degreasers, however, should be provided with suitable baffles and otherwise protected from drafts to avoid entrainment of trichloroethylene vapors. Where equipment is located in pits or depressions, separate mechanical exhaust ventilation should be installed at the lowest level.

4.3.2 Intakes to exhaust ventilating systems should be as close as possible to the point where

the vapor escapes or to the source of contamination and designed to draw the vapor away from the operator but not across his face.

4.4 AIR ANALYSIS

4.4.1 The maximum allowable concentration (threshold limit) is 200 ppm. by volume in air for an eight hour working day.

4.4.2 When checking concentrations of trichloroethylene vapor in the atmosphere, care is required to make certain that the sample is representative of the air breathed by the workers, and of the daily fluctuations which may occur.

4.4.3 Continuous recording instruments, arranged to give audible and visible signals when a predetermined concentration of trichloroethylene vapor in air is reached, are available.

4.4.4 Testing methods are described in the following references:

Flame Test Method, Using the Halide Torch:
- V. A. Stenger et al., Ind. Eng. Chem., Anal. Ed., *11*:121 (1939)
- F. H. Goldman, J. Ind. Hyg. & Toxicol., *25*:181 (1943)

Thermal Decomposition Method:
- J. C. Olsen et al., Ind. Eng. Chem., Anal. Ed., *8*:260 (1936)
- H. F. Smyth, Ind. Eng. Chem., Anal. Ed., [illegible] (1936)
- H. Elkins et al., J. Ind. Hyg. & Toxicol., [illegible] (1937)
- B. D. Tebbens, J. Ind. Hyg. & Toxicol., [illegible] (1937)
- W. F. von Oettingen, J. Ind. Hyg. & Toxicol., *19*:413 (1937)

Vapor Pressure Method:
- C. Couchman et al., J. Ind. Hyg. & Toxicol., *21*:256 (1939)
- K. Kay et al., J. Ind. Hyg. & Toxicol., *21*:264 (1939)
- L. Silverman et al., J. Ind. Hyg. & Toxicol., *21*:270 (1939)

Gas Interferometer Method:
- F. A. Patty, J. Ind. Hyg. & Toxicol., *21*:469 (1939)
- G. Harrold et al., J. Ind. Hyg. & Toxicol., *21*:491 (1939)

Adsorption Method:
- W. Cook et al., J. Ind. Hyg. & Toxicol., *18*:194 (1936)
- L. Cralley et al., J. Ind. Hyg. & Toxicol., *25*:172 (1943)

Photometric Method:
- V. F. Hanson, Ind. Eng. Chem., Anal. Ed., *13*:119 (1941)

Colorimetric Method:
- H. M. Barrett, J. Ind. Hyg. & Toxicol., *18*:341 (1936)

See also American Standards Association, "Allowable Concentration of Trichloroethylene", Approved Aug. 6, 1946, Z37.19—1946. (200 ppm).

5. EMPLOYEE SAFETY

5.1 EMPLOYEE EDUCATION AND TRAINING

Safety in handling trichloroethylene depends, to a great extent, upon the effectiveness of employee education, proper safety instructions, intelligent supervision and the use of safe equipment.

The education and training of employees to work safely and to use the personal protective equipment or other safeguards provided for them is the responsibility of supervision. Training classes for both new and old employees should be conducted periodically to maintain a high degree of safety handling procedures. Workers should be thoroughly informed of the hazards that may result from improper handling of trichloroethylene. They should be cautioned to prevent spills and thoroughly instructed regarding proper action to take in case they occur. Each employee should know what to do in an emergency and should be fully informed as to first aid measures.

In addition to the above, employee education and training should include the following:

(a) Instruction and periodic drill or quiz regarding the locations of safety showers, eye baths, bubbler drinking fountains, or the closest source of water for use in emergencies.

(b) Instructions to avoid all unnecessary inhalation of vapors of trichloroethylene and all direct contact with the liquid.

(c) Instructions to report to the proper authority all equipment failures and/or signs of illness.

