

Chemical Safety Data Sheet SD-24

PROPERTIES AND ESSENTIAL INFORMATION

FOR

SAFE HANDLING AND USE

OF

PERCHLOROETHYLENE

ADOPTED 1948

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.



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SL 029444

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SL 029445

Chemical Safety Data Sheet

PERCHLOROETHYLENE

Adopted August, 1948

1. NAME

Chemical Names: Perchloroethylene; Tetrachloroethylene
Common Name: Perchloroethylene
Formula: $\text{CCl}_2:\text{CCl}_2$

2. PROPERTIES

2.1 Grade: Technical

2.2 Important Physical and Chemical Properties

Physical State: Liquid at normal temperatures.

Color: Clear, water-white.

Odor: Chloroform-like, ethereal.

Vapor Density (Air = 1): 5.83

Boiling Point (760 mm.): 121.2°C (250°F).

Melting Point: -23.35°C (-8°F).

Flash Point: None.

Corrosive: Suitably stabilized perchloroethylene may be used in the presence of air, water and light with any of the common construction metals at temperatures up to 140°C (284°F).

Dangerously Reactive: No.

Hygroscopic: No.

Light Sensitive: No. See "Corrosive," above.

Specific Gravity at $20^\circ/4^\circ\text{C}$ ($68^\circ/39^\circ\text{F}$) (Water = 1): 1.623

VAPOR PRESSURE OF PERCHLOROETHYLENE

Temperature		Vapor Pressure
$^\circ\text{C}$	$^\circ\text{F}$	mm Mercury
14	57	10.0
22	72	15.8
35	95	30.9
50	122	63.5
65	149	118.1
75	167	173.3
95	203	350.0
105	221	481.0
121.2	250	760.0

2.3 Hazardous Properties

2.3.1 HEALTH HAZARDS (See 8. HEALTH HAZARDS AND THEIR CONTROL).

Perchloroethylene is toxic by inhalation, by prolonged or repeated contact with the skin or mucous membrane, or when taken by mouth. The liquid can cause eye injuries. Although toxic, perchloroethylene may be handled safely if proper precautions are constantly observed.

The generally recognized maximum allowable concentration is 200 parts per million by volume in air for an 8-hour working exposure.

2.3.2 FIRE HAZARD

Perchloroethylene is nonflammable (See 6.2 Fire and Explosion Hazards).

3. USUAL SHIPPING CONTAINERS

Perchloroethylene is not regulated by the Interstate Commerce Commission.

3.1 Type and Size

Tank cars, ICC Spec. 103 or 103W.

Metal drums, non-returnable, ICC Spec. 17E, 55 gallon maximum.

3.2 Label or Identification

3.2.1 Each container (including tank cars) should carry an identifying label or stencil.

3.2.2 The caution label to be placed on each container under the agreement between the United States Public Health Service and the producers is given below.

3.3 Disposal and Return Precautions

3.3.1 TANK CARS. Empty tank cars should be returned as promptly as possible in accordance with instructions received from the shipper. Shipper's routing instructions should always be followed strictly.

3.3.2 DRUMS. Before returning shipping containers to suppliers, usual precautions regarding the complete drainage of contents and the proper closing of all openings should be observed.

PERCHLORETHYLENE

(Tetrachloroethylene)

WARNING! VAPOR HARMFUL

Use only with adequate ventilation

Avoid prolonged or repeated breathing of vapor

Avoid prolonged or repeated contact with the skin

Do not take internally

4. UNLOADING AND EMPTYING

(See also 3. USUAL SHIPPING CONTAINERS)

4.1 Health Hazards. (See 8. HEALTH HAZARDS AND THEIR CONTROL)

Perchloroethylene is toxic by inhalation, by prolonged or repeated contact with the skin or mucous membrane, or when taken by mouth. Although toxic, perchloroethylene may be handled safely if proper precautions are constantly observed.

