

Handling Chlorine

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General

1. The hazards involved in the use and handling of chlorine are moderate if certain precautions are observed. The comparatively few accidents caused by it have been in most instances due to a lack of knowledge of the properties of chlorine or to failure to follow recognized safety precautions. Particular attention is called to "Interstate Commerce Commission Regulations for the Transportation by Rail of Explosives and Other Dangerous Articles in Freight, Express and Baggage Services," effective October 1, 1930, and supplements thereto, published as Pamphlet No. 9 by the Bureau of Explosives.

2. Large quantities of chlorine are used in the preparation of bleaching agents, fire extinguishing fluids, solvents, antiseptics, anaesthetics, and fumigants; in the purification of drinking water; and in connection with the disposal of sewage and industrial waste.

Properties

3. Chlorine is not found free in nature. Commercially it is produced almost entirely by electrolysis of sodium chloride or potassium chloride. As an article of commerce it is shipped as a liquid under pressure in steel containers which must conform to Interstate Commerce Commission regulations. The liquid in approved containers at temperatures above

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-28.5 degrees Fahrenheit has a gage pressure which is expressed in Figure 1. Liquid chlorine is an amber colored, oily fluid, about one and one-half times as heavy as water. At temperatures above -28.5 degrees, the liquid gasifies at atmospheric pressure. Chlorine as a gas is of a greenish-yellow color with a characteristic suffocating odor, and is about two and one-half times as heavy as air. Neither the gas nor the liquid is flammable or explosive in itself. A small gas leak in a chlorine container will gradually

increase because of the corrosive action of chlorine in air, which always contains some moisture. Additional information on the properties of chlorine will be found in such publications as "Lunge's Textbook of Inorganic Chemistry," "Tables of the Smithsonian Institute," "Mellor's Treatise on Organic and Theoretical Chemistry," "International Labor Office Brochure No. 34," and "Thorp's Dictionary of Applied Chemistry."

Physiological Effects

4. Physiologically, chlorine is a skin, mucous membrane and respiratory irritant. Exposure of the body to two per cent of chlorine in the air for ten to twenty minutes will cause marked irritation and blistering of the exposed areas. In sufficiently high concentration the gas may cause death. (See Table A.) When death results, it is generally caused by smothering or stifling; that is, by inability to breathe and by the spasmodic closures of the bronchial tubes. With exposure to chlorine gas

there is at first general excitement as indicated by restlessness, urination, irritation of the eyes and throat, sneezing, copious salivation, retching and vomiting. This is followed by difficult or labored respiration. Respiratory distress increases until eventually death may occur from apparent asphyxiation. Medical authorities claim that the effect of chlorine on the skin and mucous mem-

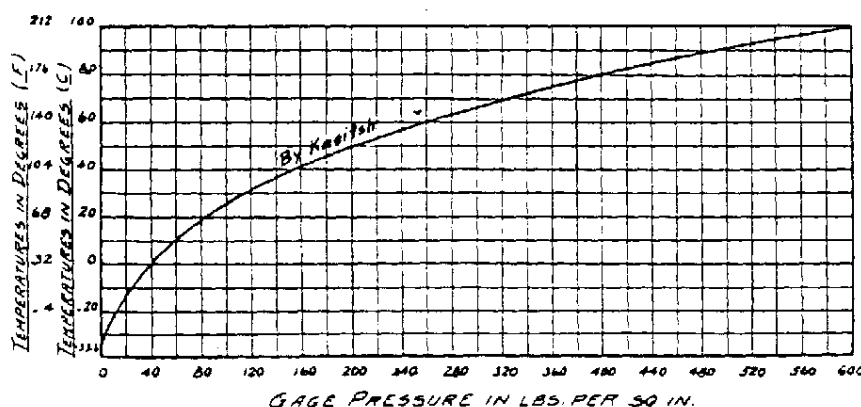


Figure 1. Curve showing gage pressures of chlorine at different temperatures. The pressure of chlorine in containers increases with a rise in temperature. It is, therefore, important that the containers be kept away from excessive heat.

