f. Joints Bonded and Inspected. Where a structure or pipe line is continuously employed as a ground return circuit, all joints shall be bonded and appropriate periodic inspection shall be conducted to ascertain that no condition of electrolysis or fire hazard exists as a result of such use.

g. Inspection. All ground connections shall be checked to determine that they are mechanically strong and electrically adequate for the required current.

2-8-28 HAZARDS OF INADEQUATE VENTILATION. Under conditions of improper ventilation, welding operations may cause health hazards. These hazards are almost entirely due to: the presence of gases, dusts, and fumes containing lead, zinc, cadmium, florine, or compounds thereof; the possible formation of oxides of nitrogen; and extreme heat.

2-8-29 VENTILATION REQUIRED. When any of the above hazards are present, either adequate forced ventilation shall be provided or an individual air respirator shall be worn by the operator.

2-8-30 VARIABLES AFFECTING VENTILATION. The attention of commanding officers is invited to the variables listed below which must be evaluated for their effect on calculations of minimum forces general ventilation requirements for spaces regularly used for welding operations.

a. Dimensions of space, with special regard to height of ceiling.

b. Number of operators (gas or electric).

c. Composition and coatings of metals to be welded.

d. Type and size of electrodes, and amperage used.

e. Rate of welding.

f. Variations in "natural" ventilation due to weather conditions.

g. Whether welding fumes tend to rise quickly and blow away from operator due to convection currents, or tend to rise slowly and concentrate around operator's head before dissipation.

h. Tendency of fumes to stratify above the working level.

i. Tendency of fumes to form flocculent dust.

j. Accident hazards involved in reduced visibility.

k. Excessive deposits of fume-dust on other shop equipment.

l. Excessive heat generated by gas and electric arc welding

2-8-31 SPACE CLASSIFICATION. Three space classifications have been adopted for convenience in setting ventilation standards, as follows:

Class I: Spaces of 50,000 cubic feet and over

Class II: Spaces of 5,000 to 50,000 cubic feet

Class III: Spaces under 5,000 cubic feet.

2-8-32 WHERE POSITIVE VENTILATION NOT REQUIRED.

a. Outdoor welding Operations. For welding operations on uncoated ferrous metals conducted in the open air, positive ventilating devices or respiratory protective equipment are not required However, where an operator is engaged in welding or cutting lead-bearing steels, lead or cadmium-bearing paint, whether indoors or out, an air-line make or local exhaust ventilation shall be used. Where conditions do not permit their use, a filter-type respirator, approved for protection from lead fumes may be used, but only for short intermittent periods of work.

b. Class I Spaces. Where welding of uncoated ferrous metals is the largest proportion of the work carried on in spaces over 50,000 cu. feet, positive ventilation is not required for the protection of welders provided:

(1) Welding bays are not structurally blocked, thereby obstructing cross ventilation.

(2) No welding operations are on the inside of tanks, boilers, or other closed iron or steel containers.

(3) A space allowance of 10,000 cubic feet is assured each operator.

2-8-33 INDIVIDUAL VENTILATION DEVICES.

a. Exhaust Ducts. Where welding of uncoated ferrous metals is the largest proportion of the work carried on, an individual positive ventilation device for each operator shall be so designed and installed as to remove toxic fumes and dust at their source. This ventilation may be in the form of individual portable exhaust pipes, exhaust ducts from a central duct system, wall or roof fans, or any other equivalent means which will insure fume removal or dilution.

b. Toxic Exhaust Fumes. All ventilating devices installed, particularly portable temporary devices, shall be carefully scrutinized to insure that fumes, dust, etc., are not being exhausted into the same space or into other spaces, thus creating unrecognized hazards. Steps shall also be taken to insure that air replacing what is drawn is clean and respirable.

c. Hood Devices or Hose-Nozzles. The effectiveness of either a hood device or hose-nozzle in removing fumes at their source depends upon the nearness of the intake openings to the welding operation. In the following table, which sets the minimum air-flow standards for removal of welding fumes, dusts, and gases at their point of origin, allowance is made for variables in the welding zone services, ranging from below 8 inches up to 15 inches from the arc or torch to the exhaust intake:

INDIVIDUAL POSITIVE VENTILATION
DEVICES FOR INDOOR WELDING
(on uncoated ferrous metals)

Welding zone distance to exhaust intake from arc or torch	Class I 50,000 cu. ft. or over	Class II 5,000 to 50,000 cu. ft.	Class III under 5,000 cu. ft.
	Minimum air flow per operator - cu. ft. per minute.		
Up to 8 inches	200	225	250
8 to 10 inches . . .	250	275	300
10 to 12 inches . . .	300	350	375
12 to 15 inches . . .	350	400	450

2-8-34 GENERAL SHOP OR SPACE VENTILATION.

a. Wall or Roof Fans. During welding of uncoated ferrous metals in confined spaces where individual ventilating devices are unavailable, a fan or fans (wall or roof) or other positive ventilating device shall be installed to insure fume dilution and general space ventilation at the following minimum air rate:

GENERAL SHOP VENTILATION
WELDING UNCOATED FERROUS METALS

Space	Minimum air flow cubic feet per minute per operator	Or Complete air change[1] each
Class I	350	20 minutes.
Class II	350	15 minutes.
Class III (space per operator)		
4-5,000 cu. ft.		4 minutes.
3-4,000 cu. ft.		3 minutes.
2-3,000 cu. ft.		2 minutes.
Less than 2,000		1 minute.

[1] The volume of the space divided by the cfm capacity of the blower, equals the theoretical time to change the air once.
[2] At least 1,000 cubic feet as well as the indicated space ventilation should be assured each operator.

b. Fan Efficiency. Particular attention is called to the necessity for selecting a type of fan capable of developing the required air volumes and pressure against the resistance of the exhaust system.

c. Screened Spaces. When electric welding must be performed in space entirely screened on all sides, the screens shall be so arranged that no serious restriction of ventilation exists. It is desirable to have the screens mounted on end posts so that their bottom edges are about two feet above the floor unless the work is performed at so low a level that the screen must be extended nearer the floor to protect nearby workers from welding glare. In the latter case the screens must clear the deck by several inches.

2-8-35 INDOOR WELDING OF GALVANIZED IRON OR STEEL, BRASS OR BRONZE.

a. Frequently and Regularly.

(1) The forced general ventilation prescribed in 2-8-34 shall be increased by at least 10 percent; or the individual ventilation devices prescribed in 2-8-33c. shall be used.

(2) Individual ventilating devices prescribed in the table in 3-8-33c. shall be provided. General shop ventilation standards are insufficient to protect the operator from the fumes of these metals.

b. Infrequently and Irregularly. (Class I, II, and III spaces) If these spaces are not already provided with the degree of ventilation prescribed in (1) above, it will be satisfactory to provide each welder working on galvanized iron or steel, brass, or bronze, with a portable individual ventilating device for use while such operations are being performed.

c. Inside Tanks or Closed Containers. When welding on galvanized iron or steel, brass, or bronze, inside tanks, or other closed containers, it shall be required that the operator be furnished an approved type of airline respirator or hose mask, and that its use is strictly enforced.

2-8-36 EXPLOSIVE FUMES.

a. Dangers. It must be borne in mind that certain gas and air-mixtures such as acetylene and oxygen may accumulate in concentrations which are not toxic but may be explosive. The required ventilation shall be governed by the more dangerous condition.

b. Exhaust to Atmosphere. Utmost care shall be taken that the exhausted vapors are not allowed to discharge into any other compartment. Exhaust shall be only to the outside atmosphere. Hatches, companionways, ports, etc., in the vicinity of the exhaust shall be closed to keep vapors from drifting into other compartments. When necessary, temporary means shall be provided at the outboard ends of temporary exhaust tubes.

c. Do Not Use Oxygen. When forced ventilation of a space is required or used, it should not be accomplished by injecting oxygen in lieu of fresh air. Such a procedure is likely to raise the oxygen concentration of the air in the tank and substantially change the flammability limits.

d. Flame Arresters. Wire-gauze flame arresters shall be in place on tank vents used for outlets, and similar flame arresters shall be provided at the outboard ends of temporary exhaust tubes.

e. Blowers. If weather conditions are such that the exhausted vapors will not be quickly dissipated, air-motor-driven blowers or those driven by explosion-proof electric motors should be used to assist in the dispersal. Electric blowers not equipped with explosion-proof motors shall not be used. If blowers are not used in quiet, humid weather, it is possible for a stream of explosive vapor to drift several hundred yards to a source of ignition, from which a flame will flash back to the source of the vapors.

2-8-37 CERTIFICATION OF CLOSED COMPARTMENTS. No person shall enter any closed compartment or poorly ventilated space in any MSTS vessel unless and until a "gas-free" certificate has been issued by the safety engineer or his authorized representative to certify that the danger of poisoning or suffocation of personnel, or the danger of ignition or explosion of flammable gases has been eliminated or reduced to the lowest practical minimum.