4.2 Fire Hazard

Perchloroethylene is nonflammable. (See 6.2. Fire and Explosion Hazards)

4.3 Tank Cars

4.3.1 Unloading operations should be conducted by carefully instructed, reliable employees under adequate supervision (See 6.4 Employee Education and Training).

4.3.2 Care should be taken that the car is spotted accurately and that the track is level.

4.3.3 It is considered good practice that derrails be placed at one or both 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.

4.3.4 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. The legend "STOP—TANK CAR CONNECTED," with the letters in "STOP" four inches high, should be used. Signs are available from safety equipment dealers.

4.3.5 Shipper's instructions for unloading should always be followed, and all caution markings on both sides of tank or dome should be read and observed.

4.3.6 In the event of a leak in the tank car or the fittings that cannot be stopped by following the previous instructions from the supplier or by simple adjustment or tightening, the supplier should be immediately telephoned or wired for further instructions.

4.3.7 Normally, tank cars containing perchloroethylene are equipped with a bottom out-

let fitting, valve, and cap. After the operator is certain that the bottom outlet valve is closed, the cap should be removed with caution in the event that solvent has collected below the bottom outlet valve. The bottom outlet fitting should then be connected with standard piping to the suction side of the unloading pump which is to deliver the tank car contents to storage.

4.3.8 The dome cover should then be opened, taking due care to allow slow release of any pressure which may have accumulated in the car.

4.3.9 After the operator checks all valves and piping connections, the bottom outlet valve should be opened by operating the hand-wheel or lever just inside the car dome, and the piping inspected for leaks under the gravity head of solvent. If the connections are tight, the unloading can proceed by pumping from tank car to storage. (Further details as to bottom unloading of tank cars are set forth in MCA Manual TC-4).

4.4 Drums

4.4.1 Drums should be unloaded carefully to prevent damage. They should not be dropped or bumped.

4.4.2 Each shipment should be examined carefully for leaking drums. If any are found, they should be handled with particular care by turning the leaking part 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.

4.4.3 Before emptying contents, the drums should be supported and blocked substantially to prevent movement.

4.4.4 A satisfactory method of removing perchloroethylene 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 short shanks, threaded with Briggs standard straight iron pipethreads. A resilient gasket of suitable material should be used to insure a tight fit. Bung opening and faucet must have the same type and number of threads per inch (M.C.A. Manual Sheet D-32). Workmen should be protected from vapor and liquid. (See 6.5 Personal Protective Equipment).

4.4.5 To remove the body plug, the bung should be placed up and a bung or plug wrench used. The operator should stand to one side

and face away during the operation. After plug starts, one full turn should be given. If accumulated internal pressure vents, it should be allowed to drop to atmospheric pressure; then only should the plug be loosened further or removed.

5. STORAGE

5.1 Hazards

5.1.1 HEALTH HAZARDS (See 8. HEALTH HAZARDS AND THEIR CONTROL).

Perchloroethylene is toxic by inhalation, by prolonged or repeated contact with the skin or mucous membrane, or when taken by mouth. Although toxic, perchloroethylene may be handled safely if proper precautions are constantly observed.

5.1.2 FIRE HAZARD (See 6.2 Fire and Explosion Hazards).

5.1.3 CORROSION. Under normal conditions, perchloroethylene may be stored satisfactorily in galvanized iron, black iron or steel equipment (see 2.2 Important Physical and Chemical Properties).

5.1.4 VOLATILITY. Perchloroethylene is less volatile than water. (See 2.2 Important Physical and Chemical Properties).

5.2 Conditions of Storage

5.2.1 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 unloading and 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.

5.2.2 Each storage tank should have a vent large enough (usually 2-inch) 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 drying 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 drying chamber so that a mercury seal ½ inch deep can be installed as a safety vent in case the chamber plugs from excess moisture. Mercury should not be spilled in any work space, and open mercury surfaces in work spaces should be avoided).

5.2.3 Although perchloroethylene is nonflammable, because of various possible hazards such as danger from lightning or the proximity of other storage tanks containing flammable liquids, safe practice would indicate that perchloroethylene storage tanks should be adequately grounded to discharge static electricity. (See NFPA pamphlet "Static Electricity"). Local conditions should determine in each case whether or not storage tanks should be grounded.

