Compressed Gases

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1. This pamphlet has been prepared primarily for the promotion of safe practices in the handling and storage of cylinders containing compressed gases.

2. The Interstate Commerce Commission, in its shipping regulations, defines a compressed gas as "any material with a gage pressure exceeding 25 pounds per square inch at 70° F.; or any liquid flammable material having a vapor pressure exceeding 40 pounds per square inch, absolute at 100° F., March to October, inclusive, or exceeding 45 pounds per square inch, absolute at 100° F., November to February, inclusive, as determined by the method described in Appendix No. 1 of the I.C.C. Regulations." These regulations apply only to continental United States.

3. Many compressed gases are flammable and when mixed in certain proportions with air will explode if ignited. This pamphlet [illegible] the gases commonly used in industry and discusses the precautions that should be taken to prevent their uncontrolled burning or exploding. Problems confronting the gas manufacturer are not discussed.

4. If compressed gases are delivered to the consumer in cylinders, the cylinders should be manufactured and maintained in accordance with the specifications of the Interstate Commerce Commission and should be filled with gas and marked in accordance with these regulations. The regulations are contained in the Bureau of Explosives Pamphlet No. 9 which may be procured from the Bureau of Explosives, 30 Vesey Street, New York City. Compressed gases may be classified as follows:

a. Combustible non-liquefied gases.
b. Combustible liquefied gases.
c. Non-combustible non-liquefied gases.
d. Non-combustible liquefied gases.

5. Flammable gases are sometimes termed "red label" gases because Interstate Commerce Commission regulations require any cylinder containing such a gas [illegible] to bear a red label. Non-flammable gases are commonly termed "green label" gases for the same reason.

6. Even though not intended to be shipped in interstate commerce and designed only for local use, all cylinders containing compressed gases should be constructed in compliance with the appropriate I.C.C. specifications and filled in accordance with the regulations.

7. In the following paragraphs, general precautions applying to all gas cylinders are discussed. Gases commonly used in industry and the precautions applying to those particular gases are then treated in alphabetical order.

Precautions for All Gases

Handling

8. Do not abuse or mishandle gas cylinders. They should never be dropped, permitted to strike each other, or to strike any other object. A cylinder under pressure is both delicate and explosive, and the records of many serious explosions indicate the seriousness of mishandling. Workmen, whose duty it is to handle cylinders under pressure, should be trained carefully and work only under expert supervision.

9. A lifting magnet should never be used in handling cylinders, for if the electric power should fail, the cylinders would drop and a rupture might result. Neither should a rope or chain sling be used, because of the possibility of a cylinder slipping and falling. Where a crane is used to move cylinders, a safe cradle or platform is most practical.

10. Empty cylinders should be segregated from full cylinders and, before

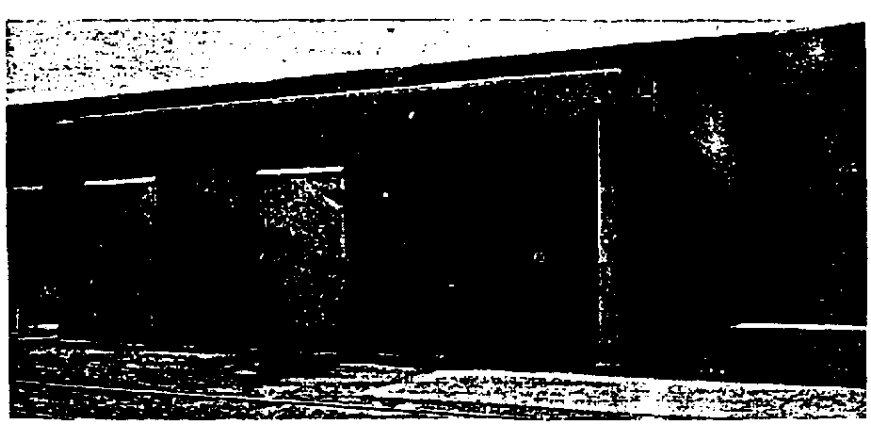
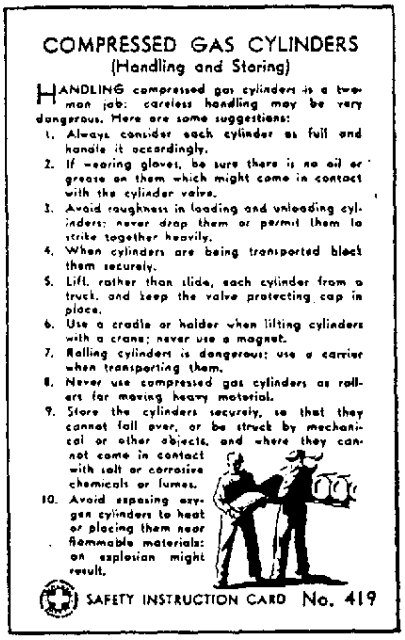


Figure 1. A fire-resisting storage house for compressed gases.



COMPRESSED GAS CYLINDERS
(Handling and Storing)

HANDLING compressed gas cylinders is a two-man job: careless handling may be very dangerous. Here are some suggestions:

1. Always consider each cylinder as full and handle it accordingly.
2. If wearing gloves, be sure there is no oil or grease on them which might come in contact with the cylinder valve.
3. Avoid roughness in loading and unloading cylinders; never drop them or permit them to strike together heavily.
4. When cylinders are being transported bleet them securely.
5. Lift, rather than slide, each cylinder from a truck, and keep the valve protecting cap in place.
6. Use a cradle or holder when lifting cylinders with a crane; never use a magnet.
7. Rolling cylinders is dangerous; use a carrier when transporting them.
8. Never use compressed gas cylinders as rollers for moving heavy material.
9. Store the cylinders securely, so that they cannot fall over, or be struck by mechanical or other objects, and where they cannot come in contact with salt or corrosive chemicals or fumes.
10. Avoid exposing oxygen cylinders to heat or placing them near flammable materials: an explosion might result.

SAFETY INSTRUCTION CARD No. 419

Figure 2. Reproduction of N.S.C. Safety Instruction Card.

shipping, all valves on cylinders should be closed and the protecting valve caps, if used, should be secured in place. This will prevent damage to the valve and threads. Cylinders containing combustible or noxious gases, not provided with valve protection caps or not having their valves protected by being recessed into the cylinder, should be shipped crated. Empty cylinders should be returned to the vendor promptly.

Precautions During Use

11. It is advisable for every gas cylinder to be equipped with a metal cap protecting its discharge valve against damage, unless the valve is protected by a recess in the head of the cylinder. When the cylinder is not connected for use, valve caps should be kept in place. Should an unprotected valve be knocked accidentally against an object, gas under high pressure might escape and considerable damage result.

12. Various methods are used to keep caps for cylinders from becoming misplaced or lost. In one company, a ring and chain attachment is provided. In another plant, each oxygen cylinder is provided with a wire loop which holds the cap when it is not in its regular place. In another concern, the man to whom the oxygen cylinder is charged is held responsible for the return of the cap and is told that if the cap is lost, it will cost the company $1.50.