5.2 PERSONAL PROTECTIVE EQUIPMENT

5.2.1 Availability and Use

While personal protective equipment is not an adequate substitute for good, safe working conditions, adequate ventilation, and intelligent conduct on the part of employees working with trichloroethylene, it is, in many instances, the only practical means of protecting the worker,

particularly in emergency situations. One should keep firmly in mind that personal protective equipment protects only the worker wearing it, and other unprotected workers in the area may be exposed to danger.

The correct usage of personal protective equipment requires the education of the worker in proper employment of the equipment available to him. Under conditions which are sufficiently hazardous to require personal protective equipment, its use should be supervised and the type of protective equipment selected should be capable of control over any potential hazard.

The following personal protective equipment should be used when indicated.

5.2.2 Eye Protection

Chemical Safety Goggles: Cup-type or rubber framed goggles, equipped with the approved impact resistant glass or plastic lenses, should be worn whenever there is danger of trichloroethylene coming in contact with the eyes. Goggles should be carefully fitted by adjusting the nose piece and head band to ensure maximum protection and comfort.

Spectacle-Type Safety Goggles: Metal or plastic rim safety spectacles with unperforated side shields which can be obtained with prescription safety lenses or suitable all plastic safety goggles may be used where continuous eye protection is desirable, as in laboratories. These types, however, should not be used where complete eye protection against trichloroethylene is needed.

Face Shields: Plastic shields (full length, eight inch minimum) with forehead protection may be worn in addition to chemical safety goggles where complete face protection is desirable. Chemical safety goggles should always be worn as added protection where there is danger of material striking the eyes from underneath or around the sides of the face shield.

5.2.3 Respiratory Protection

Severe exposure to trichloroethylene may occur in tanks during equipment cleaning and repairs, when decontaminating areas following spills, or in case of failure of piping or equipment. Employees who may be subject to such exposures should be provided with proper respiratory protection as described below.

NOTE: Respiratory protective equipment must be carefully maintained, inspected, cleaned and sterilized at regular intervals, and always before use by another person.

(a) *Self-contained Breathing Apparatus* which permits the wearer to carry a supply of oxygen or air compressed in the cylinder, and the self-generating type which produces oxygen chemically, allow for greater mobility. The length of time a self-contained breathing apparatus provides protection varies according to the amount of air or oxygen supply carried. No cylinder (or compressed) oxygen should be used in tanks or other confined spaces.

(b) *Positive Pressure Hose Masks* supplied by externally lubricated blowers. Since these masks depend on a remote air supply, they should be used only where conditions will permit safe escape in the event of air supply failure. Care must be taken to locate the blower air source in an area which is free of air contaminants.

(c) *Air-line Masks* supplied by plant compressed air are suitable for use only where conditions will permit safe escape in case of failure of the compressed air supply. Such masks should be used only in conjunction with a suitable reducing or demand-type valve, excess pressure relief valve, and filter. The compressed air should be checked frequently to make certain that harmful gases from the decomposition of the lubricating oil used in the compressor, or impure air supply, are not present.

(d) *Industrial Canister Type Gas Masks,* equipped with full face pieces and approved by the U.S. Bureau of Mines, fitted with the proper canister for absorbing trichloroethylene vapor, will afford protection against concentrations of trichloroethylene not exceeding 2 per cent by volume when used in accordance with the manufacturer's instructions. The oxygen content of the air must not be less than 16 per cent by volume. The masks should be used for relatively short exposure periods only. They may not be suitable for use in an emergency since, at that time, the actual vapor concentration is unknown and it may be very high. The wearer must be warned to leave the contaminated area immediately on detecting the odor of a harmful vapor; this is an indication that the mask is not functioning properly or that the vapor concentration is too high.

NOTE: Where carbon monoxide may be encountered in addition to trichloroethylene, the mask should be equipped with an "all purpose canister" and a "timing device" as approved by the U.S. Bureau of Mines.

5.2.4 **Head Protection**

"Hard" hats should be worn where there is danger from falling objects. If hard hats are not considered necessary, soft-brimmed hats or caps may be worn to give protection against liquid leaks and splashes.

5.2.5 **Foot Protection**

NOTE: Trichloroethylene attacks natural rubber.

Safety shoes with built-in steel toe caps, and made of leather or some suitable impervious material such as Neoprene, are recommended for workers handling containers of trichloroethylene. Overshoes of a similar suitable material may be worn over leather safety shoes. Footwear should be thoroughly cleaned and ventilated after contamination.