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

5.2.5 Ventilation should be provided at the floor level, as well as in the usual higher locations. Note that vapor is 5.83 times heavier than air (see 2.2 Important Physical and Chemical Properties). Perchloroethylene should not be stored in pits, depressions, basements, or unventilated areas.

6. HANDLING

6.1 Health Hazards (See 8. HEALTH HAZARDS AND THEIR CONTROL).

Perchloroethylene is toxic by inhalation, by prolonged or repeated contact with the skin or mucous membrane, or when taken by mouth. Although toxic, perchloroethylene may be handled safely if proper precautions are constantly observed.

6.2 Fire and Explosion Hazards

6.2.1 Perchloroethylene is nonflammable and nonexplosive. It will not support combustion.

6.2.2 Perchloroethylene vapor exposed to high temperatures, such as occur in open flames and open electric heaters, may be decomposed to toxic and corrosive substances. Such combustion products should be vented to the outside of the building.

6.3 Spills and Leakage

6.3.1 Spills should be cleaned up immediately. Employees performing this work should

wear adequate personal protective equipment (See 6.5 Personal Protective Equipment).

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

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

6.4 Employee Education and Training (See 8.2.3 Employee Education).

6.4.1 Safety in handling perchloroethylene (and other hazardous chemical products) depends upon the effectiveness of employee education, training, and supervision.

6.4.2 The education and training of employees to work safely and to use the personal protective equipment or other safeguards provided for them is a responsibility of supervision.

6.4.3 Employee education and training should emphasize the need of handling perchloroethylene according to the methods outlined in this manual.

6.4.4 Before being placed on the job, new employees should be thoroughly instructed and quizzed in respect to the proper handling of perchloroethylene. Older employees should be reinstructed and quizzed periodically. Each employee should be instructed not to use perchloroethylene for personal cleaning purposes.

6.4.5 Each employee should know the location, purpose, use, and maintenance of personal protective equipment and be thoroughly trained in when and how to use it. (See 8.3 Personal Protective Equipment)

6.4.6 Each employee should know the location of safety showers, bubbler drinking fountains for flushing the eyes, and faucets for washing out hose lines.

6.4.7 Only reliable, dependable, and properly trained employees should be given the responsibility of operating valves which control the flow of perchloroethylene to and from storage tanks, tank cars, and containers.

6.4.8 Employees should be trained to report to the proper authority all suspected leaks or equipment failures, and any signs of illness or skin afflictions.

6.4.9 Each employee should know what to do in an emergency (See 6.3 Spills and Leakage) and in rendering first-aid measures (see 8.4 First Aid and Medical Treatment), and should realize the necessity for prompt administration of first aid in case of contact with perchloroethylene or exposure to the vapor.

6.5 Personal Protective Equipment

6.5.1 AVAILABILITY AND USE

The following personal protective equipment should always be used for the purposes mentioned and as specified in 8. HEALTH HAZARDS AND THEIR CONTROL and in other sections of this Manual Sheet.

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 perchloroethylene. Such equipment may protect the individual wearing it while others in the area may be exposed to danger. The correct usage of personal protective equipment requires the education of the worker in the proper employment of the equipment available to him (see 6.4 Employee Education and Training). Under conditions which are sufficiently hazardous to require protective equipment, its use should be carefully supervised. In all cases, the type of protecting equipment selected should depend upon the degree of hazard existing.

6.5.2 EYE PROTECTION

6.5.2.1 *Chemical Safety Goggles.* Cup type or rubber framed goggles equipped with approved impact resistant glass or plastic lens should be worn whenever there is danger of the material coming in contact with the eyes. Goggles should be carefully fitted by adjusting the nose piece and head band to insure maximum protection and comfort.

6.5.2.2 *Spectacle Type Safety Goggles.* Metal or plastic rim safety spectacles with unperforated side shields which can be obtained with prescription safety lens or suitable all plastic goggles may be used where continuous eye protection is desirable. These types, however, should not be used where complete eye protection against chemicals is needed.