2-8-38 DEFINITION OF TERMS.

a. Closed Compartments or Poorly Ventilated Spaces. Closed compartments or poorly ventilated spaces are any spaces that are not well ventilated, or which have been closed for any appreciable length of time. Unventilated storerooms, blisters, double bottoms, tanks, cofferdams, pontoons, voids, idle furnaces, cold boilers, etc., are typical. The term also includes spaces which are normally occupied or regularly used, but which have been vacated and sealed because of damage, or for some other unusual reason.

b. Hot Work. Hot work is work involving welding, flame cutting, the use of open-flame equipment, or any work involving heating metal to or above a red heat. Riveting and any cold work involving the probability of striking sparks shall be considered as hot work, except when, in the opinion of the gas-free tester, circumstances do not necessitate such a classification (see article 92-454, BuShips Technical Manual). The precautions applicable to hot work shall apply to all other sources of flames, sparks, or intense heat, such as lighted cigarettes, open flame or electric cooking apparatus, non-explosive-proof lights, electric motors, etc.

c. In Way Of. In way of means within, or on the exterior boundary of, spaces containing flammable or explosive materials; or anywhere in the vicinity of such materials (see below).

(1) In addition to its obvious meaning, the term "within" also includes work performed from the outside of a space but which involves flame cutting, welding, or riveting through the plating, or which involves the possibility of heating to red heat the inside face of the plating or any other metal within the space. For example, flame cutting through a bulkhead between two tanks is hot work within both tanks. It is not hot work "within" the tank the workmen are in and "on the exterior boundary" of the adjoining tank. In such a case, it is not permissible to inert the tank being cut into. Both tanks shall be cleaned and gas-freed.

(2) The exterior boundary, is the outer face of the plating surrounding a space, or any metal work immediately contiguous thereto.

d. In Vicinity Of. Any location inside or outside the vessel where flammable or explosive materials are stowed, or where dangerous amounts of the materials or vapors therefrom may collect due to broken containers, overflow, seepage, air currents, or other causes shall be considered "in the vicinity of" the materials which are the source of the danger. This term includes the two immediately above, but the more specific terms are used when applicable.

e. Flammable or Explosive Materials.

(1) Explosives (bombs, warheads, depth charges, etc.); ammunition (gun, machine gun, small arms ammunition, pyrotechnics, etc.); rocket bodies, motors, etc. as listed in Bureau of Ordnance Manual.

(2) Combustibles (wood, cordage, bedding, etc.); and the "semisafe" and "dangerous" materials carried in relatively small quantities in cans, drums, etc., and listed in Chapter 30 of the BuShips Technical Manual.

(3) The "semisafe" and "dangerous" materials carried in bulk and listed in Chapter 14 (Bureau of Ships Technical Manual) are specifically, liquids, semi-solids, and solids capable of evolving flammable hydrocarbon or other organic gases or vapors at atmospheric temperatures or when heated. Alcohol, gasoline, diesel oil, fuel oil, and lubricating oil (and their residues) are typical liquids. Bitumastic compounds and coal are typical semi-solids and solids, respectively. Bulk quantities of oxygen supplying liquids, such as hydrogen peroside, nitric acid, and liquid oxygen, are not included in the scope of this definition.

2-8-39 GAS-FREE ENGINEER.

a. Qualifications. In a vital unit such as a ship, floating drydock, or shipyard, the gas-free engineer is a person qualified by training and experience to analyze hazardous conditions, especially with respect to entry into closed compartments and who has been authorized to decide in specific instances which precautionary measures shall be taken to safeguard personnel.

b. Responsibilities.

(1) He shall post a suitable label or tag near the entrance to the space or in some conspicuous location, describing the condition of the space.

(2) Or, he shall remain on the scene of operations until normal or safe conditions are restored.

(3) He may train and authorize competent persons to make preliminary inspections, gas tests, etc.

(4) The gas-free engineer or his authorized representatives shall have authority to order men out of compartments or to suspend work whenever an unsafe condition is found to exist. However, he shall immeidately notify the ship superintendent, or the repair superintendent, commanding officer, engineer officer, or other responsible authority of any such cessation of work and of the reasons therefor.

(5) Before work is resumed, a new gas-free certificate shall be obtained. (See 3/27/64 issue of Federal Register Safety & Health Regulations for Ship Repair, Article 1501.14(d)).

c. Limitation of Authority. When dictated by very urgent service requirements, the authority of the gas-free engineer may be abridged or relaxed as necessary but only with the approval of such authority as named in the preceding paragraph. Under such circumstances, and if it is practical to do so, the gas-free engineer shall be consulted as to the safest practical alternatives, and his recommendations shall be followed insofar as the circumstances permit.

d. Locating Spaces According to Ship's Plans. The engineer officer shall be consulted before opening any closed compartment aboard ship. If possible, the spaces to be opened or inspected shall be located by reference to the ship's plans. Reliance only on verbal information from the ship's personnel frequently results in opening the wrong space, which may have unforeseen and serious consequences.

e. Information on Labels. Every certificate, label, or tag issued by the gas-free engineer shall give complete information regarding the compartment or space to which it applies, and the date and time it was issued. If it shows a SAFE designation, it shall also show the date and time after which the safe condition cannot be depended upon to exist and the safe notation is not valid. To minimize confusion and misunderstandings, the limitations and applicability of the safety notations as well as their definitions are given in the following paragraphs. However, these definitions are not intended to indicate which conditions must be attained or whether to clean, gas-free, inert with gas, blanket with steam, or press-up the space. The procedures necessary to attain the conditions that the gas-free engineer has recommended and further definitions of terms are given in parts 3, 4, 5, and 6 of Chapter 92 of the BuShips Technical Manual.

2-8-40 DEFINITIONS OF SAFETY NOTATIONS.

a. Colored Labels. In connection with the requirements herein that the safety classification be shown on a tag hung outside a

space, it is suggested that such tags be printed invarious colors. Tags shall be colored and printed as designated by applicable MSTS instructions or ASA Z35.1 shall be used.

b. Not Safe for Men -- Not Safe for Hot Work. This tag is to be used when the following conditions have been found to exist:

(1) Workmen are in danger of poisoning due to hydrocarbon or other gases in excess of the limits of toxicity either present or likely to be evolved under prevailing conditions; or they are in danger of suffocation due to oxygen deficiency.

(2) There is danger of fire or explosion in the presence of hot work due to the existence of concentrations of flammable vapors within the limits of flammability; or due to the presence of residues likely to evolve dangerous amounts of flammable gases or vapors under the conditions prevailing; or due to the presence of flammable or explosive materials which are likely to be affected by the hot work; or due to the fact that the surrounding spaces have not been protected as required.

c. Safe for Men -- Not Safe for Hot Work. To be used when the following conditions have been found to exist:

(1) Hydrocarbon or other gases in excess of the limits of toxicity are not present and are not likely to be evolved by the entry of workmen or by prevailing atmospheric conditions and the oxygen content of the air is sufficient for workmen.

(2) There is danger of harm to workmen or of fire or explosion in the presence of hot work due to the existence of one or more of the same conditions enumerated in b.(2) above.

d. Safe for Men -- Safe for Hot Work. To be used when the following conditions have been found to exist:

(1) Hydrocarbon or other gases in excess of the limits of toxicity are not present, and are not likely to be evolved under any working conditions likely to prevail and the oxygen content of the air is sufficient for workmen.

(2) Flammable or explosive materials or vapors have been removed, or adequately protected and surrounding spaces have been protected as required.

e. Inerted -- Not Safe for Men Inside -- Safe for Men and Hot Work Outside. To be used when the following conditions have been found to exist:

(1) A nonflammable (inert) gas has been introduced into the space in the manner specified in Bureau of Ships Technical Manual, Article 92-461, et seq., and the concentration of inert gas in equal to or more than the minimum value specified in Article 92-462(a), and will be maintained so continuously. The oxygen content of the air in the space will not support combustion or life.

(2) Adequate measures have been taken to isolate the space from occupied spaces, and to ensure that it will remain isolated until the inerting medium is disposed of.

f. Pressed-Up With -- Safe for Men and Hot Work Outside. To be used when the following conditions have been found to exist:

(1) The space has been entirely filled with water or oil (the certificate shall show which liquid has been used -- no other liquids are permitted to be used.)

(2) Means have been provided to verify that the level of the liquid remains at or above the topmost point of the space to be welded, and to insure that no person attempts to enter the space.

2-8-41 EXPLOSIVES.

a. Removal from Welding Area. When the gas-free engineer finds that contemplated hot work is in way of explosives, torpedoes, ammunition, etc., he shall comply with the Bureau of Weapons provisions to remove all explosives to safe storage until normal conditions are restored.

b. Responsibility for Moving. If the requirement that explosives be moved is applicable, the gas-free engineer shall notify the gunnery officer (or the first lieutenant on ships not having a gunnery officer), who will be responsible for having the moving of the explosives done in the manner prescribed in the Bureau of Weapons Manual. The gas-free engineer shall not assume the responsibility of ordering that explosives be moved or of directing how they shall be moved; but he shall not issue a "SAFE" certificate for the space until he is satisfied that the explosives are a safe distance from the hot work. When he is satisfied, he shall classify and tag the space "safe for hot work."

2-8-42 COMBUSTIBLE MATERIALS. When hot work is contemplated in way of cordage, timber, or bedding; paints or chemicals in relatively small quantities in cans or drums; etc. they shall be removed from the space, or steps shall be taken to protect the materials from the effects of the hot work. When the gas-free engineer is satisfied that adequate precautions have been taken, he shall classify and tag the space "safe for hot work."