13. When cylinders are used in an upright position, precautions should be taken to prevent them from being accidentally tipped over. In many instances the cylinders can be placed in clip racks.

14. No attempt should be made by the consumer under any circumstances to mix gases in a cylinder. Cylinders should be filled only by or with the consent of the owner, and then only in strict accordance with the regulations of the Interstate Commerce Commission and any local governing bodies.

15. Alterations or repairs to cylinders, or to valves, should be made by the gas supplier only. Users should never tamper with safety devices or with valve equipment.

16. The markings on cylinders should all be maintained clear and legible. Markings should not be changed without authority of the Bureau of Explosives, as provided in the Interstate Commerce Commission Regulations. Each cylinder should be marked by the gas supplier in letters at least one inch high and with the name of the gas the cylinder contains.

17. Make sure that the threads on regulators or other unions correspond to those on the cylinder valve outlet. Never force connections that do not fit.

18. Cylinder valves should be opened slowly. Cylinders, not provided with hand wheel valves, should have spindle keys on the valve spindles or stems while the cylinders are in service. Wrenches or other tools should not be used for opening cylinder valves, except where they have been provided or approved by the gas supplier. When empty cylinders are being returned, see that all valves are fully closed.

19. Cylinders of certain compressed gases should not be used without reducing the pressure through a suitable regulator attached to the cylinder valve. An exception may be in cases where the consuming device is not equipped with shutoff valves. Manufacturers' recommendations should be followed in all cases. Before a regulator is removed from a cylinder, close the cylinder valve and release all gas from the regulator. Combustible gas regulators, hose or other appliances, should never be interchanged with similar equipment intended for use with other gases.

20. Before making connection to a cylinder valve outlet, open the valve for an instant to clear the opening of particles of dust or dirt. This is generally termed "cracking the valve." Always, however, point the valve opening away from the body but not toward anyone else. An exception to cracking the valve in this manner could, of course, be when the cylinder contains a highly toxic gas such as HCN. Also, never crack the valve of a cylinder containing a combustible gas near a flame or other possible source of ignition.

21. After attaching the regulator, and before the cylinder valve is opened, see that the adjusting screw of the regulator is released (turned counter clockwise). Never permit the gas to enter the regulator suddenly. Open all valves slowly. Before removing the regulator from the cylinder close the cylinder valve and release all gas from the regulator.

22. Never try to stop a leak between a cylinder and the regulator by tightening the adjusting nut, unless the cylinder valve has first been closed.

23. Do not allow sparks, molten metal, electric current, excessive heat, or flames to come in contact with the cylinder, hose or regulator.

24. Regulators or hose equipment should never be interchanged. For in-

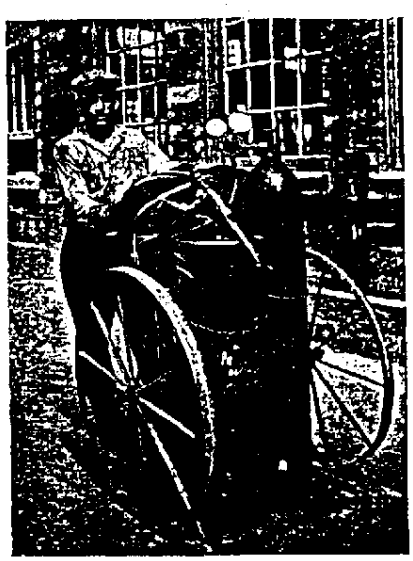


Figure 3. A cart for transporting welding equipment.

stance, where such equipment is used for one gas, it should be used for that gas only. Do not use oil or grease on attachments for oxygen cylinders.

25. When a large volume of acetylene, oxygen or other gases is to be used and more than one cylinder is required, manifolds should be used for coupling the cylinders together, but they should be of a design approved by insurance underwriters and recommended by the gas supplier. It is advisable for users of manifolds to purchase them from reliable manufacturers, by whom they should also be installed.

Storing Cylinders

26. Cylinders should be stored on end away from continuous dampness, on a concrete platform with a shed roof and side walls extending approximately half way down from the roof. Dividing walls should be installed also to furnish separate compartments for each kind of gas in storage. If valve protective hoods become frozen or filled with ice and snow, let them thaw out naturally in a warm room. Never use a steam hose to thaw them out, as fusible plugs may be melted and the entire contents of the cylinder released.

27. Cylinders containing compressed gas should never be stored near highly flammable substances, such as oil and gasoline. Where a considerable number of cylinders are stored it is advisable to have storage spaces segregated by fire resisting and heat resisting walls or partitions. This will facilitate removal in case of fire when gases under pressure not ordinarily hazardous may have the pressure considerably increased because of expansion due to the heat.

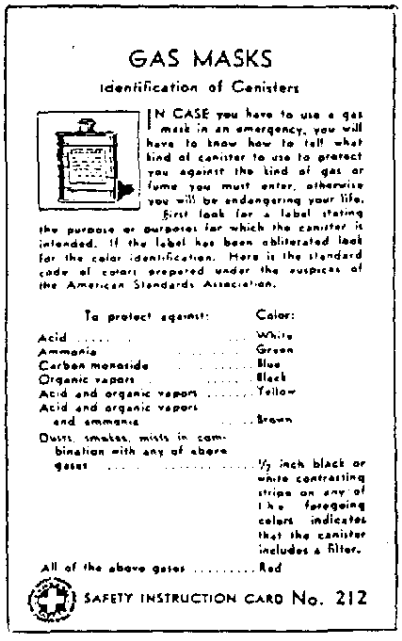
28. Do not store cylinders near elevators or gangways, or in locations where moving objects may strike or fall upon them. To avoid confusion, always store full cylinders and empty cylinders in different groups and also store charged cylinders containing the same gas together. Cylinders containing compressed gases should never be exposed to continuous dampness. Rusting will cause the caps to stick and will give other trouble. Store cylinders in a dry place and keep them away from corrosive chemicals or fumes.

29. When cylinders must be stored in the open, care should be taken to protect them against excessive variations of temperature. In winter, cylinders should be protected against an accumulation of ice or snow. In summer, they should be protected from the continuous direct rays of the sun.

General Precautions

30. Compressed gas cylinders should never be used for any purpose other than as containers for the particular gas for which they were designed. They should never be used as rollers for moving heavy materials because of the possibility of weakening the cylinder.

Figure 4. The interior of a fire-resisting store house for compressed gases.



GAS MASKS

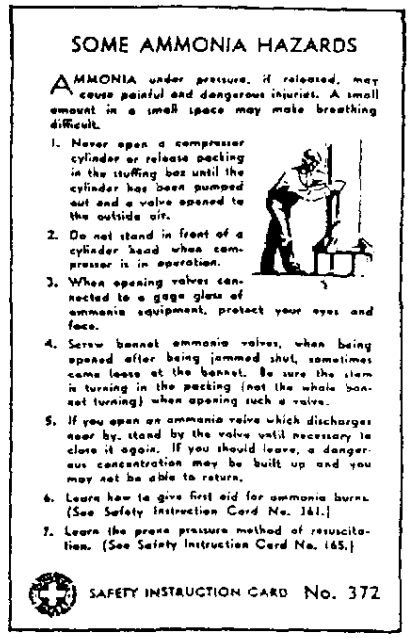
Identification of Canisters

IN CASE you have to use a gas mask in an emergency, you will have to know how to tell what kind of canister to use to protect you against the kind of gas or fume you must enter, otherwise you will be endangering your life. First look for a label stating the purpose or purposes for which the canister is intended. If the label has been obliterated look for the color identification. Here is the standard code of colors prepared under the auspices of the American Standards Association.