6.5.2.3 *Face Shields.* Plastic shields (full length, 8 inch minimum) with forehead protection may be worn in lieu of, or 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 from around the sides of the face shield.

6.5.3 RESPIRATORY PROTECTION

Respiratory Protective Equipment must be carefully maintained, inspected, cleaned and sterilized at regular intervals, and always before use by another person. Personnel wearing such equipment must be carefully instructed in its operation and limitations.

6.5.3.1 Air or oxygen supplied masks, equipped with full face pieces, must be worn for protection where an oxygen deficiency less than 16 per cent by volume or a concentration of a harmful gas above 2 per cent by volume may be encountered, such as:

- (a) In emergencies when the vapor concentration is not definitely known.
- (b) When the harmful vapor concentration is over 2 per cent by volume or lacks a distinguishable odor.
- (c) When the oxygen content of the air may be less than 16 per cent by volume.
- (d) In tank and equipment cleaning and repair work.
- (e) When the exposure period is to be over 30 minutes duration.

Only masks approved by the United States Bureau of Mines should be used and the manufacturer's instructions must be carefully followed. Types generally available include:

- (a) 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 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 from impure air supply are not present.
- (b) Positive pressure hose masks supplied by externally lubricated blowers are usually preferred to the air line type. Since these masks also depend on a remote air supply, they should be used only where conditions will permit safe escape in the event of an air supply failure. Care must be taken to locate the blower or air source in an area which is free from air contaminants.

- (c) Self-contained breathing apparatus which permits the wearer to carry a supply of oxygen or air compressed in a cylinder, or 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. In tank work where small manholes are encountered, a self-contained breathing apparatus is usually unsuitable because of its bulk.

6.5.3.2 Industrial canister type gas masks, approved by the United States Bureau of Mines, fitted with the proper canister for absorbing perchloroethylene vapor, (or gas), and equipped with full face pieces, will afford protection against concentrations not exceeding 2 per cent by volume when used in accordance with the manufacturer's instructions. The oxygen content of the air must be not less than 16 per cent by volume. The masks should be used for relatively short exposure periods only, i.e., for less than 30 minutes. 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 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 perchloroethylene, and in case the possibility of such dual exposure exists, the workers should be provided with air or oxygen supplied masks in addition to masks equipped with all-purpose canisters and timing devices as approved by the United States Bureau of Mines.

6.5.4 HEAD PROTECTION

6.5.4.1 Safety, or "Hard" hats will provide protection against accidental liquid leaks, falling tools, or other objects.

6.5.4.2 Brimmed felt hats may be substituted for safety hats where the danger of falling objects is remote.

6.5.5 FOOT PROTECTION

Leather or rubber safety shoes with built in steel toe caps are recommended. Rubbers may be worn over leather safety shoes.

6.5.6 BODY, SKIN, AND HAND PROTECTION

6.5.6.1 Aprons made of solvent-proof plastics, oil-resisting synthetic rubber or other suitable protective material should be used for protection against accidental contact with perchloroethylene.

6.5.6.2 Gloves made of oil-resisting synthetic rubber or other suitable protective material should be worn to protect the hands from perchloroethylene.

6.6 Engineering Controls

6.6.1 *LOCATION OF PROCESS.* Processes should not be located near open flames, open electric heaters or high temperature operations, since perchloroethylene vapor exposed to such high temperatures may be decomposed to toxic and corrosive substances (see 6.2.2.).

6.6.2 *DESIGN OF EQUIPMENT.* Processes should be designed so that the operator is not exposed to direct contact with perchloroethylene 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 experts. The manufacturers of perchloroethylene, 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.

6.6.3 *SYSTEM TYPES.* Depending upon the process, perchloroethylene is commonly used in the two systems described below. Either one of the two system types may be adapted to other various uses of perchloroethylene.