2-8-43 MSTS VESSELS.

a. For General Repairs and Overhaul. Vessels at commercial or Naval shipyards, at sea or at advanced bases, or alongside repair ships shall empty, clean, and gas-free bulk stowage tanks, cofferdams, pumprooms, etc., and other spaces (such as shaft alleys, wells, sumps, bilges, and voids coated with bitumastic or filled with oil for corrosion protection) within which hot work is to be done and which is subject to accumulation of combustible or toxic gases. Bunder tanks containing fuel oil needed to keep steam up or to keep auxiliary machinery operating need not be emptied. Cargo-heating coils and cargo-smothering lines and vent lines shall be steamed and blown. Cargo pumps and cargo lines shall be blown with steam or flushed with water. Spaces thus cleaned and gas-freed shall be labeled "Safe for men -- Safe for hot work -- EXCEPT on the piping."

b. Piping. Any piping, pumps, valves, etc. likely to contain flammable liquids (intake, discharge, distribution, and service systems; heating, displacement, and smothering and vent systems; and ladders, grabs, etc., made of tubing in bulk tanks), on which hot work will be done; or likely to be affected by hot work nearby; or not tight enough to prevent leakage into the space to be worked in or on shall be disconnected and blanked off, and shall be cleaned and gas-freed or inerted. The safety notation specified in the previous paragraph shall be modified to indicate which piping is "Safe" and which is "Not Safe". Other spaces containing substantial quantities of liquids in "package stowage" or as a result of an accident in a free state, shall be emptied by any practicable means.

c. Care of Adjacent Area. The gas-free engineer should not confine his attention to the vessel alone. Utmost care should be taken to avoid spilling flammable liquids into a drydock or allowing oil or oily waters to discharge overboard to create a serious fire hazard in harbor areas. When welding inboard alongside a pier, the pier in vicinity of the hot work should be "wet down" and any oil slick on the water around the vessel should be cleared. Waste, rags, etc. soaked with flammable liquids should be disposed of promptly and carefully.

d. Restoring Operating Conditions. When work is finished on a vessel, any tank vents, hatches, valves, etc. which were closed, locked, or sealed while hot work was in progress shall be checked to insure that proper operating conditions have been restored. This is especially important with regard to tank vents in order to avoid damage when tanks are refilled. Inert gases in spaces which must be entered shall be dissipated as specified in Article 92-462(h), Bureau of Ships Technical Manual, and the space made "Safe for men."

e. Procedures. Special instructions and precautions for localized repairs involving hot work on the vessel in way of explosive or flammable cargo spaces, and for examination, cleaning, painting, and repairs not in way of cargo spaces are given in Bureau of Ships Technical Manual, Chapter 92-402(2), (3), 403,421, and 422.

2-8-44 SUSPECTED COMPARTMENTS.

a. Gas-Free Engineer Responsible. Every closed compartment or poorly ventilated space, and all tanks, cofferdams, voids, bilges, etc., shall be considered UNSAFE for hot work until the gas-free engineer has inspected the space and has indicated that adequate safety measures have been taken.

b. Naked Lights. Matches, cigarette lighters, open flames, ordinary electric lights, flashlights, or any sparking electric apparatus shall not be allowed in suspected compartments or in the vicinity of open hatches, etc., leading thereto. Cleaning parties shall only use the approved explosion-proof, self-contained battery-fed portable lamps bearing approval of underwriters laboratories for use in Class 1, Group D, or approved as permissible by the U. S. Bureau of Mines, and lamps listed by U. S. Coast Guard as approved for such use.

c. No Smoking. Smoking shall not be permitted in confined spaces or areas.

d. Fire Extinguishers. Suitable fire extinguisher apparatus shall be provided in the vicinity of unsafe compartments or spaces.

e. Adjacent Spaces. Each space that is subject to accumulation of hydrocarbon or other gases and is in contact with a space in or on which repairs will be made (including spaces in contact at the corners or in contact with the top or bottom) shall be inerted. Classify and label "INERTED -- NOT Safe For Men INSIDE -- Safe For Men and Hot Work OUTSIDE." In the case of a minor repair, only those contacting spaces need be inerted which, in the judgment of the gas-free engineer, may possibly be affected by the hot work (as when working on the boundary of a tank but very close to the bulkhead between it and another tank). Other contacting spaces need not be inerted for a minor repair.

f. Regeneration of Gas. The possibility of regeneration of gas due to open pipes or other generation of gas due to open pipes or other connections between clean and dirty tanks should be recognized and guarded against.

g. Drifting Fumes. Care shall be taken to insure that hatches, pipes, passageways, companionways, innerbottoms, etc. subject to gas

accumulation, and not cleaned or inerted, are kept closed and that vents are so arranged that flammable fumes or vapors cannot drift into the vicinity of the hot work. Tanks in which there is piping on which men are working, and spaces or piping that are inerted, should be isolated from other spaces containing toxic flammable liquids or vapors by blanking off interconnecting pipe lines, or by closing valves and securing with rope or seizing wire or other suitable measures.

h. Leakage. In addition to the cargo tanks, service tanks, ballast tanks, settling tanks, and other compartments in which flammable liquids are present intentionally, it will be found that toxic flammable vapors from dripping of liquids from pipe joints, pumps, valves, and leaky containers or from seepage, drainage, or other causes, often contaminate the air in pumprooms, cofferdams, cargo holds, voids, shaft alleys, sumps, bilges, etc.

i. Coated Containers. Compartments which are often coated with bitumastic or filled with oil for corrosion protection, and which become filled with flammable vapors when heated, include voids, rudders, skegs, ramps (for landing craft), struts (fabricated), and water tanks.

j. Water Tanks. Always use care in entering or working on water tanks. Even if they are not coated with bitumastic, or are not near enough to oil tanks to be subject to oil leakage, they frequently contain explosive, toxic methane (marsh gas) from the decomposition of organic materials in stagnant water.

k. Changing Conditions. Shifting of ballast, disconnecting of pipe lines, shifting of the vessel from one berth to another, and similar operations may result in release of flammable liquids or vapors. If such operations are done after a "SAFE" certificate has been issued, particular care should be exercised to insure that an unsafe condition has not been created.

l. For Examination, Cleaning, and Painting. When a vessel is in a Naval shipyard for this purpose, the gas-free engineer shall exercise extra vigilance to make sure that incidental repairs involving hot work for which the need has become evident in the course of other work, are not undertaken until the location has been inspected and any necessary safety measures taken. While the vessel is in the shipyard, all spaces subject to gas accumulation shall be kept closed; or shall be opened and entered only after the proper precautions as prescribed by the gas-free engineer have been taken.

2-8-45 AIR SAMPLING AND ANALYSIS.

a. Testing Air. The air in tanks which have been empty for a long time and the air in other closed or poorly ventilated spaces

shall be tested for the presence of toxic or flammable concentrations of hydrocarbon or other vapors. Air conditions shall be checked with the flame safety lamp and the combustible gas or carbon monoxide gas indicator or by chemical analysis as frequently as circumstances appear to require. A check shall be made before men enter if work has been suspended overnight or for any similar period. Persons entering spaces for tests should be equipped with fresh-air-line masks and lifelines tended by reliable men outside. If one or more of the tests show any positive indication of the presence of any flammable vapor, regardless of whether it is below, within, or above the explosive range, the space shall be gas-freed and cleaned by the applicable procedures indicated in BuShips Technical Manual, 92-451-454.

b. Flame Safety Lamp. The flame safety lamp is generally to be used only to show the presence or absence of sufficient oxygen to support life, but the presence or development of other dangerous conditions is indicated by the action of the flame as follows:

(1) flame dies out -- deficiency of oxygen (less than 16 percent);

(2) flame goes out with slight "pop" -- explosive concentration of gas;

(3) flame flares up then goes out -- rich concentration of explosive gas;

(4) flame flares up brightly -- lean concentration of explosive gas.

c. Combustible Gas Indicators. These indicators are capable of detecting all mixtures of air or oxygen with combustible gases or vapors from fuel oils, gasoline, alcohol, acetone, etc. and of illuminating or fuel gas, hydrogen, and acetylene. They are sensitive in showing the presence of concentrations of these vapors or gases up to the lower explosive limit and give an accurate measurement of the percentage concentrations of the mixture if it is in or beyond the explosive range. They are not, however, sufficiently sensitive to measure accurately the small concentrations of flammable gases which can have an appreciably toxic effect when breathed for an extended period of time (8 hours or more), nor do they detect nonflammable gases which are toxic.

d. Carbon Monoxide Indicators. These devices are much more sensitive in detecting carbon monoxide than the combustible-gas indicators but are limited to the detection of this one gas.

e. Determination of Safe Conditions. There is satisfactory assurance of freedom from toxic concentration of flammable gases when:

(1) the space has been thoroughly ventilated;

(2) tests with the combustible-gas indicators (and with the carbon monoxide indicators when available) have given no indication of the presence of combustible gases (if any gas is indicated by the instrument, even though below the flammability limit, it is probable that the concentration is above the toxicity limit); and

(3) tests with the flame safety lamp have indicated no oxygen deficiency.

f. Physical Symptoms Indicating Toxic Gas. The conditions noted above do not give positive assurance of freedom from toxic concentrations of nonflammable gases, such as carbon-dioxide, nitrogen, carbon-tetrachloride vapors, etc. However, when the space has been thoroughly ventilated, and there is no oxygen deficiency as indicated by the flame safety lamp, workers in such atmospheres will receive warning of danger through such symptoms as labored breathing, excessive fatigue from slight exertion, dullness, etc., a considerable time before more serious reactions are experienced.