To protect against:	Color:
Acid	White
Ammonia	Green
Carbon monoxide	Blue
Organic vapors	Black
Acid and organic vapors	Yellow
Acid and organic vapors and ammonia	Brown
Dusts, smokes, mists in combination with any of above gases	½ inch black or white contrasting stripe on any of the foregoing colors indicates that the canister includes a filter.
All of the above gases	Red

SAFETY INSTRUCTION CARD No. 212

Figure 5. Reproduction of N.S.C. Safety Instruction Card.



SOME AMMONIA HAZARDS

AMMONIA under pressure, if released, may cause painful and dangerous injuries. A small amount in a small space may make breathing difficult.

1. Never open a compressor cylinder or release packing in the stuffing box until the cylinder has been pumped out and a valve opened to the outside air.
2. Do not stand in front of a cylinder head when compressor is in operation.
3. When opening valves connected to a gage glass of ammonia equipment, protect your eyes and face.
4. Screw bonnet ammonia valves, when being opened after being jammed shut, sometimes come loose at the bonnet. Be sure the stem is turning in the packing (not the whole bonnet turning) when opening such a valve.
5. If you open an ammonia valve which discharges near by, stand by the valve until necessary to close it again. If you should leave, a dangerous concentration may be built up and you may not be able to return.
6. Learn how to give first aid for ammonia burns. (See Safety Instruction Card No. 161.)
7. Learn the prone pressure method of resuscitation. (See Safety Instruction Card No. 165.)

SAFETY INSTRUCTION CARD No. 372

Figure 6. Reproduction of N.S.C. Safety Instruction Card.

31. Never use compressed gas to dust off clothing, as this may cause serious injury to the eyes or body. Serious accidents have resulted from this use of gases. In one case an employee suffered a severe injury in attempting to blow dirt out of a wound when the gas entered under his skin and inflated his entire forearm.

32. Cylinders should always be considered as full and handled with corresponding care. Accidents have resulted where the container was thought to be empty, but all of the pressure had not been released. The cylinder valve should always be tightly closed when the cylinder is not in use or when it is empty.

33. In transporting cylinders one should load or stow them so as to allow as little movement as possible. They should be secured to prevent the possibility of violent contacts.

34. Oxygen and anesthetic gases are sometimes sold in large cylinders. Hospitals have purchased these gases in large cylinders, and then transferred the gas to the smaller cylinders used in the anesthesia machines. The practice of

refilling small cylinders is attended with hazard and should be done only by competently trained persons. Many industrial plants also charge small cylinders for use with protective masks, taking their supply from large tanks. The same is true in these cases.

35. Receiving charged cylinders or shipping empty cylinders should be in charge of an experienced man. Considerable difficulty and confusion will be avoided if this suggestion is followed.

Gases Used in Industry

36. Table I lists the gases used in large quantities in industry, and several of their characteristics.

37. In the following paragraphs each of these gases will be discussed. While it is impracticable to give a complete discussion of each, a few of their uses will be mentioned, together with their chemical and physical characteristics and special remarks pertaining to particular hazards. For a discussion of health hazards of gases see Health Practices Pamphlet No. 9, "Gases and Vapors."

Acetylene

38. The chemical formula for acetylene is C_2H_2. It is a colorless gas with a strong, unpleasant odor in the commercial grade, highly flammable. It burns in air with a smoky flame except where a special burner is provided. It is used to considerable extent for illumination, but finds its principal industrial value when burned with oxygen. This combination produces an extremely hot flame, widely used in cutting steel and for welding purposes. Under no circumstances should acetylene be brought into contact with unalloyed copper except in a blowpipe or torch. Alloys containing less than 67 per cent copper may be used where needed.

39. Some reliable authorities (Le Chatelier) state that the gas forms flammable mixtures with air in a wide range (from approximately 2.8 per cent to 65.0 per cent). Other authorities place this range at 2.5 per cent to 80 per cent.

40. Acetylene cylinders should be used and stored always in an upright position. Acetylene is dissolved in a solvent liquid, usually acetone, producing a porous mass which fills the cylinder. The acetone will thus be prevented from draining out into the valves and other fittings.

41. Acetylene cylinders as received are charged to a pressure of 250 pounds per square inch, based at a temperature of 70° F. Acetylene should never be utilized at a pressure exceeding 15 pounds per square inch (this means the working pressure in the lines or hose) because of the possibility of an explosion.

42. Always keep the cylinder valve spindle key or the wrench in place on the valve spindle when the cylinder is in use. (See paragraph 18.) When returning empty cylinders, see that the valves are fully closed.

43. The pressure does not accurately indicate the amount of gas contained in the cylinder unless the temperature and acetone content are also taken into consideration.

44. Never use an open flame to detect combustible gas leaks. Use soapy water. During freezing weather, linseed oil may be used.

45. In case acetylene should leak from the cylinder valve and cannot be shut off with the spindle, remove the cylinder to a safe location and tag it as having a "defective valve." Place a warning near the cylinder not to approach it with a lighted cigarette or other source of ignition. Then notify the supplier and follow his instructions as to its further handling and return.

46. Cylinders containing acetylene should be stored in a separate group, never with oxygen or chlorine cylinders. In shops or plants using both oxy-acetylene and electric welding apparatus, care should be taken to avoid the handling of these equipments in any manner which may permit the compressed gas cylinders to come in contact with electric welding apparatus or electric circuits.

Ammonia (Anhydrous)

47. The chemical formula for anhydrous ammonia is NH_3. It is a colorless gas with a pungent odor and is used widely as a refrigerating agent as well as in many chemical processes. It is ir-

TABLE I

	Gas	Physical State as Shipped	Effect When Breathed[1]	Flammable	Flammable Range with Air (%)
1.	Acetylene	Dissolved	Anaesthetic	Yes	2.5 to 80.0
2.	Ammonia	Liquid	Irritant	Yes	16.0 to 26.0
3.	Butane*	Liquid	Anaesthetic	Yes	1.6 to 6.5
4.	Carbon dioxide	Liquid	None	No	None
5.	Chlorine	Liquid	Irritant	No	None
6.	Ethylene	Liquid	Anaesthetic	Yes	3.0 to 34.0
7.	Ethyl chloride	Liquid	Anaesthetic	Yes	4.3 to 14.8
8.	Helium	Gas	None	No	None
9.	Hydrogen	Gas	None	Yes	4.1 to 75.0
10.	Hydrogen cyanide	Liquid	Toxic	Yes	12.7 to 27.
11.	Methyl chloride	Liquid	Anaesthetic	Yes	8.3 to 19.7
12.	Nitrogen	Gas	None	No	None
13.	Nitrous oxide	Liquid	Anaesthetic	No	None
14.	Oxygen	Gas	None	No	None
15.	Propane*	Liquid	Anaesthetic	Yes	2.1 to 7.5
16.	Sulphur Dioxide	Liquid	Irritant	No	None

Explanation of terms:

[1]Anaesthetic. These gases exert a drug-like action when breathed, as they are absorbed into the blood. They may cause death when breathed in considerable quantities.