6.6.3.1 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 adequate cooling capacity. Where vapor degreasing units are installed in locations free from draft conditions and used to clean free draining material, an exhaust is not ordinarily required. However, where either the location or the nature of the work leads to more than normal diffusion losses or substantial vaporization, an exhaust system should be installed.

6.6.3.2 Both completely closed and partially closed equipment has been designed for

the use of perchloroethylene 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 insures against leakage of solvent liquid and vapor during the cleaning operation. Partially closed systems are likewise adapted to metal degreasing operations in some conveyorized vapor units.

6.6.4 VAPOR MEASUREMENTS

6.6.4.1 When checking concentrations of perchloroethylene 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.

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

6.6.4.3 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.*, 8:379 (1936)

H. Elkins et al., *J. Ind. Hyg. & Toxicol.*, 19:474 (1937)

B. D. Tebbens, *J. Ind. Hyg. & Toxicol.*, 19:204 (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)

Absorption Methods:

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)

6.7 Ventilation

6.7.1 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 perchloroethylene vapors. Where equipment is located in pits or depressions, separate mechanical exhaust ventilation should be installed at the lowest level.

6.7.2 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.

6.8 Tank and Equipment Cleaning and Repairs

6.8.1 The hazardous nature of tank and equipment inspection, cleaning, and repairs requires that the foreman and crew be selected, trained, and drilled carefully. They should be fully familiar with the hazards, and the safeguards necessary for the safe performance of the work. Written approval should be secured from the Plant Management or Safety Department before such work is started. All tank work should be under the direct supervision of a foreman.

6.8.2 Wherever possible, enclosures should be cleaned from the outside, using the clean-out doors.

6.8.3 Pipe lines into or out of the tank or other apparatus should be shut off, disconnected, preferably by removing a complete small section, and a blank flange should be installed on the open end to protect against human error and unsuspected leaks. Valves, cocks, and blank flanges in the pipe line should not alone be relied upon.

6.8.4 Danger signs should be placed suitably to indicate when workmen are in the tank or other apparatus.

6.8.5 It should be assured that the tank can be left by the original entrance.

6.8.6 Electrical switches should be locked in the off position, the drive belts should be removed, and provision should be made against accidentally starting the agitating equipment or other moving parts located inside the tank

or adjacent to the entrance. Some state regulations *require* that the agitating equipment be disconnected.

6.8.7 Before entering a tank and during the course of the work, tests should be made by a qualified person to determine that no further drying is necessary, that no oxygen deficiency exists, and that no harmful gas or vapor is present.

6.8.8 Before directing men to enter a tank, an inspection of the interior should be made by the foreman who should be equipped with a hose mask, an air-line mask, or self-contained breathing apparatus, together with rescue harness and life line. Another responsible person should be on guard during the inspection.

6.8.9 Special ventilation and a continuous fresh air supply are recommended during the entire time men are cleaning, inspecting or repairing the tank.

6.8.10 Proper personal protective equipment should be worn by anyone entering a tank for inspection, cleaning, or repairs (see 6.5 Personal Protective Equipment, and 8.3 Personal Protective Equipment).

6.8.11 One man on the outside of the tank should keep the men in the tank under constant observation, and at least two other men should be available to aid in rescue if any of those in the tank are overcome.

6.8.12 A hose mask, an air-line mask, or self-contained breathing apparatus, together with rescue harness and life line, should be located outside the tank entrance. This equipment should be used for rescue, regardless of the type of respiratory protection or the air supply which is provided for employees inside the tank.

6.8.13 In addition to protecting the workmen actually engaged in cleaning and repairing the tank, attention should be paid to the protection of workers in nearby areas.

6.8.14 Although perchloroethylene is non-flammable, safe practice would indicate that the portable electric lights and power tools should be of the three-wire, grounded, explosion-proof type approved for use in hazardous locations. They should be maintained in excellent condition.

6.8.15 Cleaning or making repair inside a tank may be hazardous even though the tank contained a non-toxic, nonflammable material. In addition to the above and to the precautions

generally recommended for tank work, further precautions are recommended as follows:

(a) Before entering the tank, it should be emptied, dried and clear of perchloroethylene vapor.