2-8-46 TOXIC GASES.

a. Physical Effects of Petroleum Vapor. Breathing of the vapors from petroleum products gives effects ranging from mild exhilaration, through irritation of the eyes, severe headache and complete intoxication, to unconsciousness and death. The effects become more pronounced as the percentage of concentration and time of exposure are increased. An added danger associated with breathing these vapors is the danger of accidents resulting from the dizziness induced by small concentrations not otherwise harmful.

b. Toxicity Limits. These gas concentrations of several hydrocarbons and of hydrogen sulfide as itemized in Article 92-459, BuShips Technical Manual and U. S. Department of Labor Safety and Health Regulations for Ship Repairing, Article 8.21(3)(b) as revised to date, are generally accepted as the maximum concentration to which men can be exposed without harmful effects. These toxicity limits are also very much lower than the flammability limits of these gases.

c. Use Masks If In Doubt. In addition to regular procedures, the cleaning of gasoline tanks shall be undertaken only by vessels equipped with portable air-motor driven ventilation sets. See Bureau of Ships Technical Manual, 92-452 for safe operating procedures and for personnel protection.

d. Carbon Monoxide. Carbon monoxide may be present in compartments painted with a linseed oil base paint and sealed immediately thereafter.

e. Hydrogen Sulfide. Hydrogen sulfide and other toxic gases will be generated by mildewing or rotting foodstuffs or other organic matter such as cloth, leather, and wood. Mildewing and rotting are accelerated when the space is warm and humid, as when cruising in the tropics or when an area has been flooded as a result of damage or accident.

f. Carbon Dioxide. An excess of carbon dioxide is frequently found in refrigerator spaces even though the spaces are undamaged and the foodstuffs are perfectly edible. This is due to the lack of ventilation and the tendency of foods to absorb oxygen slowly and give off CO_2. The concentration is rarely high enough to be dangerous unless a man stays in the space longer than a few minutes at a time, in which case he is liable to be overcome and eventually suffocated.

g. Rusting Metal. Oxygen deficiency can be caused by the rusting of metal in a tank which has been cleaned to bare metal and then sealed.

h. Additional Hazards. The above examples are only a few of the many ways dangerous conditions can occur in poorly ventilated spaces, and illustrate the necessity for careful adherence to safety precautions.

2-8-47 GAS FREEING CONTAMINATED SPACES.

a. Containers of Flammable Substances. Welding, cutting, or other work involving heat or sparks should never be done on barrels, used drums, tanks, or other containers which have held a flammable substance until they have been cleaned so thoroughly as to make absolutely certain that no flammable solids, liquids, or vapors are present.

b. Tools. In cleaning contaminated spaces, power operated or manually operated spark producing devices shall not be used. However, the use of small hand tools is permitted.

c. Gasoline Tanks. In addition to regular procedures, the cleaning of gasoline tanks shall be undertaken only by vessels equipped with portable air-motor-driven ventilating sets. Cleaning of gasoline tanks on vessels not so equipped shall be done only in approved shipyards, except in imperative emergency. See Bureau of Ships Technical Manual 92-452 for safe operating procedures and for personnel protection.

d. Scale on Plating. When thoroughly cleaning a tank, sludge or scale on the plating should receive special attention. Oils with high sulfur content and gasolines are particularly

corrosive and scale-forming and such coatings holds liquids like a sponge. The space may appear clean and gas indications may be negative, but when the scaled plates are heated, entrapped liquid will probably vaporize and mix with the large volume of air to form an explosive mixture. In removing scale, care should be taken to avoid chipping through thin plating.

e. Opening Sealed Compartments. In any sealed tank or compartment especially those closed because of damage, there is always the possibility that pressure has been built up inside. Whenever possible, the seal around the manhole or other opening should be broken before all hold-down bolts or other fastenings are completely removed. This will prevent the cover or door from being flung violently against the men nearby in case there is pressure behind it, and will enable the cover to be replaced if there is water or gas behind it that threatens to flood the next compartment.

f. Inaccessible Spaces. Particular care should be taken in cleaning spaces with extremely limited accessibility such as barges and innerbottom tanks.

2-8-48 CLEANING METHODS.

a. Steam Cleaning Method. This method is most commonly used to remove materials which are easily volatile. The equipment and materials required for steam cleaning are simple and available to almost any Naval activity. Safe operating procedures are described in Section 92-451, BuShips Technical Manual.

b. Other Recognized Processes. Cleaning with chemical compounds such as caustic soda, and the conditions under which cleaning may be abridged or omitted are outlined in 92-453 and 92-454, BuShips Technical Manual.

c. Carbon-Tetrachloride Prohibited. The use of CCl_4 (carbon tetrachloride) is prohibited without written approval of COMSTS.

2-8-49 INERTING AND PRESSING UP.

a. Inerting with Gas. In an apparently clean container there may still be traces of oil or grease under the seams even though the vessel may have been cleaned and flushed with caustic soda solution. The heat of the welding or cutting operation may cause such oil or grease to give off flammable vapors to the extent that an explosive mixture may be formed inside the container. Such mixtures can be prevented from burning or exploding by mixing in a quantity of an inert or nonflammable gas equal to a substantial percentage of the

volume of the vapor-air mixture. Carbon-dioxide, nitrogen, and helium are suitable for this purpose.

b. Blanketing with Steam. In the necessity for making emergency repairs and when it is impractical to obtain or use one of the inert gases or to clean and gas-free the spaces, steam may be used in lieu of inert gas to blanket the compartment. However, steam shall never be used under any circumstances in spaces containing flammable materials in closed containers, or in magazines, or spaces adjoining magazines.

c. Pressing-Up. Pressing-up is an alternative to inerting. In this procedure, the tank or space shall be completely filled with water, fuel oil, or lubricating oil. The gas-free engineer shall take steps to insure that there are no pockets between structural members, or on the high side under a slanting top, or on a listed ship into which the vapor-air mixture will be compressed and from which the liquid will be excluded.

d. Venting of Containers. Make sure that jacketed container or other hollow parts are sufficiently vented before heating, welding or cutting. Remember that air or any other gas which is confined inside a hollow part will expand greatly when heated. The internal pressure created may be sufficient to cause the part to act like a bomb.

e. Be Suspicious of Light Metal Parts. A metal part which is suspiciously light is probably hollow, and should be drilled to vent it before heating. Every possible precaution should be taken with jacketed vessels, tanks, or containers to vent the confined air sufficiently before doing any hot work.

f. Vents. Vents and telltales shall be provided when needed to eliminate vapor pockets and to verify the liquid level. However, drilling and tapping for them shall not be permitted on gasoline or alcohol tanks, but may be done on other tanks. Drilling and tapping shall be done slowly under a steady stream of water.

g. Oil Filled Spaces. Spaces entirely filled with oil should be vented before heating to prevent damage due to expansion of the oil.

h. Safe Operating Procedures. For inerting and pressing up of contaminated spaces, details are given in BuShips Technical Manual Section 92-461, and 464.

PART 2
GENERAL SAFETY PRECAUTIONS

CHAPTER 9
FUELS AND COMPRESSED GASES

SECTION I - HYDROCARBON FUELS

SECTION II - GASOLINE

SECTION III - COMPRESSED GASES AND CYLINDERS

2-9-1 DEFINITION AND SCOPE. This section deals with general precautions for hydrocarbon fuels such as gasoline, diesel oil, kerosene, pentane, heptane, octane, including leaded fuels. Specific directives for dock loading will be found in Chapter 2-2 (Seamanship). Specific probmems connected with a particular field of activity are covered in the appropriate chapter. Propane, butane, and other liquefied petroleum gases, will be found under the compressed gas section of this chapter.

2-9-2 INSTRUCTION OF PERSONNEL. Because of the hazards involved in the widespread use of gasoline and other hydrocarbon fuels and the varying circumstances under which they are handled, it is important that thorough instructions be given all personnel concerning these dangers and the methods of preventing fires and explosions.

2-9-3 FLASH POINT. The hazards of handling hydrocarbon products are related to flash point. The flash point of a liquid is the lowest temperature at which it gives off vapor near the surface of the liquid or within a vessel in sufficient quantity to form flammable mixtures with air. Products which give off flammable vapors at or below 80° F., such as gasoline, solvents, and most crude oils are the most hazardous of all petroleum products to handle. Certain petroleum products may be slightly less hazardous to handle such as kerosene, light and heavy fuels, and lubricating oils which have a flash point above 80° F. Kerosene has a flash point of about 115° F., and will not ignite at ordinary atmospheric temperatures; but if it is heated above 110° F., it will give off sufficient vapors to burn and may explode under certain conditions described in 2-9-16.

2-9-4 STORAGE BUILDINGS.

a. Construction Features. Nonflammable materials should be used for construction of buildings in which hydrocarbons and other flammables are to be stored. Open type structures are preferred.

b. Aboveground Tanks. For large aboveground tanks, concrete, earthen, or other nonflammable material berms are required.

c. Lighting. Explosion-proof type fixtures shall be used.

d. Ventilation. Natural ventilation of open type buildings is sufficient.

e. Lightning. Storage spaces should be adequately protected from lightning by use of lightning arresters.

f. Inspection. Containers should be periodically inspected for leaks at bungs and chimes, and bungs tightened using a new gasket if necessary to stop leaks.

g. Surroundings. The area surrounding hydrocarbon fuel storage should be cleared in order to cut down the spread of fire should it occur.