5.2.6 **Body, Skin and Hand Protection**

Sustained or intermittent skin contact with liquid trichloroethylene may produce dermatitis at the site of contact. It is imperative that contaminated clothing be removed promptly and laundered or thoroughly dried before re-use. Affected areas of the body should be washed thoroughly with soap and water (except the eyes). As a general hygienic measure, facilities for personal cleanliness should be provided and washing before lunch and at the end of the work day should be encouraged.

Clothing made of neoprene or other impervious material may be worn to protect the body against trichloroethylene splashes. These garments must be cleaned inside and out each time they are used.

6. FIRE FIGHTING

As stated in Section 3.2, fires involving trichloroethylene are unlikely, but if they do occur, they may be controlled by carbon dioxide, dry chemical or foam.

7. HANDLING AND STORAGE

7.1 USUAL SHIPPING CONTAINERS

Trichloroethylene is not regulated by the Interstate Commerce Commission.

7.1.2 **Type and Size**

Tank cars:

ICC 103, up to 10,000 gallons capacity.

Tank trucks:

ICC Specifications MC 300, MC 301, MC 302, MC 303 or MC 304.

Metal drums:

ICC Specifications 17E, or CFC Rule 40, Section 5C, 55 gallon maximum.

7.1.3 **Labeling and Identification**

7.1.3.1 Each container should carry an identifying label or stencil.

7.1.3.2 The Manufacturing Chemists' Association recommends that all containers of trichloroethylene should bear a label as shown on p. 10 in addition to, or in combination with any label, warning or other statement required by statutes, regulations or ordinances.

7.2 DRUMS

7.2.1 Drums should be unloaded carefully to prevent damage. Do not drop or bump.

7.2.2 Each shipment should be examined carefully for leaking drums. If any are found, they should be handled with particular care by turning leak up to prevent further leakage, and should be removed to a safe place where the leakage can be stopped by tightening the plug or by some other approved method.

7.2.3 Before emptying contents, substantially support the drums and block them to prevent movement.

7.2.4 A satisfactory method of removing trichloroethylene from drums is by means of a rotary pump. If emptied by gravity, the drum should be placed on a rack and a faucet inserted in the end bung. Faucets should have

TRICHLOROETHYLENE

WARNING! VAPOR HARMFUL

Use only with adequate ventilation.
Avoid prolonged or repeated breathing of vapor.
Avoid prolonged or repeated contact with skin.
Do not take internally.

MCA Chemical Safety Data Sheet available.

short shanks threaded with Briggs standard straight iron pipe threads and preferably self-closing. A resilient gasket of suitable material should be used to ensure a tight fit. Bung opening and faucet must have the same type and number of threads per inch (MCA Manual Sheet D-32). Protect workmen from vapor and liquid (See 5.2).

7.2.5 To remove the body plug, place bung up, and use a bung or plug wrench. Stand to one side and face away during the operation. After the plug starts, give one full turn. If accumulated internal pressure vents, allow it to reduce to atmospheric pressure; then only should the plug be loosened further or removed.

7.2.6 Before returning shipping containers to suppliers, observe usual precautions regarding complete drainage of contents and properly close all openings.

7.3 TANK CARS

7.3.1 Unloading

7.3.1.1 Unloading operations should be conducted by carefully instructed, reliable employees under adequate supervision (See 5.1).

7.3.1.2 Shipper's instructions should always be followed and all caution markings on both sides of tank and dome should be read and observed.

7.3.1.3 The train or engine crew should accurately spot the car at the unloading line. The unloading track should be level.

7.3.1.4 Car number should be compared with that on shipping papers or invoice to verify contents of car and avoid mixing of products.

7.3.1.5 It is considered good practice that derails be placed at the open end or ends of the unloading track approximately one car-length from the car being unloaded, unless the car is protected by a closed and locked switch or gate.

7.3.1.6 The hand-brake should be set and standard rail clamps should be installed to block the wheels at the time of unloading. Metal "CAUTION" signs should be fastened to the track. Signs should be 12" x 15", painted light blue. Use the legend "STOP TANK CAR CONNECTED", with the letters in "STOP" four inches high. Signs are available from safety equipment dealers.