(b) Since perchloroethylene vapor is 5.83 times heavier than air, the tank may be ventilated through openings in the bottom, or by a mechanical exhaust with intake at the lowest part of the vessel.

(c) Ventilation should be continued during cleaning, repairing or inspection.

6.9 Repackaging and Blending

6.9.1 The repacker should carefully review this entire manual and become familiar with the hazardous properties of perchloroethylene and the safeguards which should be taken to handle it safely. Only ICC specification containers should be used (see 3.1) and they should be labeled properly (see 3.2).

6.9.2 Repackaging should be done with adequate attention to the health hazards involved (see 8. HEALTH HAZARDS AND THEIR CONTROL).

6.9.3 Special labeling on small containers may be required by State statutes, regulations, or ordinances (see 3.2 Label or Identification).

6.9.4 Perchloroethylene may be added to flammable solvents to form less flammable or relative nonflammable mixtures. It should be noted, however, if the flammable solvent is less volatile than perchloroethylene, that the mixture will tend to become more and more flammable on evaporation. If the flammable portion is more volatile than perchloroethylene, the vapor may be highly flammable although the liquid mixture is nonflammable.

6.9.5 When perchloroethylene is added to other solvents, the health hazards of the various components of the mixture must be given careful consideration.

6.9.6 The addition of other products to perchloroethylene may affect its corrosive properties.

7. WASTE DISPOSAL

7.1 Waste disposal of perchloroethylene and materials containing it depends to a great ex-

tent upon local conditions. It should be assured that all Federal, State and local regulations regarding health and pollution are followed. The supplier will be able to furnish good advice.

7.2 The residue from distillations of perchloroethylene may be poured on dry sand, earth, or ashes at a safe distance from occupied areas and allowed to evaporate.

8. HEALTH HAZARDS AND THEIR CONTROL

This section includes not only recognized first aid procedures and information of interest to the layman, but also suggestions which may be of value to the attending physician.

8.1 Hazards

8.1.1 Perchloroethylene is toxic by inhalation, by prolonged and repeated contact with skin or mucous membranes or by oral intake. Although toxic, perchloroethylene may be handled safely if proper precautions are constantly observed. Prolonged, excessive, or repeated exposures to the product in any form are hazardous.

8.1.2 The signs and symptoms of perchloroethylene poisoning are the result of effects on the nervous system (narcosis), lungs, skin and mucous membranes. In contrast to chloroform and carbon tetrachloride, injuries to the liver and kidneys are rare. When such injuries occur they are usually of slight degree. The clinical picture varies with the type of exposure and the amount of the chemical product which is absorbed either at one time or at repeated times.

8.1.3 Symptoms of excessive exposure include irritation of the eyes, nose and throat, sleepiness, cough, cramps in the abdomen, nausea, and in some cases excitement.

8.1.4 **TOXIC EFFECTS AFTER INHALATION.** The generally accepted maximum allowable concentration in air is 200 parts per million by volume for an 8-hour day. When exposed to higher concentrations of vapor, workers usually complain of tears and burning of the eyes and irritation of the nose and throat. There may also be nausea, vomiting, drowsiness, an attitude of irresponsibility and even an appearance resembling that of alcoholic intoxication. Like other chlorinated hydrocarbons, perchloroethylene acts as an anesthetic.

8.1.4.1 *Acute Poisoning*

8.1.4.1.1 When the worker inhales an excessive amount of vapor within a short period of time, acute poisoning may occur. The first reaction is irritation of the eyes, nose and throat, and fullness in the head with mental confusion. There may be headache, dizziness, stupefaction, nausea, and vomiting.

8.1.4.1.2 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 6.8 Tank and Equipment Cleaning and Repairs).
- (c) When perchloroethylene is handled carelessly (see 6.4 Employee Education and Training).