2-9-5 FACTORS NECESSARY FOR COMBUSTION.

a. Fuel. Fuel in the form of vapor must be present when anything burns, because it is not the actual substance which is consumed by the flame, but the vapor of the substance in combination with the oxygen of the air. A piece of wood held in a flame will not catch fire until it has been heated to a point where vapor is given off. As previously stated, petroleum products give off flammable vapors at or below 80° F., and therefore constitute greater fire hazards at lower ambient temperatures than those products with a higher flash point. Gasoline, a highly volatile, flammable product,

will vaporize at ordinary temperatures and pressures. Therefore, at ordinary temperatures and pressures, gasoline furnishes the first factor necessary for combustion.

b. Oxygen. A gasoline vapor-air mixture containing from about one percent to six percent gasoline vapor would have sufficient fuel (vapor) and sufficient air (oxygen) to explode. Thus, if anywhere from one to six cubic feet of gasoline vapor were introduced into a box containing 100 cubic feet of air, a mixture would exist which would readily ignite or explode upon the introduction of flame. Explosion will not take place if the mixture is either too rich or too lean.

c. Heat. Sufficient heat to raise the fuel to its ignition temperature is sometimes supplied unintentionally by a number of sources such as sparks or flame, if necessary precautions are not taken. Spontaneous ignition may also ignite flammable vapors, if they are present.

d. Occurrence. Since all petroleum products, at given temperatures and pressures, furnish the first factor necessary for fire -- namely fuel in the form of vapor -- all possible sources of ignition must be effectively controlled in the presence of these products. Because of the importance of these factors of ignition in fire precautions, they are discussed at some length in the following paragraphs.

2-9-6 FUEL OIL VAPOR.

a. Hazards.

(1) Fuel oil itself is non-explosive, very difficult to ignite in bulk, and is not normally capable of spontaneous combustion. The vapor from this oil, however, is explosive when mixed with air in certain proportions described in 2-9-16.

(2) Vapors of many petroleum products are highly toxic when inhaled or ingested.

b. Characteristics. This vapor is heavier than air and tends to accumulate in low levels, such as bilges and bottoms of tanks, where it may remain undiscovered until ignited by a naked light or spark.

c. Where Found. Vapor is always present in a partially filled tank that has contained fuel oil or other hydrocarbon products unless the vapor has been removed by artificial means. It is expelled through the vents from such tanks while they are being filled.

d. Leaking. A fuel leak allowed to continue in any part of the fuel-burning system may result in an accumulation of enough vapor to form an explosive mixutre with the air.

e. Detection of Vapor. Portable vapor-indicator instruments have been developed for detecting the presence of hydrocarbon vapors, and these instruments should be freely utilized, not only for detecting vapors during the tank cleaning process described in Chapter 2-8 of this Instruction but also for detecting vapors in cofferdams, voids, and storeroom spaces in which oil leaks occur, or in which hydrocarbon vapor is suspected to have collected.

f. Freeing Tanks of Vapor. Whenever a tank is to be entered or whenever any work is to be done in it requiring heated rivets, hammering, etc., or whenever such work is done in the vicinity of open tanks or pipes, all such tanks and all pipes leading to or from such tanks shall be cleared of vapors, after the fuel oil has been removed. See BuShips Technical Manual, Chapter 92-451.

g. Ventilation of Tank. Fuel-oil and other hydrocarbon tanks shall be continuously ventilated by means of a portable blower during the time that work is being done in them.

2-9-7 CONTROLLING VAPORS.

a. Spills. Take care that no spills occur.

b. Overflow. Avoid spills from overflow when loading storage tanks by gaging tanks prior to loading.

c. Leaks. Never neglect leaks. Make frequent inspections for leaks in tank seams, tank shells, and pipe joints. All outlets from tanks, except vents, shall be closed.

d. Cleaning Up Spills. If spills or leaks occur, clean them up immediately. Gasoline-soaked ground should be washed with water or covered with sand or dry earth. The area should be policed until flammable vapor has been eliminated.

e. Temperature Control. When temperatures are excessively high, cool storage tanks by sprinkling, or by playing water over them.

f. Closing Containers. Keep gasoline containers, whether empty or full, closed tightly.

g. Empty Containers. Beware of empty gasoline containers.

h. Ventilation. Insure proper ventilation of all enclosed spaces in which vapors may accumulate.

2-9-8 ACCIDENTAL IGNITION CAUSES. Ignition of the explosive mixtures may be caused by an open light, electric spark, static discharge, heat of the filament of broken electric lamps, smoking sparks from funnel of galley, fires under boilers, arcing of the brushes of a motor, grounds or shorts in electric circuits, arcing in any electric apparatus, opening any electric switch carrying current even in a flashlight, the turning off of an ordinary electric switch, induced electric charges formed by rubbing two surfaces together, motion of a rapidly moving belt. Refer to Chapter 2-15 of this manual and to Bureau of Ships Technical Manual, Chapter 67, Section V for possible hazards due to operation nearby of radio and other electronic transmitting equipment. Ignition can occur in so many ways that reliance cannot be placed upon safety measures designed to control this feature alone, and the most careful precaution is necessary to prevent the accumulation of gasoline vapor. However, the following precautions shall be most strictly observed and eternal vigilance maintained to prevent the ignition of hydrocarbon vapors.

a. Naked Lights. While oil, gasoline, and other hydrocarbons are being received or discharged, no naked light or smoking and no electrical apparatus liable to spark shall be permitted on board ship or within 50 feet of an oil hose, tank, compartment containing a tank, pump, or the vent from a tank. The carrying of matches or cigarette lighters on the person while at work loading, unloading, or cleaning tanks shall be prohibited. Portable lights of all kinds shall be explosion-proof in the vicinity of fluid oil. Their wires shall be well insulated.

b. Smoking. "No Smoking" signs and other appropriate visual warnings shall be conspicuously posted in the vicinity of loading and handling of petroleum products and the cleaning of tanks.

c. Bearer of Naked Light. No tugboat, locomotive, automobile, or other gasoline or diesel propelled equipment will be allowed to approach within 200 feet of loading operations unless specific approval is granted by the vessel's master and the commanding officer or his representative.

d. Clothing. In highly hazardous areas, personnel are not permitted to wear outer or under garments made of wool, silk, or synthetic textiles such as rayon and nylon, as these materials can generate sufficient static electricity to cause ignition of highly flammable products.

e. Static Electricity.

(1) Static electricity is produced when gasoline or similar flammable liquids undergo movement such as flow through a hose,

agitation of petroleum liquid, or when poured from one receptacle to another or when passed through a filter.

(2) Dangerous static charges are frequently accumulated and discharged in such a way that fires and explosions result unless proper precautions are taken.

(3) Moving parts of machines, particularly in dry atmospheres may cause static electricity. Grounding of machines prevents the accumulation of dangerous charges. Moving belts which are not electrically conductive, such as those employed for conveyors and power transmission are also sources of static electricity. One method of combatting this source is the use of rubber belting containing a conducting component.

(4) Moving trucks and other moving vehicles are capable of generating static electricity. At one time the National Fire Protection Association required trucks to drag ground chains, but this requirement has now been dropped.

(5) The metal nozzle at the end of gasoline or other hydrocarbon fueling hose should be bonded to the coupling which is attached to the pump by a copper wire inside the hose and the nozzle should be held in contact with any metal tank or receptacle which is being filled with gasoline. An induced charge of electricity of considerable voltage may be accumulated by the friction of fuel flowing through a metal funnel when loosely placed over the inlet of a container being filled. Therefore, the funnel should be in metallic contact with the supply outlet.

(6) All metal receptacles, funnels, etc., used in the handling of gasoline should be in contact with each other or should be bonded together and grounded.

f. Electrical Storms. Never load or unload flammable products during electrical storms.

g. Repair Work. Do not perform any mechanical work or repair involving hot work such as burning, cutting, or welding unless a permit is issued by proper authority.

h. Spontaneous Ignition. If large masses of certain combustible materials which have been soaked in oil are allowed to stand and the heat liberated from the slow oxidation process is not allowed to escape, the temperature of the mass rises. If this heating is allowed to proceed, the material reaches its ignition temperature and starts to burn. Thus accumulation of oily waste or paint-soaked rags in combustible buildings and containers is a cause of fires. For this reason materials subject to spontaneous ignition must be stored in a

way least likely to accelerate oxidation and most likely to cause any heat of oxidation to be absorbed by the surroundings. Use only self-closing metal receptacles for discarding oily waste and dispose of such collections daily.

i. Electrical Apparatus. Inspect electrical apparatus frequently and correct any condition likely to cause sparking. Whenever possible, open switches, and pull fuses before work is done on electrical equipment.

j. Engine Operation. Shut off gasoline tank-truck engines during the entire period of filling or discharging unless the truck is designed for engine operation to drive transfer pumps through a power take-off or unless the truck is approved for using gasoline in engines for operating pumps.

k. Vents. Care shall be taken that the flame arresters in the vent pipes from tanks are kept intact and no smoking, sparks, or flames shall be permitted in the immediate vicinity of such vents. The flame arresters shall be kept free from paint and accumulations of soot or lint.