Irritant. These gases are not absorbed into the blood but injure the surface tissues of the breathing passages. Death may result from continuous exposure because of the contraction of the respiratory tract.

Toxic. Poisonous. This gas exerts a a chemical action on body tissue and prevents it from absorbing oxygen from the blood.

None. These gases are harmless when breathed in small quantities, but death may result from suffocation when inhaled in large quantities because they prevent oxygen from reaching the lungs. (This does not apply to oxygen.)

Note: — Oxygen, chlorine and nitrous oxide sometimes support combustion much more vigorously than does air. Many materials will burn in them that will not burn in air. This fact should not be disregarded in their handling and use.

*Classed under heading of Petroleum and Hydrocarbon gases in the discussion.

ritating and corrosive and in concentrations of two volumes in 1000 may produce dangerous irritation of the mucous membranes, permanently injuring respiratory passages and eyes. Heated to 1200° F., and mixed with a proper proportion of air, it will burn or explode in contact with a source of ignition. Such explosions have frequently proved very serious. Gas masks with suitable canisters, hose masks, or self-contained oxygen breathing apparatus and eye protection should be worn in case of leaks. In strong concentrations, moreover, ammonia may attack the skin and the breathing apparatus will not give full protection. Ammonia reacts with copper and brass but does not ordinarily affect iron and steel.

48. Cylinders of ammonia should always be stored in a cool place.

49. A cylinder of ammonia should never be connected to an ammonia refrigerating system except when the system is being charged or drained. Never withdraw ammonia from the system except with the permission of the owner of the cylinder, and then the cylinder should be charged only to the amount recommended.

50. Should it become necessary to withdraw ammonia from a refrigerating system into cylinders, care should be taken to avoid overcharging of the cylinders so used. Only empty ammonia cylinders should be used for this purpose and in order to insure that they are empty, the valve should be opened and left open for five minutes prior to attaching to the system which is to be emptied. The cylinder should then be placed on a scale and its tare weight determined. The tare weight should check closely with the tare weight furnished by the cylinder owner, and should there be a difference, the smaller of the two weights should be used. The cylinder can then be connected to the system but should also be weighed from time to time while filling and the amount charged should preferably be less than the weight given in Table 2.

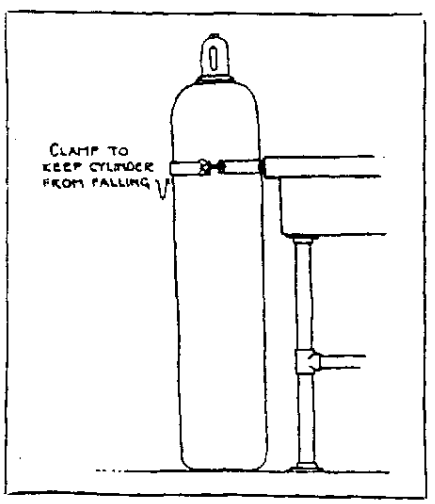


Figure 7. A clamp to prevent cylinders from falling while being used.

Table No. 2

CHARGING AMMONIA CYLINDERS

(Maximum Amounts)

Pounds of Ammonia	Dimensions of Cylinder
150	7 ft. long by 12 in. diameter
150	58 in. long by 15 in. diameter
100	7 ft. long by 10 in. diameter
100	56 in. long by 12½ in. diameter
50	46 in. long by 10 in. diameter
50	43 in. long by 10½ in. diameter
40	42 in. long by 10 in. diameter
25	28 in. long by 10 in. diameter

—Compressed Gas Manufacturers Assn., Inc.

51. When cylinders are used to return withdrawn ammonia, the customer should inform the manufacturer, giving the numbers of the cylinders so that such cylinders may be promptly weighed, examined, and cleansed before recharging with pure ammonia.

Butane

52. Butane is one of the group of liquefied petroleum gases. Its chemical formula is C_4H_{10}, and it boils below 32° F. Fire and explosion hazards similar to those encountered with commercial gasoline are involved in handling butane and its varying mixtures. It is quite flammable and explosive when mixed with the proper amount of oxygen or air, and ignited.

53. Butane is a refrigerant, and care must be taken not to allow the liquid to come in contact with the flesh. Because of rapid evaporation a very small quantity may cause freezing with resultant blisters similar to those caused by a burn. The eyes should be protected by goggles whenever there is exposure.

54. The vapor is about twice as heavy as air. Leakage will, therefore, seek lower levels and will flow along like water. Since the vapor is colorless and odorless, it may be taken into the lungs of an individual without his knowledge. Butane, when inhaled, acts to exclude the oxygen necessary to support life and the inhalation of large quantities may, therefore, cause serious trouble.

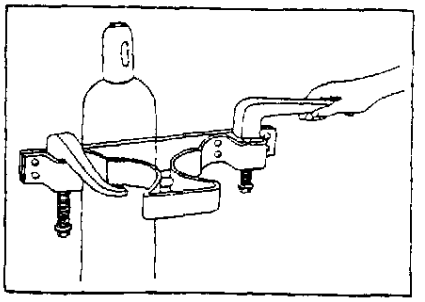


Figure 8. A rack for compressed gas cylinders. Note how the arms which hold the cylinder in place lock themselves in either the closed or open position.

55. Containers for liquefied petroleum gases should be handled with the same precautions observed in the case of cylinders of other flammable gases. Installation should be only by competent and well trained men.

Carbon Dioxide

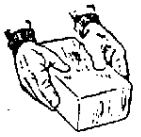
56. This gas is shipped, liquefied under pressure, in cylinders, and sometimes is known as carbonic acid gas. The chemical formula is CO_2. It is heavy, inert, colorless and odorless. The principal use of carbon dioxide is in the manufacture of soda water and other carbonated beverages. It is also used in refrigerating units. CO_2 dissolves in water, and is a weak acid which will attack copper, and such pipes or containers with which it may come in contact should have a block tin lining.

57. An atmosphere of carbon dioxide will not support life. Breathing small amounts results only in respiratory stimulation. Higher concentrations may produce physiological effects that are independent of suffocation. A 10 per cent concentration may produce unconsciousness. The principal hazards in the handling and use of this gas, however, are in connection with its pressure.

58. Artificial heating of cylinders should be avoided whenever possible, but if it is necessary to prevent freezing of the gas during discharge from the cylinder or to speed up the rate of

DRY ICE

Dry ice (solid carbon dioxide, temp. about —110°) can cause frostbite similar to a severe burn. In a tight container, the pressure can cause an explosion.