7.3.1.7 Tank cars should be unloaded through the dome connection, preferably by pump.

7.3.1.8 If necessary to discontinue unloading a tank car for any reason, all unloading connections must be disconnected. All valves must first be tightly closed, and the closures of all other openings securely applied.

7.3.2 Return Precautions

7.3.2.1 As soon as the tank car is completely unloaded all valves must be made tight, the unloading connections removed, and all other closures made tight, except the heater coil connection and steam connections.

7.3.2.2 Empty tank cars should be returned as promptly as possible, in accordance with instructions received from the shipper. The shipper's routing instructions should always be strictly followed.

7.4 TANK TRUCKS

7.4.1 Ordinarily all operations concerning the tank truck and its appurtenances (fittings,

pumps, hose, etc.) are the responsibility of the driver. Therefore unloading operations should be carried out by reliable and properly instructed employees in cooperation with the driver.

7.4.2 The shipper should be consulted for details on proper unloading procedure.

7.4.3 Before unloading a truck, the engine should be stopped and not started again during the entire unloading operation unless it is necessary to operate the pump by power take-off.

7.4.5 Truck brakes should be set and, if necessary, the wheels blocked.

7.4.6 It is preferable that truck unloading facilities be level and paved and so located that the truck can be easily and safely maneuvered to the unloading spot.

7.4.7 Air pressure should never be used for unloading tank trucks.

7.5 STORAGE

7.5.1 Corrosion

Under normal conditions, trichloroethylene may be stored satisfactorily in galvanized iron, black iron, or steel equipment. Aluminum is unaffected by trichloroethylene but is not generally recommended for storage equipment because of its possible use for some of the other more active chlorohydrocarbons which may react explosively with aluminum under certain conditions.

7.5.2 Drums

7.5.2.1 Drums of trichloroethylene should be stored in a cool place, bung up. To prevent evaporation losses, bungs should be kept tight at all times.

7.5.2.2 Ventilation should be provided at the floor level, as well as in the usual higher locations. Note that vapor is 4.54 times heavier than air (See 2.2). Do not store in pits, depressions, basements, or unventilated areas.

7.5.3 Tanks

7.5.3.1 Each tank, either vertical or horizontal, should have a top and bottom manhole at least 22 inches in diameter, in addition to filling, vent, and measuring device openings, which should be 2 inch flanged connections in the top of the tank. A 2 inch or 2½ inch bottom outlet should be provided for use as a drain during clean-out operations. Vertical tanks should be of the closed top design, and the top should be caulked or welded vapor-tight.

7.5.3.2 Each storage tank should have a vent of diameter at least equal to that of the fill pipe or discharge pipe, whichever is the larger, to permit the escape of vapor during filling. Vents from indoor tanks should terminate outdoors, in such a location that escaping vapor will not contaminate any work space air. The vent is usually protected against entry of moist air by being extended down over the side of the tank into a chamber filled with lump calcium chloride for removal of moisture in the air. It is recommended that a tee be provided in this line above the dryer so that a mercury seal ½ inch deep can be installed as a safety vent in case the dryer plugs from excess moisture. Do not allow mercury to be spilled in any work space. Avoid open mercury surfaces in work spaces.

7.6 SPILLS AND LEAKAGE

7.6.1 Spills should be cleaned up immediately. Employees performing this work should wear adequate personal protective equipment (See 5.2).

7.6.2 Rags or mops wet with trichloroethylene should be placed in closed containers or in a safe place out of doors until they can be dried safely.

7.6.3 Clothing wet with trichloroethylene should be removed immediately. The clothing should not be used again until dry and free of the odor of trichloroethylene. Dry clothing out of doors or in a properly ventilated area.

7.7 REPACKAGING AND BLENDING

7.7.1 Repackaging should be done with adequate attention to the health hazards involved (See 10.).

7.7.2 A label on small containers may be required by State statutes, regulations, or ordinances (See 7.1.3).

7.7.3 Trichloroethylene may be added to flammable solvents to form less flammable or relatively nonflammable mixtures. It should be noted, however, if the flammable solvent is less volatile than trichloroethylene, the mixture will tend to become more and more flammable on evaporation.