2-9-9 FIRE FIGHTING EQUIPMENT AND EXTINGUISHING METHODS. Specifications and instructions relative to the care, use, location, etc., of fire fighting methods and fire-extinguishing equipment are given in Bureau of Ships Manual, Chapter 93, NAVSHIPS 250-004 Fire Fighting Manual, MSTS Damage Control Manual, and CG Manual 239 - Fire Fighting for Tank Vessels.

2-9-10 TOXIC HAZARD. Petroleum fuel vapors may cause anesthetic effects when inhaled. Inhalation of atmospheres containing 0.07 to 0.28 percent by volume of gasoline vapors (equivalent to about 5 to 22 percent of the lower explosive limit) may cause slight dizziness in some individuals after 3 minutes exposure; 1.1 to 2.2 percent by volume causes intoxication after 10 to 12 breaths. Longer exposure or greater concentrations may cause unconsciousness or death.

a. Permissible Limit. The maximum permissible concentration of petroleum vapors in which it is safe for personnel to work an 8-hour day is 500 parts per million (0.05 percent by volume). Since the lower explosive limit is 1 to $1\frac{1}{4}$ percent for most fuels, it should be remembered that the concentration of vapors which can be tolerated by personnel is far below that required to produce explosive mixtures with air.

b. Symptoms. First symptoms of exposure to toxic vapors are headaches, nausea, and dizziness. If such symptoms are noted, they should be taken as warning of the presence of dangerous amounts of vapors in the air. Recovery from these early symptoms is usually

prompt after removal to fresh air. However, if men are overcome by vapors, they should receive immediate medical attention. First aid consists of prevention of chilling and of the application of artificial respiration if breathing has stopped.

2-9-11 LEAD POISONING.

a. Tetraethyl Lead. The toxicity of heavy concentrations of vapors from gasoline or other fuel is increased if it contains tetraethyl lead, added for antiknock purposes. This lead compound may be inhaled with the fumes or may enter the body through the mouth or by absorption through the skin and is very poisonous.

b. Contaminated Tanks. No tank used for leaded gasoline shall be assumed to be free from the hazard of lead poisoning until the tank has been thoroughly cleaned, even though the combustible gas indicator shows that it is free of gasoline vapor. Special protective clothing and a fresh air hose mask must be worn until such time as the tank is declared lead free.

c. Repeated Exposure. Lead poisoning may result from repeated exposure to gasoline vapors in an enclosed or inadequately ventilated area where leaded gasoline has been spilled in considerable quantity. There is also danger of lead poisoning from fumes given off by stoves or other gasoline burning equipment in which leaded fuel is used. Therefore a deleading device should be used and adequate ventilation should be insured. If operating personnel are exposed persistently to leaded gasoline, they should be rotated on the job in order to limit the period of individual exposure.

2-9-12 INJURY TO SKIN AND EYES.

a. Contact. Gasoline may cause skin irritations if allowed to remain in contact with the skin, particularly under soaked clothing or gloves. Clothing or shoes through which gasoline has soaked should be removed at once. Gasoline should be washed from the skin with soap and water. Repeated contact with gasoline removes the protective oils from the skin and causes drying, roughening, chapping, and cracking, and in some cases infections of the skin which may become serious.

b. Gloves. Oil-resistant rubber gloves should be worn as protection by persons handling petroleum products.

c. Gasoline as Cleaner. Gasoline shall not be used for cleaning purposes under any circumstances.

2-9-13 SWALLOWING GASOLINE. If a person swallows gasoline, first aid should be given immediately. Giving the victim a large quantity of warm, salty water to drink in order to induce vomiting is an effective aid. Medical attention should be secured immediately.

2-9-14 ENTERING TANKS.

a. Installations Ashore. No person shall be required or permitted to enter a tank which has contained liquid petroleum fuel except under the conditions and observing the precautions prescribed in NAVDOCKS P-342, "Fuel Storage Tank Cleaning at the Shore Establishment" (Finished Product Tanks).

b. Installations Afloat. No person shall be required or permitted to enter a storage tank or storage space which has contained liquid petroleum fuel except under the conditions and observing the precautions prescribed in Chapter 92, Bureau of Ships Technical Manual.

2-9-15 EXPLOSIVE PROPERTIES. Gasoline is a highly volatile liquid giving off a vapor which, when combined with air in the proper proportion, forms an explosive mixture that can be set off by a slight spark or flame. A violent explosion, followed by fire if liquid gasoline is present, will result. Air at ordinary atmospheric temperatures can absorb as much as 28 percent of gasoline vapor, the amount depending on the volatility and grade of the gasoline, the most volatile grades causing the higher percentages.

2-9-16 FORMATION OF EXPLOSIVE MIXTURE.

a. Amount of Gasoline Required. The lower limit of explosibility of gasoline vapor and air is about 1.4 percent gasoline vapor by volume while the higher limit is about 6.0 percent gasoline vapor in air, by volume. One quart of gasoline left exposed in a closed space will render explosive upon complete evaporation under ideal conditions about 520 cubic feet of air, or a space of 10 by $6\frac{1}{2}$ by 8 feet. One cubic inch of gasoline will do the same thing for a space of 9 cubic feet or a space 3 by 3 by 1 foot. These figures will give an idea of the small amount of gasoline needed to produce a large volume of explosive mixtures.

b. Burning Vapor. Under certain conditions, gasoline or gasoline vapor will burn freely and without explosion if ignited immediately after it is spilled and before there is time for the formation of more than a small volume of explosive vapor.

c. Heating Container. A fire on or near a container of gasoline having a restricted opening may generate enough heat to vaporize the gasoline too rapidly for an explosion to occur inside the container. The vapor thus generated will issue from the opening

at a high rate and burn as it mixes with the air. However, if the opening is too small, the vapor pressure may build up and burst the container.

2-9-17 BEHAVIOR OF GASOLINE VAPOR.

a. Dangerous Quantities of Vapor. Gasoline vapor is heavier than air, and the highest percentage of vapor in air will be found near the bottom of the stowage space; however, the vapor will gradually spread throughout the whole space. It should be recognized that, due to the difficulty of preventing small leaks, danger from sparks or flame is always present wherever gasoline is used or stowed. It is, therefore, of the utmost importance to prevent the accumulation of the vapor in dangerous quantities; this can usually be done by proper ventilation.

b. Vapor Movement. A dangerous feature of gasoline vapor is that it may travel along a current of air for a considerable distance and then be ignited, the flash traveling back to the source of supply and causing an explosion or fire at some distance from the spark or flame. In this connection, whenever gasoline enters a scupper pipe or other drain line, the drain line shall be thoroughly flushed immediately thereafter with a hose from the fire main.

c. Connected Compartments. When a compartment in which gasoline is left is connected, as by an open pipe or drain, with other compartments, gasoline vapor may work its way to them. In such connecting compartments, therefore, there is a danger that gasoline vapor may be present which may be ignited by any source of spark or flame.

2-9-18 VENTILATION.

a. Required Systems. Natural supply and mechanical exhaust ventilation is provided for spaces containing gasoline tanks or containers and for control compartments in the gasoline-stowage system. As a precaution the ventilation system should be in operation continuously whenever gasoline is aboard ship. The exhaust should be taken from low points of the compartments. Gasoline stowage tanks and compartments not otherwise ventilated and all spaces into which gasoline vapors issue, shall be continuously ventilated by means of a portable blower during the time work is going on in them. An air motor driven exhaust blower is preferred although explosion-proof electric motor driven blowers are also provided.

b. Portable Drums. All vessels carrying cargo gasoline in drums in enclosed spaces shall be provided with an adequate natural air supply and forced exhaust ventilation to gasoline holds. Ventilation shall be in operation at all times so as to prevent

accumulation of gasoline vapors and possible formation of explosive mixtures of gasoline vapor and air. Unless such ventilation is provided, gasoline shall not be carried below decks without special authority from area commanders. If practicable, the gasoline holds shall be protected with an inert gas flooding system.

c. Hull Ventilation. Hull intake blowers shall be stopped in the vicinity of loading connection to prevent gasoline vapors being carried into the ship's ventilation system.

2-9-19 SMOKING AND NAKED LIGHTS.

a. Naked Lights. No smoking and no naked lights (such as oil lanterns, open flames, candles, etc.) should be permitted in the vicinity of gasoline drums, cans, stowage, piping, or spaces through which such piping passes. This refers to naked lights for illumination, and not to oxyacetylene flames, welding arcs, etc., in connection with hot work.

b. Lights and Fixtures. In the vicinity of explosive vapors all lights, whether fixed or portable, shall be of the explosion-proof, non-ferrous wire-guarded type.

c. Repairs. When making repairs or alterations involving hot work or sparks in gasoline holds or necessitating the introduction of steam pipes or electric leads into gasoline holds, precautions as outlined in Chapter 2-8, Section 3, shall be taken.

2-9-20 EXPLOSION-PROOF AND SPARK-PROOF EQUIPMENT. Electric motors and switches in gasoline holds and pumps shall be explosion-proof. Power operated or manually operated spark producing devices shall not be used when working on any part of a system or unit designed for storing or handling combustible liquids. However, the use of small hand tools is permitted.

2-9-21 JOINTS IN PIPING. Joints and valves in gasoline piping should be inspected at frequent intervals and kept absolutely free from leaks.