1. Wear gloves when handling dry ice or metal that has been in contact with dry ice.
2. Never put dry ice in any drink; even a small piece will cause a painful frostbite.
3. Never place dry ice in any tight container except one designed for the purpose.
4. When sawing dry ice, see that guards are in place. Use a wooden strip to push ice against the blade.
5. In a small enclosed space, gas from dry ice can cause suffocation. If warned by quickened breathing, dizziness or ringing in the ears, get into fresh air immediately.
6. Learn how to apply artificial respiration.

SAFETY INSTRUCTION CARD No. 417
National Safety Council

Figure 9. Reproduction of N.S.C. Safety Instruction Card.

discharge, the cylinder may be immersed in a bath of lukewarm water. The use of a flame, or of an electric or other heater, should be strictly forbidden. The temperature of the heating medium should never exceed 120° F.

59. Carbon dioxide cylinders are sometimes brought into rooms of high temperature in order to recharge refrigerating systems. Exposure to higher temperatures may cause the gas to expand sufficiently to break the rupture disc. Instances have been known where fragments of the disc have struck workmen, causing painful injuries. Persons in the vicinity should protect themselves against this hazard.

60. Care should always be exercised to avoid the backing up of water into the cylinder — particularly in winter weather—because of the danger of freezing. Every effort should be made to prevent foreign matter from entering the cylinders or valves.

61. Carbon dioxide should never be used for carbonators in bottling plants or soda fountains, or for similar use, without reducing the pressure through a suitable regulator attached directly to the cylinder. This is an important precaution.

62. Before attaching the pressure regulator to the cylinder, open the cylinder valve a little and then close it. This will insure its easy operation, thereby avoiding damage to the regulator by an outrush of gas from a suddenly opened valve.

63. Cylinders should be weighed before any gas is withdrawn and again after recharging the system, and the two weights recorded. The difference will be equal to the weight of the gas that has been withdrawn. This weighing and recording procedure should be followed every time gas is discharged from a cylinder so that the quantity of gas remaining may be ascertained at any time by referring to the record. In this way, partly full cylinders will not be confused with empties.

64. In opening and closing valves always use the tools supplied by the gas manufacturer and avoid the dangerous practice of striking the valve wheel with a hammer or other such object.

65. Seltzer water is ordinary water saturated at a very high pressure with carbon dioxide. At a temperature of 40° F., a pressure of 100 pounds is necessary to carbonate the water successfully. With higher temperatures, the charging pressure increases rapidly and, in consequence, the danger of breakage of the container likewise mounts.

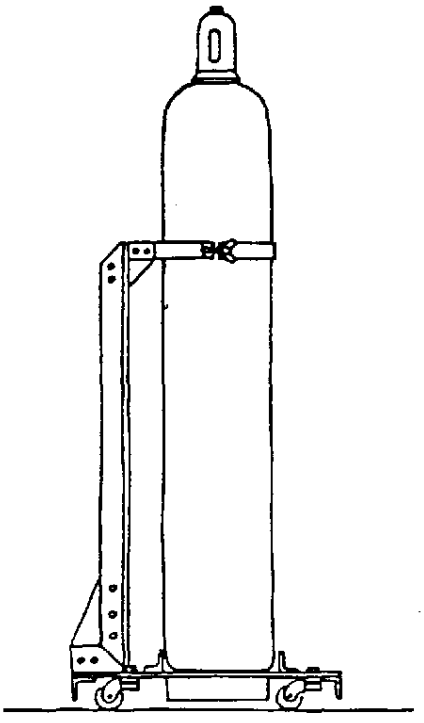


Figure 10. A truck for moving cylinders about the plant.

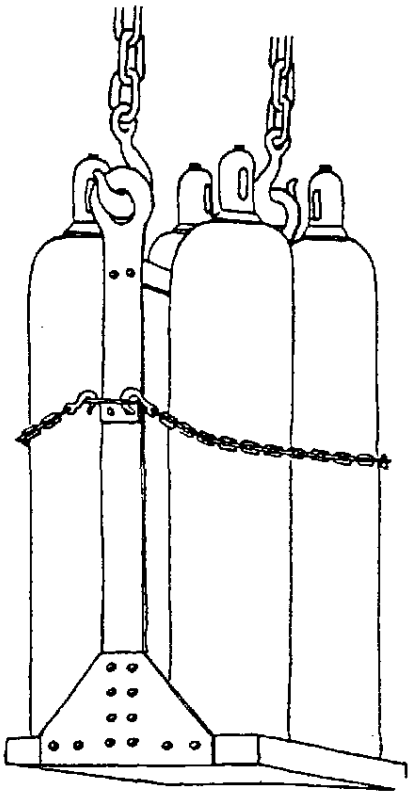


Figure 11. A cradle or carrier for handling cylinders with a crane.

66. Carbon dioxide is sometimes shipped frozen into solid blocks (dry ice). Its principal hazard is that of severe "burn" or frost bite through bodily contact with the solid. Another possible hazard is the generation of carbon dioxide gas in quantities sufficient to cause suffocation. Carbon dioxide gas liquefies when compressed to about 1000 pounds per square inch at a temperature of about 80° F. The liquid carbon dioxide is allowed to escape from cylinders into large tanks where "snow" is produced, which is then hydraulically compressed into hard blocks. This ice is commonly supplied to the trade in ten-inch cubes packed individually in brown wrapping paper and shipped in insulated containers. Dry ice does not melt but changes directly from the solid state into a dry non-flammable gas which is heavier than air. A pound of ice will produce at ordinary temperatures about nine cubic feet of carbon dioxide gas. Dry ice should never be

placed in a closed container as the rapid generation of gas may build up a dangerous pressure. Gloves should be worn whenever it is necessary to handle the ice or metal objects with which it has been in contact, unless some other protection has been afforded.

Chlorine

67. The chemical formula for chlorrine is Cl_2. Commercially, chlorine is produced almost entirely by electrolysis of sodium chloride or potassium chloride. It is shipped as a liquid under pressure in steel containers which must conform to I.C.C. regulations. It is an amber colored, oily fluid about 1½ times as heavy as water. At temperatures above —28.5° F. the liquid gasifies at atmospheric pressure, the gas being of greenish-yellow color with a characteristic suffocating odor. The gas is heavier than air. Suitable gas masks with U. S. Bureau of Mines approval should always be available to workers exposed to the gas. For further information on chlorine, see Safe Practices Pamphlet No. 71, "Safe Handling of Chlorine."

68. Chlorine is used in the preparation of bleaching agents, fire extinguishing fluids, solvents, antiseptics, anesthetics, fumigants, in the purification of drinking water, and in connection with sewage and industrial waste disposal.

69. Every container holding chlorine, either gas or liquid, presents a hazard, and such containers must be handled with extreme care. The Chlorine Institute has formulated a number of rules for handling chlorine containers and as these are extensive, reference is again made to Safe Practices Pamphlet No. 71.

Figure 12. Direct regulator and reducing valve away from you when opening valve.