7.7.4 When trichloroethylene is added to other solvents, the health hazard of each of the constituents of the mixture must be given careful consideration.

7.7.5 The addition of other products to trichloroethylene may affect its corrosive properties.

8. TANK AND EQUIPMENT CLEANING AND REPAIRS

(HAZARDS AND THEIR CONTROL)

This work is probably the most hazardous of all operations which involve the use or handling of trichloroethylene in industry. All precautions pertaining to education, protective equipment and health hazards should be reviewed and understood.

8.1 PREPARATION OF TANKS AND EQUIPMENT

8.1.1 Tank and equipment cleaning should be under the direction of thoroughly trained personnel who are fully familiar with all of the hazards and the safeguards necessary for the safe performance of the work.

8.1.2 Tanks and equipment, pumps, lines and valves should always be drained and thoroughly flushed with water before being repaired. Workmen should never be allowed to attempt to repair equipment while it is in operation and the lines full. If pipe sections are to be removed and flanges opened, the lower bolts should be loosened first and although the lines have been flushed, care should be taken to avoid personal contact with the liquid draining, or dripping from the equipment. All spillage from the lines or equipment should be removed immediately.

8.1.3 The tank or equipment to be repaired should first be emptied of all liquid, and all pipes leading to and from the tank (except vents) after draining should be disconnected or blanked off. Agitator motor line switches should be locked open.

8.1.4 The tank should be steamed to remove residual trichloroethylene and vapors. Steam lines should be large enough to raise the tank temperature above the boiling point of trichloroethylene (87°C.) and the steaming should be continued until the trichloroethylene vapors have been removed.

8.1.5 The tank should then be cooled, preferably by filling with water and draining once or twice.

NOTE: The volatilized trichloroethylene in the steam effluent should be controlled so as to avoid contaminating the air in the work area in excess of safe limits (See 4.3).

8.1.6 The tank should then be purged with fresh air and the air should be tested for trichloroethylene vapor and for oxygen content before permitting personnel to enter (See 4.4).

8.2 ENTERING TANK

8.2.1 No one should enter a tank or confined space until a work permit has been signed by an authorized person indicating that the area has been tested and found to be safe. Furthermore, no workman should enter a tank or vessel that does not have a manhole opening large enough to admit a person wearing a safety harness, life line, and emergency respiratory equipment. It should be ascertained that the tank or vessel can be left by the original entrance.

8.2.2 One man on the outside of the tank should keep the men in the tank under observation and another man should be available nearby to aid in rescue if any of the men in the tank are overcome (See 8.3).

8.2.3 A supplied air respirator or self-contained breathing apparatus, together with rescue harness and life line should always be located outside the tank entrance for rescue purposes, regardless of the type of respiratory equipment or air supply which is provided for employees inside the tank (See 8.3).

8.2.4 Special ventilation is recommended during the entire time men are cleaning, repairing, or inspecting the tank. Ventilation can be accomplished by exhausting or removing vapors from the bottom of the tank either through its bottom openings, or by exhausting the vapors from the tank bottom by means of a large flexible duct where tanks have a top opening only. On tanks having only a top opening, care must be exercised to ensure complete removal of vapors from the entire tank. Care must also be taken to avoid having exhaust gases recycled into the tank.

8.2.5 During the course of the work, frequent tests (See 4.4) should be made to determine that the atmosphere in the tank is being maintained within the safe range. This precaution is necessary because residues not completely removed by washing may recontaminate the tank atmosphere.

8.2.6 In all cases, if repair work is interrupted, the tank atmosphere should be checked thoroughly and a new work permit issued before resumption of work.

8.3 EMERGENCY RESCUE

Under no circumstances should a rescuer enter a tank to remove a victim of over-exposure without proper respiratory protection, a safety harness and an attached life line. The free end of the life line should be manned by an attendant located outside the tank. Another attendant should be immediately available to assist in the rescue if needed. The rescuer should be in view of the outside attendant at all times or in constant communication with him.

8.4 EXTERIOR REPAIR WORK

8.4.1 Exterior tank repairs, including repairs to steam coils, cutting, riveting and welding, should be permitted only after thorough cleaning and testing of the tank to make sure it is free of vapors and after a work permit has been issued by an authorized person.