2-9-22 HAZARDS IN HOLDS. Where tanks, trucks, and other equipment with gasoline remaining in tanks are lowered into holds, inspection shall be made for leaks in the tanks, fuel lines, and carburetors. The hold shall be adequately ventilated and motors shall not be started if there is evidence of accumulation of flammable vapors.

2-9-23 STOWING PORTABLE CONTAINERS.

a. Special Storerooms. Gasoline when carried in drums or cans shall be carried in the paint and flammable-liquids storeroom, in vessels having such storerooms.

b. Weather Deck. In vessels having no flammable-liquid storeroom, gasoline shall be carried in drums or cans on the weather deck and so located and stowed that the containers may be readily jetisoned.

c. Fuel for Emergency Fire Pumps. Fuel mixture for emergency fire pumps is furnished in 7½-gallon containers. On vessels having not more than two P-500 emergency fire pumps, one filled container shall be stowed in a rack adjacent to each pump. On vessels provided with more than two P-500 emergency fire pumps, the quantity shall be increased on the basis of one container for each two additional pumps.

d. Near Stern. Whenever practicable, subject to the foregoing, weather deck stowage shall be near the stern of the vessel.

e. Prohibited Areas. Weather deck storage shall not be in the vicinity of hatches, galleys, heat-producing spaces, ventilation inlets or exhausts from such spaces, ready service magazines, or in or close to the line of fire of guns.

f. Release Racks. Quick-release type rack, where fitted, should be inspected frequently.

g. Gasoline Carried Below Deck. On vessels where gasoline in drums or cases is authorized to be carried as cargo in holds or between decks it shall be stowed in a hold separated by an oil-tight steel structure from all other cargo, with direct access to the weather deck, and not adjacent to boiler or machinery spaces or uptakes. The drums shall be well secured to prevent movement that might cause sparks or rupture of drums, wood dunnage being used for this purpose. The greatest care should be taken to see that only tight containers are stowed.

h. Inspection. Inspectors must check that no leaking containers are brought aboard ship, and that containers damaged during placement or transfer are reinspected. Before stowing, all drums shall be carefully inspected especially at chimes and bungs, and any that show signs of leakage shall be rejected.

2-9-24 CARE OF CONTAINERS.

a. Designated Use. Gasoline containers shall not be used as containers for other materials unless they have been previously surveyed and assigned to such materials and so marked.

b. Foreign Substances. Care shall be taken that no dirt, water, or other foreign matter is allowed to get into gasoline containers.

c. Rough Treatment. Gasoline drums are normally subject to hard usage and care shall be exercised that they are not abused. They shall not be struck together or against a structure in such a way as to cause sparks.

2-9-25 ISSUE. All issues of gasoline shall be made under the supervision of a reliable man who shall remain in charge until all containers are securely closed and who shall see that all safety precautions are carried out and that all chances of fire are eliminated. Drums shall be periodically inspected thereafter for leaks at bungs and chimes, and plugs tightened using a new gasket if necessary. A nonsparking metal faucet installed in a drum will be considered as fulfilling the requirements of a plug.

2-9-26 LEAKY CONTAINERS.

a. Detection. Inspect for leaky containers, and if any are found, immediately transfer the contents to a tight container and clear the leaking one of any vapor. Defective gaskets and plugs should be replaced.

b. Cleaning Faulty Tanks. Water shall not ordinarily be introduced into a gasoline drum, but if a leaky container cannot be made tight by tightening the filling and vent plugs, the drum shall first be filled to overflowing with water, and then emptied and blown through with a steam jet to eliminate any vapor present.

c. Disposition of Defective Containers. Defective containers, after they have been vaporfreed, shall be returned to a distribution depot for repairs. Repairs, especially those involving HOT WORK, shall NOT be made by the ship's force except in case of emergency, and then not until the container has been vapor-freed.

2-9-27 EMPTYING CONTAINERS. The containers shall be inspected after emptying to insure that all gasoline has been drawn off and then closed by tightening the filling and vent plugs, keeping gaskets in place.

2-9-28 SHIPMENT OF CONTAINERS. Empty containers shall be inspected before shipment for ruptured seams and punctures. Gaskets, tightly secured, must be in place.

2-9-29 PREPARATION FOR ACTION.

a. Throwing Drums Overboard. Gasoline carried in drums, cans, or tanks on the weather decks of vessels should be thrown overboard before action except for such amounts as are necessary to fuel airplanes assigned to the vessel and for emergency pumps. Jettisoned containers shall be securely closed.

b. Flooding System. Gasoline stowages fitted with inert gas flooding systems should be flooded with inert gas when battle is imminent.

2-9-30 RECEIVING GASOLINE.

a. Use of Hose. When gasoline is received in bulk, as in aircraft carriers, tenders, supply ships, or at shore stations, it shall be received by hose from the source of delivery.

b. Loading Tankers. During loading of tankers the covers of cargo tanks shall be closed but not clamped. Each tank as filled should be carefully watched, and when cargo enters expansion tanks, loading should be slowed down to guard against overflow. Gasoline should be loaded entirely through the piping. It should not be poured by hose into the hatch. Hatches and ullage plates should be secured after loading is completed.

c. Insulated Cable. Before connecting hose, an insulated copper cable, at least No. 4 U.S. gage, shall be connected between the source of supply and the receiving inlet, with sufficient slack in the wire to prevent tension.

d. Safety Switch. The wire shall remain in place until the hose is removed, and a single-pole electric ground safety switch shall be provided for easy operation at some distance from either end of the hose, insuring that no spark will occur except in the switch, which should not be opened when the hose is in place.

e. Fire Protection. A method of positive communication shall be established between fueling control points and the tanks being filled. When fueling aircraft or vehicles, or filling containers, a CO_2 portable fire extinguisher shall be at hand. Spilled fuel shall immediately be swabbed up or flushed off with water.

2-9-31 ELECTRICAL BONDING. Electrical bonding wires are fabricated into the hose wall to ground the hose terminals. The No. 4 gage ground wire is also connected to these hose terminals as added precaution to guard against the accidental failure of the hose and hose wire. This would occur if the supply and receiving ships drife apart to the extent that the hose would break and spill gasoline. Immediately after the gasoline started to issue through the hose failure, the hose wire would also break and thus might give a spark to ignite the gasoline. This spark is avoided by the use of the alternate ground wire, which is long enough to remain intact when beyond the point at which the hose would fail. Some ships are equipped with quick release hose couplings to avoid hose breakage under these circumstances, but the alternate ground wire is still essential.

2-9-32 NAKED LIGHTS IN VICINITY. No smoking shall be allowed and no non-approved machinery shall be in operation in the vicinity of gasoline tanks or filling connections, and galley fires in the vicinity shall be extinguished.

2-9-33 FUEL HANDLING AT NIGHT. Gasoline shall be handled by day if possible. When handled at night, special attention must be paid to the observance of all safety precautions and only the most qualified personnel should be assigned to the duty.

2-9-34 FILLING TANKS. In filling gasoline tanks:

a. Do not vent through manhole or into interior space.

b. Close hatches and ports in the vicinity of outboard vents.

c. Ventilate interior spaces thoroughly after tanks are filled and secured.

2-9-35 DRAINING OF HOSE. When loading or delivery has been completed and the proper valves closed, gasoline remaining in the piping above the tanks should be drained into the tanks by drawing off water from the water side of the system where provision is made for this method of draining. Where the above provision is not made or where the slope of the piping is such that all of the gasoline in the piping and hose does not drain back into the tank, gasoline remaining in the piping and hose is drained into containers which can be closed and sealed. After using, gasoline hose should be carefully drained of all gasoline.

2-9-36 LARGE GASOLINE LEAKS. In cases of emergency, where it is impracticable to apply measures for ventilation given in 2-8-28 through 2-8-37, whether due to lack of facilities for ventilation, or excessive accumulation of gasoline and gasoline vapor, the most drastic precautions should be exercised along the following lines.

a. Evacuate Personnel. Remove all personnel from the compartments. Post a sentry to warn off personnel, and eliminate possible sources of ignition in the area until the regular fire and repair parties arrive.

b. Shut-Down Operations. Stop all electrical machinery (except explosion-proof inclosed motors) and turn off all electronic transmitting equipment and turn off all electric lights (except explosion-proof type) both in the compartment and in immediately adjacent passageways through which air currents might pass from the compartment containing gasoline. Do not operate switches and electric controllers inside these explosive-proof vapor filled compartments. Open the circuits at control stations outside of compartments affected.

c. Eliminate Spark Hazard. Exercise all possible precautions to prevent accidental sparking from either electrical or mechanical sources both in the compartment and in passageways immediately adjacent. See Chapter 2-15 of this Instruction and Bureau of Ships Technical Manual, Chapter 67, Section V for possible hazards due to operation of electronic transmitting equipment.

d. Shut Off Dangerous Compartment. Close and if necessary seal the compartment. Efficient rescue breathing apparatus shall be used by competent personnel; only explosion-proof lights should be used. Footgear and implements used by personnel entering the compartment shall be of such character as to eliminate the risk of striking sparks.

e. Watch Boundaries. The outer boundaries of the affected compartment should be kept under observation for gasoline leakage. Such boundaries may not be tight against gasoline, and the precautionary steps mentioned above may have to be repeated for adjacent compartments.

f. Use Gas Indicator. Use a portable combustible-gas indicator for positive determination of the existence of gasoline vapor when there is any possibility or suspicion that such vapors may exist in a compartment. Do not rely upon your sense of smell. All ships carrying gasoline are provided with these indicators.

g. Repairs. Do not undertake any repairs to or in such compartments until it is practicable to take the precautions specified in welding and allied processes, 2-8-28 thru 2-8-49.