70. Liquid chlorine, under pressure, is transported in 100 and 150 pound cylinders, in multi-unit tank cars holding 15 one-ton units; and also in single unit cars holding 32,000 pounds and 60,000 pounds respectively.

71. It has sometimes been the practice when there was a chlorine leak of possible serious consequence, to spray water on the leaking liquid. The water was frozen by the chilling action of the chlorine, and ice formed, sealing the leak for a sufficient period of time to allow the container to be removed or until necessary repairs could be made. Based on its experience and upon tests, however, the Chlorine Institute does not recommend the water treatment for a leak of either liquid or gaseous chlorine. In the hands of an expert, this treatment might prove successful, subject to temperature conditions. There are, however, few experts, and outside weather conditions cannot be predicted. It is, therefore, considered a dangerous procedure for general use.

72. Chlorine leaks may be located by using a cloth wet with aqua-ammonia. Ammonia in the presence of chlorine will produce white fumes (ammonium chloride). If leaks in containers or tank cars cannot be brought under control speedily, telephone the shipper's plant for assistance.

73. Should it become necessary to warm a container, use great care because of the low fusion point (157° F.) of the safety plugs in the valves of the cylinders and in the heads of the ton containers. Valves should never be heated. The fusible plugs on chlorine cylinders and ton containers melt at approximately 170° F., and may soften at lower temperatures. Never permit live steam or hot water to flow on these fusible plugs. To warm up cylinders of 100 or 150 pound capacity, they should be placed in a warm water bath, not more than 12 inches in depth, but under no circumstances should open flames be used in contact with cylinders to warm them and increase the rate of discharge. The temperature of the water should never exceed 100° F. It is not practical to warm ton containers by this method.

Dichlorodifluoromethane (Freon-12)

74. The main physiological effect of this gas seems to occur when the concentration in air is high enough to exclude ogygen. It is practically nontoxic. However, in the presence of a flame or hot surface, it is decomposed and products both irritating and dangerous are formed. The products of decomposition, however, are irritating and give adequate warning of their presence.

75. Extreme care should be taken should it be necessary to warm the cylinder to promote more rapid discharge, and temperatures above 125° F. should not be used. Steam or an open flame should not be allowed in direct contact with the cylinder or valve. When a cylinder is emptied of refrigerant, the valve should be closed and the cylinder disconnected from the system. The brass protection cap should be placed on the outlet connection of the valve to prevent dirt from entering the valve and also to prevent damage to the threads and to the valve connection. Cylinder hoods should be screwed in place before placing the cylinder in stock or returning it to the manufacturer.

76. Should it become necessary to withdraw dichlorodifluoromethane from a refrigerating system into cylinders, the same precautions should be taken as for other gases. The gas manufacturer should be advised of this procedure and given the serial number of the cylinder so that the particular cylinder, upon arrival at the filling plant, may be properly examined and cleaned before charging with pure gas.

77. Cylinders should be stored upright in a cool, dry place. They should be kept away from salt or other corrosive chemicals or fumes, as rusting will cause damage to the cylinders and cause the cylinder hoods to stick. Proper protection should be afforded through the use of goggles to eliminate the possibility of the liquid's coming in contact with the eyes and causing possible injuries due to its freezing action.

Ethylene

78. The chemical formula for ethylene is C_2H_4. It is a colorless, combusti-

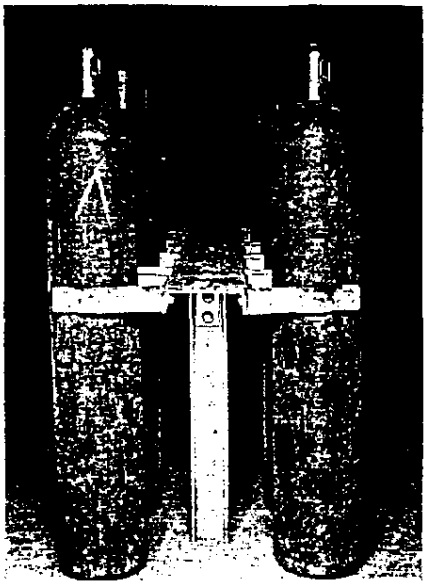


Figure 13. A good storage rack for compressed gas cylinders.

ble gas, the commercial grade having an unpleasant odor. It burns with a bright luminous flame, and when mixed with air and ignited may explode violently as do other flammable gases. It is one of the constituents of illuminating gas. It is now finding considerable use as an anesthetic by inhalation and is extensively employed in the synthetic chemical industry and for the coloring and ripening of fruits and vegetables.

79. Every precaution should be taken to prevent the possibility of ignition. The minimum ignition temperature of ethylene in air is 490° C. The precautions which apply to other gases compressed in cylinders likewise apply to this gas. For additional information on this gas see "Recommended Safeguards for the Installation and Operation of Anesthetical Apparatus Employing Combustible Anesthetics." This is a publication of the National Board of Fire Underwriters.

Ethyl Chloride

80. The chemical formula for ethyl chloride is C_2H_5Cl. It is a colorless liquid with a pungent odor similar to ether. It is volatile and flammable, burning with a green edged flame. Ethyl chloride is employed as a local anesthetic. It finds considerable use industrially as a refrigerant.

81. It is hazardous in certain mixtures with air, and if ignited, a fire or explosion may be caused. The products of combustion may be toxic. It has an anesthetic effect, a volume of 6 per cent for an exposure of thirty minutes being possibly dangerous to life. While it has a distinctive odor, it may be tolerated long enough to be dangerous.

82. All cylinders should be carefully handled and when not in use protective caps should be kept in place. Care must be exercised in storing containers of ethyl chloride, and men handling them should be entirely familiar with the content.

Helium

83. The chemical formula for helium is He. Next to hydrogen, helium is the lightest gas known and consequently has found considerable use in lighter-than-air-craft. Its great advantage here lies in the fact that it is non-combustible. It is one of the most inert substances, for it has no known compounds.

84. Helium may be stored in small cylinders which are usually shipped in box cars and are of the standard hydrogen or oxygen type. Each cylinder has an actual space capacity of about 1½ cubic feet and is shipped under a pressure of 1800 pounds per square inch. A cylinder holds an amount of gas which, when expanded to ordinary atmospheric conditions, occupies about 178 cubic feet. Cylinders are fitted with double seated valves instead of the single seated variety usually employed in handling other gases. It requires between 1100 and 1200 of these cylinders to transport the same amount of helium as one tank car. The precautions in handling and maintaining these cylinders are generally the same as for those of other gases.

Hydrogen

85. The chemical formula for hydrogen is H_2. It is an extremely light gas, colorless, odorless and tasteless. It is highly flammable and explosive in mixtures with air. It is used in hardening oils and fats, particularly soap, edible and cooking fats. It is also sometimes used as a fuel gas in flame cutting and in such welding operations as do not require the higher oxy-acetylene flame temperatures. It has extensive use in lighter-than-air-craft and is used as a cooling medium in many large generators.