8.4.2 All outside welding or burning on tanks or equipment which have contained trichloroethylene should be done only after such containers have been completely purged with steam. Purging should be continued while the repair work is in progress.

8.4.3 In all cases, if repair work is interrupted, the tank atmosphere should be checked thoroughly and a new work permit issued before resumption of work.

9. WASTE DISPOSAL

9.1 Waste disposal of trichloroethylene depends to a great extent upon local conditions. Be sure that all Federal, State and local regulations regarding health and pollution are followed. The supplier will be able to furnish good advice on this matter.

9.2 Residue may be poured on dry sand, earth, or ashes at a safe distance from occupied areas and allowed to evaporate into the atmosphere.

10. MEDICAL MANAGEMENT

10.1 HEALTH HAZARDS

10.1.1 Trichloroethylene may be harmful by inhalation, by contact with skin or mucous membranes, or when taken by mouth. However, if proper precautions are constantly observed, this compound may be handled with safety. Prolonged, excessive, or repeated exposures to the liquid, or to atmospheric concentrations of the vapor above those recommended below are hazardous.

10.1.2 The signs and symptoms of too great exposure to trichloroethylene are the result of action upon the central nervous system, or irritation of the skin, or the respiratory tract. In contrast to chloroform and carbon tetrachloride, injuries to the liver and kidneys are rare, if indeed they ever occur from industrial exposure.

10.1.3 Trichloroethylene is essentially an anesthetic. When inhaled or when taken by mouth, the clinical picture may range from slight irritation of the mucous membranes through all stages of the production of anesthesia. The stage reached depends upon the concentration inhaled, or the quantity swallowed.

10.1.4 The generally accepted Maximum Allowable Concentration of trichloroethylene in the air is 200 ppm. by volume for an 8-hour day. When exposed to higher concentrations, workers may complain of tears and burning of the eyes and irritation of the nose and throat. They may, also, experience nausea and vomiting, drowsiness, acquire an attitude of irresponsibility and behave in a manner resembling any stage of alcoholic intoxication.

10.1.4.1 *Acute Poisoning*

When a worker inhales an excessive amount of trichloroethylene vapor within a short period of time, the symptoms are essentially those of production of anesthesia. There may be, at first, irritation of the eyes, nose and throat, then dizziness, nausea, vomiting and gradual suppression of consciousness. The picture which develops depends upon the concentration inhaled and the duration of inhalation. If the concentration is high and inhalation prolonged, there will eventually be complete suppression of pain sense and almost complete loss of muscular activity. After a period of very rapid breathing, the respiration and circulation may fall and death follow. High concentrations of trichloroethylene may prevent proper utilization of the oxygen of the blood by the tissues. When this condition is present, physical activity may lead to severe or even fatal circulatory failure.

Some conditions under which acute poisoning may occur are as follows:

(a) By accident, such as equipment failure,

(b) When workers enter enclosures or tanks without having taken adequate precautions (See 8),

(c) When trichloroethylene is handled carelessly (See 5.1).

10.1.4.2 *Subacute Poisoning*

Subacute trichloroethylene poisoning may result from prolonged or repeated work in an atmosphere containing high concentrations of trichloroethylene but under conditions in which the amount absorbed is not sufficient to cause loss of consciousness.

Workers with subacute poisoning may become acutely ill and suffer from headaches, fatigue, nausea, vomiting, mental confusion and visual disturbances. There may be nerve paralysis affecting nerves to the face or to the extremities. These are part of the development of anesthesia. In some cases, after repeated exposure, a craving seems to develop so that the worker seeks further exposure and becomes an addict. In others, there may be definite action on the heart muscle producing irregular beats of the heart or rapid but inefficient contraction of the heart chambers. In rare cases, this has caused death.

Some of the conditions under which subacute poisoning might occur in employees are as follows:

(a) When the ventilation is inadequate, resulting in high concentrations of trichloroethylene,

(b) When vapor concentrations are high intermittently, due to faulty handling of the liquid,

(c) Failure of the individual to observe precautionary measures,

(d) When an acute exposure of high concentration is superimposed upon prolonged exposure to mild concentrations, circulatory failure can occur.