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Table A
Physiological Response to Various Concentrations of Chlorine Gas

Effect	Parts of Chlorine Gas Per Million Parts of Air
Minimum detectable odor	3.5
Minimum amount required to cause irritation of the throat.....	15.1
Minimum amount required to cause coughing.....	30.2
Minimum amount required to produce slight symptoms of poisoning after several hours of exposure.....	1.0
Maximum amount that can be breathed for one hour without serious effects	4.0
Amount dangerous in 30 minutes to one hour	40-60
Amount likely to be fatal after a few deep breaths.....	1000

NOTE: The above data have been taken from United States Bureau of Mines Technical Paper 248, "Gas Masks for Gases Met in Fighting Fires."

branes is caused by its reaction with the moisture present to form hydrochloric acid. They also claim chlorine is nearly 20 times as toxic as hydrochloric acid, and because of its relatively low solubility, its locus of action in the respiratory tract is much more extensive than that of hydrochloric acid.

5. In any atmosphere containing chlorine, short, shallow breathing should be used. Chlorine produces no cumulative effects, and complete recovery from mild exposure usually occurs. Since chlorine is especially irritating to persons afflicted with asthma and certain types of chronic bronchitis, such persons particularly should avoid exposure to the gas.

Protection

6. The greatest danger from chlorine occurs where there is a sudden exposure to a concentration such as may occur from a broken valve or pipe. The danger is particularly acute from chlorine in a liquid state, when it is under pressure and vaporizes readily.

7. It is imperative that some form of protection be provided for emergencies. Several types of gas masks approved by the United States Bureau of Mines, and suitable for use in atmospheres containing not more than two per cent of chlorine gas, are available. A sufficient number of such gas masks should be on hand, located at readily accessible points outside of the area likely to be affected in case of an accident. *The instructions accompanying a mask, concerning its care and use, should be followed implicitly.* Everyone who is in danger of being accidentally exposed to high concentrations of chlorine should be provided with an individual gas mask, preferably to be used

by no else. He should be familiar with the accompanying instructions and trained to hold his breath and to put the mask on quickly and properly. It is also desirable to have available for such a person rubber gloves and a suit of rubber or other impervious material. When in use, the suit should be securely fastened about the neck and at the wrists and ankles. Periodic inspections and careful maintenance of gloves, suits and approved gas masks are essential.

Handling Containers

8. Every container holding chlorine, either gas or liquid, presents a hazard, and it must be handled with care. (See Safe Practices Pamphlet No. 95, "Compressed Gases.") The word "container" as used in this paragraph applies to all containers of one ton capacity or less. The Chlorine Institute recommends that the following rules be posted in conspicuous places:

- Neither drop containers nor permit them to strike each other violently.
- Never use a lifting magnet or a sling (rope or chain) when handling containers. (Note: One National Safety Council member states, "Hoisting is to be avoided as much as practical, low rubber tired or jack trucks being preferable. Where hoisting is necessary, safe lifting clamps are preferable to ropes. The use of cables or chains as slings is very dangerous.")
- Before returning empty chlorine containers, close their valves and test for chlorine leaks at the valve outlets by applying an ammonia water soaked rag attached to the end of a stick of considerable length. The formation of a white smokelike cloud will result if there is any chlorine gas leakage. If no leakage is indicated, apply cap nuts to valve outlets and attach valve protection housings or caps securely in their

proper places. These fittings should always be kept in place except when the containers are being emptied.