86. Hydrogen, in mixture with air, has a wide explosive range (4.1 per cent to 74.0 per cent). Every effort should

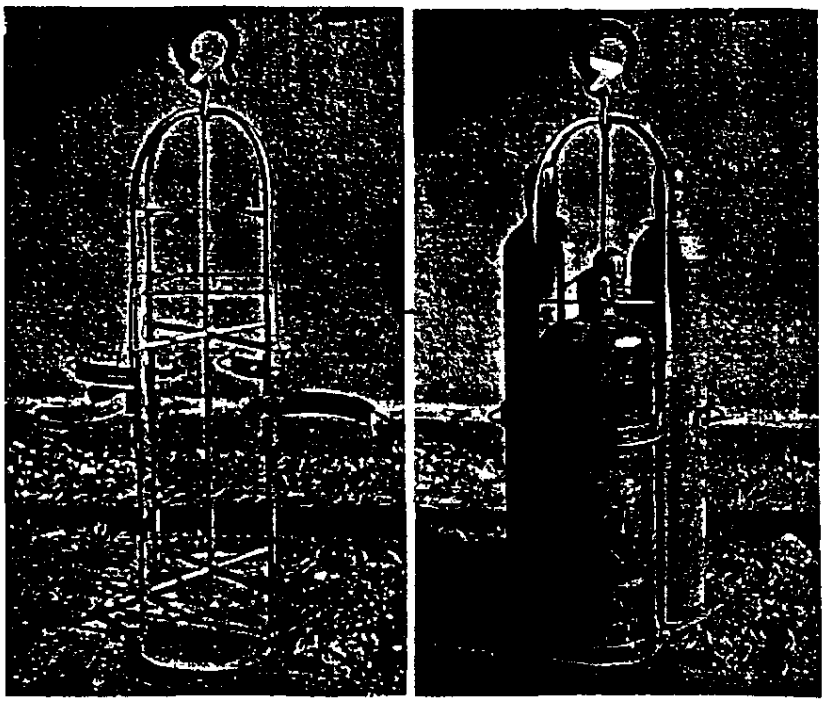


Figure 14. A device used for hoisting oxygen and acetylene cylinders aboard government battleships.

be made to handle and use this gas properly. Always keep sparks and flames away from the cylinders, hose and regulators.

87. Connections to piping, regulators, and other appliances should always be kept tight and an open flame should never be used to locate a leak. Always use soapy water. When cylinders are not in use, keep all valves tightly closed.

88. Never interchange gas regulator, hose or other appliances with equipment which has been used for other gases. This is particularly important in the case of hydrogen.

89. Cylinders containing hydrogen should always be stored in well ventilated places segregated from cylinders containing oxygen.

Hydrogen Cyanide

90. Hydrogen cyanide is also known as hydrocyanic acid or, when dissolved in water, as prussic acid. It has the formula HCN, boils at 79.7° F., and freezes at 5° F. Hydrocyanic acid is an effective fumigant for the control of insects, vermin and other pests. The very characteristics, however, which make HCN effective as an insecticide make it dangerous for human life unless it is handled properly. Its vapors are poisonous, inhalation of a large quantity or continued inhalation of small quantities causing death.

Figure 16. Use only proper tools for opening cylinder valves.

91. Liquid HCN is shipped in sealed cylinders in two sizes, namely, 75 pounds and 30 pounds. The cylinders should be stored in cool well ventilated places, shaded from the sun. They should not be stored in occupied buildings or in poorly ventilated places. In extremely warm climates, cylinders should be submerged in water to keep them cool, or they should be placed in artificially cooled storerooms. They should be kept in an upright position. It is a condition of sale of liquid HCN that cylinders must be returned to the point of origin within 90 days from date of shipment, whether the contents have been used or not. Suitable gas masks should be available and always worn when working with the gas. Either the gas or the liquid, however, may be absorbed through the skin, and masks in some cases may prove insufficient protection. Under no circumstances should a user attempt to remove a cylinder valve or make other repairs to cylinders. If operation is not satisfactory, the cylinder should be set aside and contact made with the manufacturer.

92. The use of methyl-orange test papers is suggested as an aid in detecting whether or not HCN is present. These are small strips of paper of canary yellow which, in the presence of an atmosphere containing HCN, turn pink or red and are very sensitive to relatively low concentrations of the gas. Authorities have suggested that if methyl-orange test papers do not change color within two minutes after exposure the space is safe for human occupancy. For additional information, see Table 1.

Methyl Chloride

93. The chemical formula for methyl chloride is CH_3Cl. It is a colorless gas which burns, when ignited in air, with a greenish flame liberating toxic fumes. Mixtures in certain proportions of air are explosive. It is used widely as a refrigerating agent. It is an anesthetic, and in concentrations of 2 per cent for exposures of two hours may be dangerous to life. It does not give definite warning of its presence even in dangerous concentrations, although manufacturers of this gas generally are odorizing it to avoid this hazard. Approved respiratory protection should be provided wherever the gas is present.

94. All cylinders should be carefully handled and when not in use protective caps should be kept in place. Care must be exercised in storing containers of methyl chloride, and men handling them should be entirely familiar with the contents.

FUMIGATING

With Cyanides

Hydrocyanic gas is the most penetrating and poisonous of all fumigants. For safety, follow this procedure:

1. Make a thorough search YOURSELF to see that all persons are out of the area to be fumigated and of adjacent areas into which gas might leak.
2. Station someone at each entrance to the premises to prevent entry either while the search is in progress or immediately after it is completed.
3. When closing off a room or section, leave the key in the lock of one exit—inside the door—in case someone is still inside.
4. To confine gas to the area intended, seal all cracks, holes, crevices and openings in walls, ceilings, and floors.
5. Post warning signs at all entrances. Put up barriers.
6. Enter a place under fumigation only when absolutely necessary. Wear a gas mask designed to protect against cyanide.
7. When working with a crew, team, or in pairs, never leave your work without reporting to the others when leaving, and report again when returning.
8. After fumigation has been started, work in pairs for mutual protection.
9. When gassing is complete, throw open all doors and windows. In no case permit occupants to enter until 12 hours after airing, children only after 18 hours.
10. Remove warning signs and barricades.

SAFETY INSTRUCTION CARD No. 217

National Safety Council PRINTED IN U.S.A.

Figure 15. Reproduction of N.S.C. Safety Instruction Card.

NITROUS FUMES

THE fumes referred to on this card are the red fumes that are sometimes present where nitric acid is being manufactured, used, or handled. Beware of them. Don't think, if you are big and healthy, that you can take chances with them. Follow this advice:

1. Find out, before starting work, the best way to get out of those places where fumes might occur. Then, if they do occur, get away from them as quickly as possible.
2. Wear an approved gas mask if it is necessary for you to work in fumes. Never depend on placing a handkerchief or respirator over your mouth and nose.
3. Don't think for one minute that you can get used to the fumes.
4. If you do get caught in fumes and you have a suffocating cough, or feel a soreness when you breathe, see a doctor at once. You may feel pretty good when you get away from the fumes, but after a time, varying from a few hours to a day or two, you may feel further ill effects.

SAFETY INSTRUCTION CARD No. 219

Figure 17. Reproduction of N.S.C. Safety Instruction Card.