10.1.5 Toxic Effects from External Contact

10.1.5.1 *Skin*

Trichloroethylene may cause dermatitis after repeated or prolonged contact with the skin, as occurs in prolonged or repeated handling of rags wet with the chemical product, dipping the hand into the liquid and wearing clothing saturated with it. Frequent contact of the solvent with the skin dries it by removal of the skin oils and makes it rough and red and subject to cracking. This can lead to secondary infection. If trichloroethylene, or its vapors are trapped between the clothing and the skin, there may be particularly severe action. Reddening, burning and blisters may follow such exposure.

10.1.5.2 *Eyes*

Trichloroethylene may enter the eyes either as a vapor or as a liquid (spray or splash). The irritation may cause lachrymation, burning and other symptoms. If the eyes are not promptly washed, serious eye damage may occur.

10.1.6 Toxic Effects After Oral Intake

The initial symptoms after toxic amounts of trichloroethylene are taken by mouth are those of irritation of the gastrointestinal tract, such as nausea and vomiting and, perhaps, diarrhea. Then, may follow all the stages of production of anesthesia with the same symptomatology as is produced by inhalation of the compound. In addition, when trichloroethylene is swallowed, kidney function may be completely suppressed.

10.2 PREVENTIVE HEALTH MEASURES

The most important factor in prevention of injury by trichloroethylene is to have sufficient ventilation to keep the concentration of the vapor in the air below 200 ppm. by volume. The odor of trichloroethylene is distinct and most people can notice it at concentrations of the order of 50 ppm.

10.2.1 Personal Hygiene

Employees should be instructed to report any signs or symptoms of a substandard physical condition and receive medical attention.

Those working regularly with trichloroethylene may well be provided with a folder explaining the dangerous properties of this material and a statement of proper precautions to observe.

Facilities for personal cleanliness should be provided and time allowed for thorough washing before lunch and at the end of the work day.

Careful cleansing with mild soap, followed by the use of an oily cream containing lanolin to replace skin oils which may have been dissolved by trichloroethylene, is an important aid in preventing dermatitis.

10.2.2 Physical Examinations

10.2.2.1 *Preplacement Examination*

Certain individuals have been found who are unduly susceptible to various chlorinated

hydrocarbons, as shown by previous experiences. The exposure of such individuals can be minimized by a careful preplacement physical examination. Exposures to trichloroethylene even in concentrations known to be nonhazardous to normal individuals should be prohibited in the following cases:

(a) Alcoholics,

(b) Exceedingly fleshy individuals,

(c) Undernourished individuals,

(d) Those with pulmonary diseases, stomach ulcers, high blood pressure, diseases of the liver, kidney, or heart, and

(e) Those suffering from paralysis, convulsive seizures and highly nervous states.

10.2.2.2 *Periodic Health Examinations*

Employees who are exposed regularly to trichloroethylene should be examined, at least semiannually, by a physician acquainted with the occupational hazards involved. Physical examinations should be required also when any symptoms of poisoning such as enumerated above are present in employees. Discovery of symptoms of trichloroethylene poisoning may indicate some defect in operation. This would serve as an indication to examine other exposed employees for early signs of poisoning.

11. FIRST AID

11.1 GENERAL PRINCIPLES

Most important in the case of any poisoning is quick removal from exposure. In the case of trichloroethylene poisoning, this means first removing the patient from the contaminated atmosphere and, insofar as possible, removing the trichloroethylene from the patient's respiratory tract, skin, or gastrointestinal tract.

Give the patient fresh air by moving him to a well ventilated room and by dispersing any crowd. If breathing has ceased, start artificial respiration at once.

During recovery from an anesthetic dose of trichloroethylene, there may be great excitement. Keep the patient quiet and comfortably warm, but not hot.

Call a physician immediately, explaining briefly and clearly what has happened and the exact location of the patient. *Do not give anything by mouth to an unconscious patient.*

11.2 SPECIFIC ACTIONS

11.2.1 Inhalation

A person showing symptoms of trichloroethylene vapor poisoning should be removed promptly from the contaminated area. In case breathing has stopped, effective artificial respiration, such as that obtained by the arm lift-back pressure method should be started immediately. If oxygen inhalation apparatus is available, oxygen should be administered only if one familiar with the operation of the apparatus is present to administer it. If patient is conscious, hot tea or coffee may be given as a stimulant.