- Containers must not be refilled except with the consent of the owner and then only in accordance with the Interstate Commerce Commission regulations.
- Never under any circumstances mix gases in a container; it is not only dangerous, but contrary to Interstate Commerce Commission regulations.
- It is illegal to remove or change the numbers or marks stamped on containers without written authority from the Bureau of Explosives, 30 Vesey Street, New York City.
- Never use containers as rollers, supports, or for any purpose other than to contain chlorine.
- Never tamper with the safety devices in the valves of cylinders.
- Open container valves slowly. The use of large wrenches or pipe wrenches may damage the valves.
- Make sure that the threads on regulators and unions are the same as those on the container valve outlets. Never force connections that do not fit. The outlet threads are not standard threads.
- Containers or valves should never be repaired or altered by the consumer; the owner only should undertake this work. It is illegal to ship

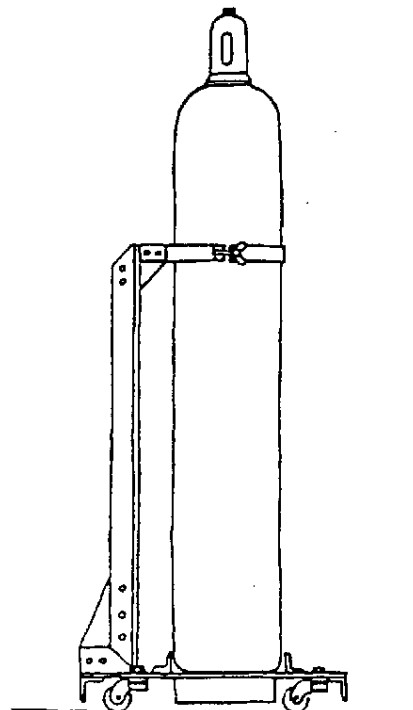


Figure 2. A low-wheel truck such as this provides a safe way of moving a cylinder from place to place when it is necessary to draw off small quantities of chlorine gas at different places.

a defective or leaking container. Telephone the owner or nearest chlorine plant for assistance in an emergency.

- i. All containers should be protected against excessive rise of temperature. Containers may be stored in the open, but in such cases should be protected against extremes of weather. During winter, containers stored in the open should be protected against accumulations of ice and snow. In summer, containers stored in the open should be screened against continuous direct rays of the sun in desert or other localities where extreme temperatures may prevail.
- iii. Never store containers near highly flammable substances such as oil, gasoline or waste.
- n. When practicable, do not store containers where they are exposed to continuous dampness.
- o. Store full and empty containers in different places to avoid confusion in handling them. (National Safety Council Note: It is also good practice either to tag the empties or to mark them with chalk.)
- p. Do not store containers near elevators or gangways or in locations where heavy objects may fall or strike on them.
- q. Chlorine canister gas masks of a type approved by the United States Bureau of Mines should be always readily available at places where chlorine is used. (National Safety



Courtesy Pennsylvania Salt Co.

Figure 3. Use only the proper tools for opening cylinder valves. Never force a valve.

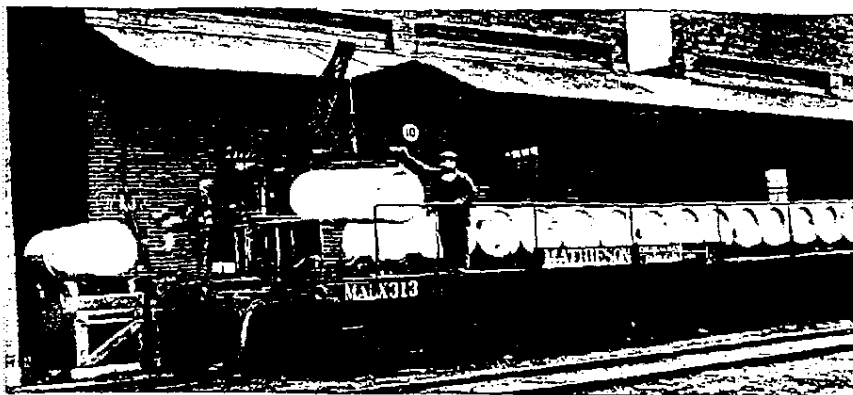


Figure 4. Loading one-ton units. Note ease with which these units may be handled.