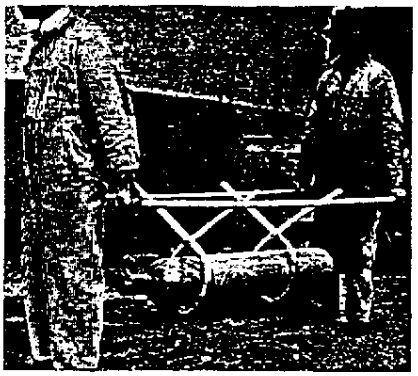


Figure 18. A carrier for transporting cylinders.

Nitrogen

95. Nitrogen, the predominant element of air, has the chemical formula of N_2. It is a colorless, odorless, tasteless gas, and under pressure the usual precautions in handling such cylinders should be observed. It is not combustible and does not support combustion. Nitrogen finds its greatest use commercially in the manufacture of ammonia and nitric acid. It is also used widely in manufacturing chemicals and in metallurgical processes.

Nitrous Oxide

96. The chemical formula of nitrous oxide is N_2O. Under ordinary temperature and pressure, it is a gas with a sweet taste and a faint agreeable odor. It is shipped in cylinders under pressure as a liquid. When inhaled it produces unconsciousness and insensibility to pain. Consequently, it is used widely as an anesthetic for short surgical operations. It is commonly called "laughing gas."

97. Nitrous oxide is non-flammable but will support combustion. The ordinary precautions applicable to other cylinders of compressed gases apply equally to those containing nitrous oxide.

Oxygen

98. The chemical formula of oxygen is O_2. It is a colorless, odorless gas and is an excellent supporter of combustion. It is non-flammable. When used with combustible gases such as acetylene, it produces a very hot flame and is widely used in industry for cutting and welding metals. For additional information see Safe Practices Pamphlet No. 23, "Gas and Electric Welding."

99. The valve of an oxygen cylinder should always be opened slowly.

100. Oil, or other flammable materials should never be permitted to come in contact with the valves, regulators, gages or any fittings of oxygen cylinders. Oil and grease in the presence of oxygen under pressure may ignite violently. Such cylinders should never be handled with oily hands or gloves. Oxygen is not flammable but supports combustion.

101. Oxygen should never be used as a substitute for compressed air and should always be designated by its proper name. It should never be termed "air."

102. Oxygen cylinders, when full are under a pressure of about 2,000 pounds per square inch at 70° F. This pressure should be reduced through a suitable regulator before use. Cylinders should be handled with care and kept away from heat. The same precautions apply as to other gas cylinders, which because of their content should be stored and used in as nearly an upright position as possible. The cylinders should not be handled by cranes, except in approved containers, slings or cradles especially designed for the purpose. Magnets, wire or cables should not be used.

103. Oxygen cylinders should be segregated from cylinders containing combustible gases. Where there are a large number of oxygen cylinders to be stored inside, it is recommended that they be stored in a separate room. It is a good practice to store full and empty cylinders in separate groups.

Petroleum and Hydrocarbon Gases

104. Petroleum and hydrocarbon gases, such as propane, butane, etc., are grouped under one heading because of similar characteristics. All of these may be classed as fuel gases, and the same general precautions apply.

105. They are used for illuminating and heating purposes and industrially with oxygen for cutting.

106. The containers should never be exposed to excessive heat or to rough handling. Sparks and flames should always be kept away from cylinders.

107. Make sure that all connections to piping, regulators, and other appliances are tight to prevent leakage. Should leaks develop, never test with an open flame. Always use soapy water. When cylinders are not in use, always keep valves tightly closed.

108. Cylinders should always be stored in a well ventilated location and as most of the gases are heavier than air particular attention should be given to venting the lower spaces of the room. They should be segregated from cylinders containing oxygen.

Sulphur Dioxide

109. Sulphur dioxide is a colorless, non-flammable, suffocating gas having an extremely irritating odor. Its chemical formula is SO_2. 500 parts per million, by volume, give a sensation of suffocation even with the first breath. It is heavier than air and is shipped as a liquid. It is employed as a refrigerant and also in the textile industry. When working with cylinders of sulphur dioxide, gas masks with suitable canisters should always be available. Workmen continually handling sulphur dioxide should wear suitable goggles.

110. In some cases it is necessary to warm cylinders to promote more rapid discharge of the gas. Extreme care should be taken to prevent such temperature from reaching more than 125° F. The fusible plugs in the cylinder melt at about 170° F., and may soften at even lower temperatures. Never use live steam or an open flame in heating a cylinder.

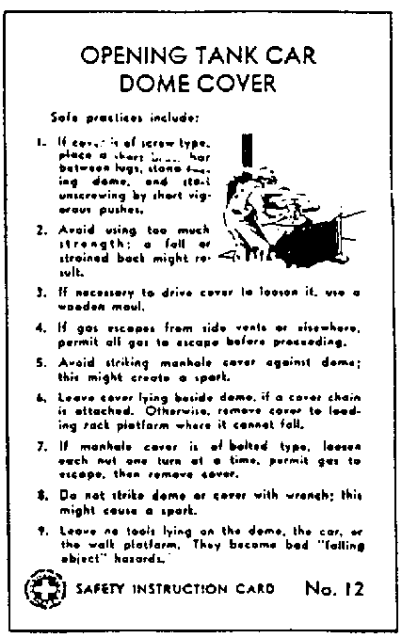


Figure 19. Opening tank car dome cover.

Figure 20. Loading one-ton units on a flat car.

111. Small cylinders of sulphur dioxide should always be stored in an upright position. (The one-ton cylinders are shipped, handled and stored horizontally.) Leaks in valves or piping containing SO_2 can be detected by the use of aqua-ammonia applied with waste or a cloth. In the presence of SO_2, white fumes will appear.

Tank Cars

112. There are special precautions which should be observed in the handling of compressed gases in tank cars:

1. Tank cars containing compressed gases should not be shipped unless they are charged by or with the consent of the owner.
2. Tank cars should not be loaded with any gas that combines chemically with the gas carried previously, until the car interior has been cleaned thoroughly.
3. Cars should be unloaded only on a properly protected private track of the consumer and in accordance with Interstate Commerce Commission regulations.
4. Whenever possible, switch tracks on which the compressed gas tank cars are placed for unloading should be devoted solely to this purpose.
5. Unloading operations should be performed only by reliable persons and under strict supervision.
6. When a tank car is spotted on a siding for unloading purposes, brakes should be set and wheels blocked. Caution signs should be placed on the tracks so as to give necessary warning to persons approaching the car. Such warning signs must be left in place until the car is unloaded and disconnected.
7. When tank cars are located on a dead-end siding, the cars may be protected on a switch end by a derail, or, if on an open siding, derails may be provided at both ends.
8. The shipping of a defective or leaky tank car is illegal.
9. Returning ton containers of one ownership on the underframe of another is illegal.
10. Changing numbers or marks stamped onto compressed gas tank cars without written authority from the Bureau of Explosives is illegal.
11. Never tamper with safety devices on tank car valves.

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