Adrenalin should never be given to a person suffering from trichloroethylene poisoning. A physician should be called at once.

11.2.2 Skin Contact

All contaminated clothing should be removed at once. Clothing, including shoes, soaked in trichloroethylene should be removed and not worn again until thoroughly dry. All affected areas should be washed thoroughly with warm water and soap. After this an ointment containing lanolin should be applied in order to replace the natural skin oils. For serious or persistent cases of skin trouble and for signs and symptoms of generalized poisoning, a physician should be consulted.

11.2.3 Contact with Eyes

If liquid trichloroethylene has entered the eyes, they should be washed promptly with copious quantities of water for at least 15 minutes. It is advisable to irrigate the eyes gently with water at room temperature in order to minimize additional pain and discomfort. Medical attention should be obtained.

11.2.4 Taken Internally

If a person has swallowed trichloroethylene, he should be made to vomit by drinking a glassful of mustard water, lukewarm salt water, or soapy warm water. If necessary, the patient should be encouraged to stick his finger down his throat to induce vomiting. This procedure should be repeated at least three times and then followed by the administration of a tablespoonful of Epsom salt. A physician should be called at once.

The medical information in this publication has been supplied by the Medical Advisory Committee of the Manufacturing Chemist's Association.

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Acetaldehyde	(1952)	SD-43
Acetic Acid	(1951)	SD-41
Acetic Anhydride	(1947)	SD-15
Acetylene	(1947)	SD-7
Acrylonitrile	(1949)	SD-31
Aluminum Chloride	(1956)	SD-62
Ammonium Dichromate	(1952)	SD-45
Anhydrous Ammonia	(1952)	SD-8
Aniline	(1947)	SD-17
Aqua Ammonia	(1947)	SD-13
Arsenic Trioxide	(1956)	SD-60
Benzene	(1956)	SD-2
Betanaphthylamine	(1949)	SD-32
Bromine	(1952)	SD-49
Butadiene	(1954)	SD-55
Calcium Carbide	(1948)	SD-23
Carbon Disulfide	(1948)	SD-12
Carbon Tetrachloride	(1946)	SD-3
Caustic Potash	(1947)	SD-10
Caustic Soda	(1947)	SD-9
Chlorosulfonic Acid	(1949)	SD-33
Chromic Acid	(1952)	SD-44
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Ethyl Acetate	(1953)	SD-51
Ethyl Chloride	(1953)	SD-50
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Ethylene Dichloride	(1947)	SD-18
Ethylene Oxide	(1951)	SD-38
Formaldehyde	(1952)	SD-1
Hydrochloric Acid	(1951)	SD-39
Hydrofluoric Acid	(1948)	SD-25
Hydrogen Peroxide	(1955)	SD-53
Hydrogen Sulfide	(1950)	SD-36
Lead Oxides	(1956)	SD-64
Methanol	(1948)	SD-22
Methylamines	(1955)	SD-57
Methyl Bromide	(1949)	SD-35
Methyl Chloride	(1951)	SD-40
Mixed Acid	(1956)	SD-65
Naphthalene	(1956)	SD-58
Nitric Acid	(1947)	SD-5
Nitrobenzene	(1948)	SD-21
Ortho-Dichlorobenzene	(1953)	SD-54
Paraformaldehyde	(1950)	SD-6
Perchloroethylene	(1948)	SD-24
Perchloric Acid Solution, preliminary	(1947)	SD-11
Phenol	(1946)	SD-4
Phosphoric Anhydride	(1948)	SD-28
Phosphorus, Elemental	(1947)	SD-16
Phosphorus Oxychloride	(1948)	SD-26
Phosphorus Trichloride	(1948)	SD-27
Phthalic Anhydride (Revised)	(1956)	SD-61
Propylene	(1956)	SD-59
Sodium Chlorate	(1952)	SD-42
Sodium Cyanide	(1949)	SD-30
Sodium, Metallic	(1952)	SD-47
Sodium and Potassium Dichromates	(1952)	SD-46
Styrene Monomer	(1951)	SD-37
Sulfur Dioxide	(1953)	SD-52
Sulfuric Acid	(1952)	SD-20
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