8.1.4.2 *Subacute Poisoning*

8.1.4.2.1 Subacute perchloroethylene poisoning may result from prolonged or repeated work in an atmosphere containing a concentration of perchloroethylene of over 200 parts per million, but under conditions in which the amount absorbed is not sufficient to cause acute symptoms during a few hours' exposure.

8.1.4.2.2 Workers with subacute poisoning may become acutely ill and suffer from such symptoms as headache, fatigue, nausea, vomiting, mental confusion and temporary blurring of the vision.

8.1.4.2.3 Some conditions under which subacute poisoning may occur are as follows:

- (a) Where the ventilation is inadequate, resulting in concentrations of higher than 200 parts per million of perchloroethylene,
- (b) Where the vapor concentrations are high intermittently, due to faulty handling of the liquid,
- (c) Failure of the individual to take adequate precautionary measures.

8.1.5 *TOXIC EFFECTS FROM EXTERNAL CONTACT*

8.1.5.1 *Skin.* Perchloroethylene 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 hands into the liquid, and wearing clothing saturated with it. Reddening,

burning and, rarely, blisters may follow such exposure. The skin becomes rough, red and dry due largely to the removal of skin oils. It cracks easily and is readily susceptible to infection. The skin has a chapped appearance. Some individuals show more intense effects from skin contacts than do others, and those found to be hypersensitive to perchloroethylene should be permanently kept away from further contact.

8.1.5.2. *Eyes.* Perchloroethylene may enter the eyes either as a vapor or a liquid (spray or splash). The resultant irritation produces lacrimation, burning and other symptoms of inflammation.

8.1.6 *TOXIC EFFECTS AFTER ORAL INTAKE.* The initial symptoms after toxic amounts of perchloroethylene are taken by mouth are those of irritation of the gastrointestinal tract such as nausea, vomiting, diarrhea and bloody stools. Such effects are usually less severe than from swallowing similar amounts of the other chlorinated hydrocarbons. The patient may complain of dizziness, perspire freely and become drowsy and later stuporous.

8.2 *Prevention and Control*

8.2.1 *VENTILATION*

8.2.1.1 The most important factor in prevention of toxic effects is to have sufficient ventilation to keep the concentration of vapor in the air below 200 parts per million. The odor of perchloroethylene is distinct and noticeable even in relatively safe concentrations, but it is weaker than that of trichloroethylene.

8.2.2 *STORAGE AND LABELING.* Containers should be labeled properly and closed tightly to minimize the danger of evaporation and spillage.

8.2.3 *EMPLOYEE EDUCATION* (see 6.4 Employee Education and Training).

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

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

8.2.4 *PREPLACEMENT PHYSICAL EXAMINATIONS.* Careful preplacement physi-

cal examinations should be made of prospective users of perchloroethylene. Such examinations should include a history of any unusual susceptibility, particularly to this material. Generally, individuals in the following groups should not be exposed to perchloroethylene:

- (a) Alcoholics
- (b) Those with marked over or underweight
- (c) Those with disease of the lungs, liver, kidneys or heart, with high blood pressure, or with chronic skin conditions.

8.2.5 PERIODIC PHYSICAL EXAMINATIONS. Employees who are exposed regularly to perchloroethylene 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 those enumerated above are present. Discovery of symptoms of perchloroethylene poisoning may indicate some defect in operation. This would serve to indicate also that other exposed employees should be examined for early signs of poisoning.

8.3 Personal Protective Equipment (See also 6.5 Personal Protective Equipment).

8.3.1 Personal protective equipment is not a permissible substitute for good, safe working conditions nor for adequate ventilation. Such equipment may protect the individual wearing it while others in the operation may be exposed to high concentrations of vapor. Equipment requires regular inspection, cleaning and replacement. This is especially true of industrial gas masks, since the canister contents and oxygen tanks become exhausted. The correct use of personal protective equipment requires education of the worker and careful supervision whenever such equipment is utilized. (See 6.4 Employee Education and Training).