Council Note: These canister masks should be located outside the apparent area of contamination so that in the event of the escape of chlorine gas, a person can get to the masks. Gas masks of the canister type do not supply oxygen and should not be used in atmospheres where the oxygen content is less than 16 per cent. In case of doubt as to the amount of oxygen in an atmosphere, it is best to use a fresh air hose mask.

- r. If it becomes necessary to warm a container, use great care because of the low fusion point (157 degrees Fahrenheit) of the safety plugs in the valves of the cylinders and in the heads of the ton containers. The valves should never be heated.
- s. Containers should be stored in an upright position, thus keeping the liquid away from the valve. (One ton containers are usually stored horizontally because of the difficulty of handling them in an upright position.)
- t. Reducing valves and gages designed only for chlorine can be used on containers for this exacting service. Consult the container owner about such matters.

Handling Tank Cars

9. Special precautions should be observed in handling tank cars of liquid chlorine. The Chlorine Institute recommends the following:

- a. Cars must be unloaded only on a properly protected private track of the consumer, or in the case of multiple unit cars where no private track is available, in accordance with Interstate Commerce Commission regulations.
- b. When possible, switch tracks on which chlorine cars are placed for

unloading should be devoted solely to this purpose.

- c. When a chlorine tank is spotted on a siding for unloading, brakes must be set and wheels blocked. Caution signs must be so placed on the track or car as to give necessary warning to persons approaching car from open end or ends of siding and must be left up until after car is unloaded and disconnected. Signs must be of metal, at least 12 by 15 inches in size and bear the words, "STOP—Tank Car Connected," or "STOP—Men at Work," the word "STOP" being in letters at least 4 inches high and the other words in letters at least 2 inches high. The letters must be white on a blue background.
- d. Tank car outlet valves should be kept closed when operator of chlorine line is not on duty and the pipe line beyond this valve should not be left full of liquid chlorine during shutdown periods.
- e. When tank cars are located on a dead end siding, the cars should be protected on the switch end by a derail. If on an open siding, derails should be provided at both ends. Keys for the derails should be in charge of the operator of the chlorine line.
- f. Unloading of single unit chlorine tank cars should be done through a coil allowing a moderate flexibility. Coil may be of heavy copper tubing for 500 pounds per square inch working pressure. A coil, however, should not be depended upon as a safety factor in case of a bump. Derails, flags, and lanterns should be used. Unloading, connecting, and disconnecting operations should be performed only in well lighted places by reliable persons who are properly instructed and made responsible for operations and who are equipped with chlorine gas masks.
- g. It is illegal to ship a defective or leaking chlorine tank car. If a tank

car is in bad order or if there is an accident, telephone the car owner or the nearest chlorine plant for assistance. The telephone numbers and residence addresses of the nearest chlorine plant organization members should be posted in the office of the person in charge of the handling of chlorine in the plant of the user, in the first-aid room, and in the office of the manager.

- h. Consult car owner about return of multiple unit tank cars. *It is illegal to return the ton containers of one ownership on the underframe of another ownership.*

Emergency Measures

10. Persons handling chlorine should be protected from leaky containers. For this purpose the Bureau of Explosives recommends that at each unloading station there be provided chlorine gas masks of a design approved by the United States Bureau of Mines, and that employees at each unloading station be instructed in the use of the masks, and also instructed as follows:

(A) How to Handle Chlorine Leaks

- (a) Keep on the windward side of the leak.
- (b) If leakage is extensive, promptly warn all persons in the path of the fumes to move to a safer location, preferably to an elevation considerably above unloading location.
- (c) Use hose to spray water freely under slight pressure on the escaping liquid. This forms chlorine hydrate, from which the evaporation of gas is slow. Caustic soda dissolved in water adds to its effectiveness as an absorbent of chlorine gas.
- (d) If tank is punctured above the liquid, the gas will escape, and as water applied to gas leakage is not effective, the tank should be turned over to bring point of leakage below the level of the liquid. Leakage of liquid can then be retarded by the use of water.
- (e) If water is not immediately available, dig a trench to draw off the liquid to a lower spot, the object being to reduce the area of the surface of liquid from which evaporation takes place. Loose earth; cement; lime, either fresh or slaked; and textiles, wet or dry, especially bagging and felt, thrown on the liquid at once will act as an absorbent or blanket and effectively retard evaporation. If available, dry ice (solid carbon dioxide) packed as well as possible around the leaking container will so reduce the pressure that the leak will be greatly reduced.