8.3.2 Employees who may be subjected to severe exposures to perchloroethylene vapor as in tank cleaning and repair work (see 6.8 Tank and Equipment Cleaning and Repairs), in intermittent operations where general ventilation is not practical, in cases of failure of piping or equipment, and in cleaning up spills, should be provided when indicated with proper eye and respiratory protection as follows:

- (a) Suitable gas-tight chemical safety goggles and/or face shields (see 6.5.2 Eye Protection),

- (b) Rescue harness and lifeline for those entering a tank or enclosed storage space. An outside attendant should maintain constant observation (see 6.8 Tank and Equipment Cleaning and Repairs),
- (c) Air or oxygen supplied masks (see 6.5.3 Respiratory Protection),
- (d) Industrial gas masks, (see 6.5.3.2 and note), with canisters approved by the United States Bureau of Mines for use in perchloroethylene vapor, should be used only when it is certain that the concentration of vapor is less than 2 per cent (20,000 parts per million) and there is no atmospheric oxygen deficiency, and then only for exposures not exceeding one-half hour.

8.3.3 To prevent dermatitis or other effects of direct contact of perchloroethylene with the skin, employees should be provided with:

- (a) Aprons (see 6.5.6.1)
- (b) Gloves (see 6.5.6.2)
- (c) Acid-type goggles where there is danger of splashing (see 6.5.2.1)

CAUTION: Protective creams cannot be relied upon to afford adequate protection.

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

8.3.5 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 perchloroethylene, is an important aid in preventing dermatitis.

8.3.6 Reliable safety equipment manufacturers can supply appropriate protective equipment if they are informed accurately of the particular product in use.

8.4 First Aid and Medical Treatment

8.4.1 GENERAL PRINCIPLES

8.4.1.1 Most important in the case of any poisoning is quick removal from exposure. In the case of perchloroethylene poisoning, this means first removing the patient from the contaminated atmosphere and, insofar as possible, removing the perchloroethylene from the pa-

tient's skin, or gastro-intestinal tract, if these areas are involved.

8.4.1.2 The patient should be given fresh air by moving him to a well ventilated room and by dispersing any crowd. If breathing has ceased, artificial respiration should be started at once.

8.4.1.3 The patient should be kept quiet and comfortably warm, but not hot.

8.4.1.4 A physician should be called immediately. He should be told briefly and clearly what has happened and the exact location of the patient. Nothing should be given by mouth to an unconscious patient.

8.4.2 SPECIFIC ACTIONS

8.4.2.1 *Inhalation.* A person showing symptoms of perchloroethylene vapor poisoning should be removed promptly from the contaminated area. In case breathing has stopped, effective artificial respiration, such as that obtained by the prone pressure method or the Eve rocking method should be started immediately. If oxygen inhalation apparatus is available, oxygen should be administered, but only if one familiar with the operation of the apparatus is present to administer it. If the patient is conscious, hot tea or coffee may be given as a stimulant. Adrenalin should never be given to a person suffering from perchloroethylene poisoning. A physician should be called at once.

8.4.2.2 *Skin Contact.* All contaminated clothing should be removed at once. Clothing, including shoes, soaked in perchloroethylene should be removed and not worn again until thoroughly free from perchloroethylene. All affected areas should be washed thoroughly with warm water and soap. After this an ointment containing lanolin should be applied in order to help in replacing 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.

8.4.2.3 *Contact with Eyes.* If liquid perchloroethylene 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 or discomfort.) Medical attention should be obtained in all cases involving contact with the eyes.

8.4.2.4 *Taken Internally.* If a person has swallowed perchloroethylene he should be made to vomit, if conscious, by having him drink a glassful or more of lukewarm water in which a teaspoonful of salt to the glassful has been dissolved; or a similar amount of warm soapy water may be used. If necessary, the patient should be encouraged to stick his finger down his throat to induce vomiting. When possible, vomiting should be induced at least three times. Following this a tablespoonful of Epsom Salt dissolved in a glass of water should be given. A physician should be called at once.

The medical information in this publication has been supplied by the Medical Advisory Committee of the Manufacturing Chemists' Association, Inc.