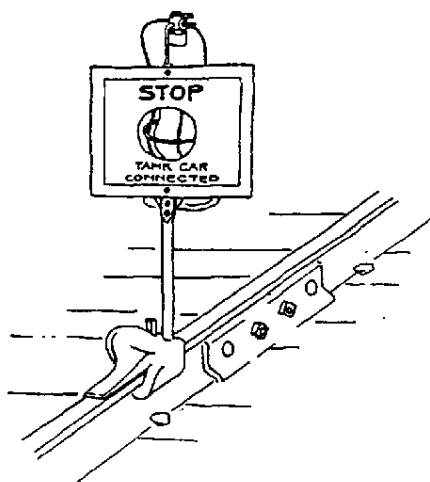


Figure 5. A portable combination derail, warning target and lantern suitable for protecting chlorine container cars against accidental shifting while being unloaded.

- (f) When attempting to plug a leak in any manner, hands and body should be protected against the escaping chlorine by the use of thick, loose-fitting gloves and a long apron of leather or similar flexible, non-porous material.
- (g) In a severe fire, leakage should not be serious as the gas will be carried upward and dissipated with the products of combustion. If the container is not leaking, every effort should be made to extinguish the fire.
- (h) When a pond or larger body of water is available nearby, the leaking tank should be entirely submerged, otherwise, if possible, tank should be moved to a point where escaping vapor will be carried by the wind away from the railroad yard or right-of-way and adjacent occupied buildings.

(B) How to Use Gas Masks

- (a) Persons delegated to use gas masks should practice regularly with them in order to become proficient in the operation of putting them on as quickly as possible in case of emergency, and also to become accustomed to breathing through them, as more power is required to draw air through the canister than is required in breathing under normal conditions. Hence, practice will aid materially in overcoming this natural handicap to the activities which the wearer has to perform while using the mask. When removing paper disk seal from canister for practice purposes, care must be taken not to injure the disk as it must be securely replaced immediately after the practice drill.

- (b) Mask should be adjusted strictly in accordance with instructions furnished by the manufacturer.
- (c) Walk up and down in an unaffected area to see that mask is working satisfactorily, and then walk slowly from the windward side, if possible, into the affected area.
- (d) Under no circumstances should a person equipped with mask run or become unduly excited so as to cause quick breathing, as under these conditions it will be more difficult to inhale through the resistance of the canister.
- (e) At least two men should always be equipped with masks at the same time, the second man holding himself in position to be of assistance to the first man in case of emergency, such as mask being torn, development of leak, or injury due to tripping or being struck by some falling object.

(C) Treatment of a Person Affected by Chlorine Gas

- (a) Remove at once to open air and away from all gas fumes.
- (b) Place patient flat on back with head slightly elevated. (National Safety Council Note: Patient should be kept warm. Do not exercise or excite him.)
- (c) If patient is not unconscious, give $\frac{1}{2}$ teaspoonful essence of peppermint or a moderate dose of bromoseltzer or a moderate stimulant. NEVER ADMINISTER MILK. (National Safety Council Note: The use of milk or cream is not recommended because they usually curdle in the stomach and cause vomiting which adds to the discomfort of the patient.)
- (d) The person affected should resist as much as possible the impulse to cough.
- (e) A physician should always be called.
- (f) If patient is unconscious and not breathing, use the prone pressure method of producing artificial respiration.

ACKNOWLEDGMENT

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