2-9-37 HYDRAULIC SYSTEMS.

a. Tank Capacity. Hydraulic stowage systems are designed on the basis of being "full" when each tank contains 5 percent water and 95 percent gasoline. Care must be taken not to exceed this condition as there will be danger of forcing gasoline overboard through the low overflow, or accumulating gasoline in the gravity tank if one is provided.

b. Empty Tanks. Tanks are considered to be "empty" when all gasoline has been discharged and displaced with salt water. Insofar as safety precautions are concerned, however, such tanks shall be considered to contain gasoline and its attendant hazards until such time as the tanks are actually evacuated and cleaned.

c. Trapped Gasoline. In particular, there will always be the possibility that, even after prolonged flushing with water, some gasoline will remain trapped in the structure at the top of a tank or in the piping; therefore, the discharge from a gasoline

pump or outlet must always be presumed to contain gasoline until or unless the tank has been evacuated of liquid and cleaned.

d. Water Hammer. Valves of a gasoline system and particularly the water supply valve of a hydraulic system, should be operated slowly to avoid water hammer which can result in serious damage to the stowage tanks.

2-9-38 USING LIVE STEAM. In using live steam, due regard must be given to the liability of overheating adjacent compartments, such as magazines, storerooms, etc. After blowing through with live steam, all manhole plates of the tanks shall be removed, and the tanks ventilated by means of a portable blower for at least 2 hours.

2-9-39 CHARACTERISTICS OF JP-4 FUEL. JP-4 fuel, although it has some characteristics of gasoline, is by no means the same substance. Due to some of the different characteristics such as lower vapor pressure, high aromatic content, etc., this fuel must be handled and stored very carefully.

2-9-40 TOXICITY. The effect of toxicity, etc., on personnel is not fully known. Tests are being conducted to determine if the elimination of light ends by adding aromatics has made JP-4 more dangerous from a health standpoint. Until tests are completed, precautions must be taken to prevent employees from breathing fumes and to prevent the fuel from coming in contact with the skin, especially if the skin has abrasions, pimples, or sores.

2-9-41 SPECIAL PRECAUTIONS. It must be remembered that JP-4 or -3 is not kerosene and cannot be handled as such. These fuels, like gasoline, can be handled safely by strictly adhering to the following rules.

a. Bonding Hose. All hose and pipes must be bonded.

b. Pumps Grounded. Pumps must be permanently grounded.

c. Velocity of Discharge. Velocity of discharge from hose or piping must not exceed that used for aviation gasoline. Careful bonding and grounds not exceeding 25 ohms resistance must be maintained.

d. Bonding Containers. Containers being filled or decanted must be bonded to filler or suction nozzle so that bonding leads to ground.

e. Electrical Appliances. All electrical appliances, wiring, motors, flashlights, etc., must be approved for hazardous locations.

f. Loading and Unloading Facilities. All loading and unloading

facilities for tank cars, tank trucks, and dock-side facilities must be grounded and bonded in accordance with the Fuels Operations Handbook DOD H-201.

g. Filled Containers. Filled containers should not be exposed to excessive heat.

h. Operating Gasoline or Electric Powered Equipment. Extreme caution should be used when gasoline or electric powered equipment (not spark enclosed) is being operated in the area.

i. Fumes. Employees should be careful not to breathe fumes or allow material to come in contact with the skin.

j. Spilled Liquid. Clothing should be changed as soon as possible, if liquid is spilled on it.

k. Goggles and Rubber Gloves. Goggles and rubber gloves should be used when filling or decanting drums, etc.

2-9-42 SHOP AREAS.

a. Separate Spaces. A shop shall have a designated area, or areas, preferably fenced in and separated from buildings, where gasoline is stored and handled.

b. Smoking. No smoking shall be tolerated within these areas. "No Smoking" signs shall be prominently displayed.

c. Fire Extinguisher. CO_2 dry chemical, or other approved type fire extinguisher for gasoline fires, shall be available at all times.

2-9-43 GASOLINE CONTAINERS.

a. Containers. Containers of gasoline for shop use shall not exceed 5 gallons in capacity. They shall be of the closed type and approved gasoline containers.

b. Marking. Small gasoline containers such as gasoline cans, drums, and small portable tanks shall be painted brilliant yellow and have the word "gasoline" plainly painted on them in black letters. On large fixed tanks, medium Navy gray may be used for the body, with black letters on a large area of brilliant yellow, indicating contents.

c. Filling. Containers may be refilled either from a tank truck brought to the designated storage area or from a pump at a filling station.

d. Spills. Spilled gasoline should be wiped up and the rags deposited in closed metal cans.

e. Disposal. Gasoline should not be dumped into drains or sewers. It may be destroyed by burning in a shallow trench in a safe area under supervised conditions.

2-9-44 MOBILE EQUIPMENT.

a. Fueling Engines. No engine of any type shall be refueled while the engine is running.

b. Spilling. Care shall be exercised to avoid spilling gasoline when tanks and containers are refilled. Gage a tank before filling to guard against filling it to overflowing.

2-9-45 GASOLINE PROHIBITED AS CLEANER. Gasoline must never be used for cleaning parts, brushes, etc. A suitable cleaning fluid such as Stoddard Solvent, is available and must be used.

2-9-46 SKIN BURNS. Gasoline spilled on clothing can cause dangerous skin burns even if not ignited. Remove gasoline soaked clothes as soon as possible, and dry them in the open air.

2-9-47 SCOPE.

a. Application. The instructions in this Chapter apply to compressed or liquefied gases used by Navy installations. Cylinders shall be fabricated and tested under Interstate Commerce Commission regulations. The instructions also apply to valves and auxiliary equipment such as safety devices, cylinder caps, etc. Strict compliance with the precautions prescribed in this Chapter will prevent many of the accidents which result from misapplication, mishandling, or improper identification of industrial gases and cylinders in the Naval service. For instruction covering specific applications of these gases and cylinders, such as oxygen and acetylene used in welding and cutting, see Chapter 2-8; for refrigeration, see Chapter 2-10.

b. Emergencies. Due allowance should be made for the hazards which may be peculiar or incident to local conditions of handling, stowage, and use. Where such conditional hazards are met or noted in the course of operations, they should be reported to the cognizant bureau for dissemination to other commands.

c. Medical Instruction. Where reference is made to first aid for personnel exposed to gas fumes, it should not be assumed that every acceptable procedure is included, or that the services of medical officers are unnecessary. The instructions of medical officers, if available, shall be followed in every case.

2-9-48 SHIP-TYPE CYLINDERS. Nonshatterable-type cylinders for high-pressure gases are standard for shipboard use and stores. Only in the event of an emergency or when nonshatterable cylinders (for a given gas or fluid) are not in Navy stores shall shatterable cylinders be accepted for ships storage and use. In such cases the shatterable-type cylinder shall be turned in as soon as possible to the nearest Naval supply point in exchange for nonshatterable cylinders when available.

2-9-49 VALVE SAFETY DEVICES. Navy Department specifications and Interstate Commerce Commission regulations require that valves designed for certain services be fitted with safety devices as a safeguard against the building up of hazardous pressures within cylinders from exposure to heat, or from overcharging, etc. In general these safety devices may be divided into four categories based on functional design.

a. Fusible Plugs. A fusible plug may be described as a threaded hex head plug, the center of which is filled with fusible metal. When the cylinder is subjected to high temperatures, the fusible metal melts, permitting gas to escape through the channel previously filled with fusible metal. This type of device is used on chlorine, freon, acetylene, etc.

b. Spring-Loaded Safety Device. Spring-loaded safety devices usually function as "pop" values when internal pressures in cylinders overcome spring tension, permitting escape of gas. Devices of this sort are used on liquefied petroleum gas valves, and operate generally at about 1.56 percent of the charging pressure indicated for the cylinders (Interstate Commerce Commission approved pressure).

c. Unbacked Safety Cap With Rupture Disk. Unbacked safety caps with rupture disks consist essentially of a safety cap covering a safety port in the valves. The cap retains a disk firmly over the safety port. Under excessive pressure (2,600 - 3,000 p.s.i.) the safety disk ruptures and allows the gas in the cylinder to vent to atmosphere. This type of safety device is used in carbon dioxide service.

d. Backed Safety Cap With Rupture Disk. Backed safety caps with rupture disks are essentially the same as described in paragraph c above, except that the disk is supported by fusible metal contained in the safety caps and blocking off escape ports. In practice, where the cylinders, valves, and, of course, the fusible metals are heated above the melting temperature, and the pressure within the cylinders then is or thereafter approaches 2,600 - 3,000 p.s.i. the disk ruptures and reduces the pressure. This type of device is used commonly on air, helium, hydrogen, nitrogen, and oxygen valves.

e. Tampering. Do not tamper with the safety devices on valves or cylinders.

f. Striking. Never hammer or strike the valve wheel in attempting to open or close valves. Use only wrenches or tools provided and approved for this purpose.

g. Connections. Be sure that the threads on regulators or other auxiliary equipment are the same as those on cylinder valve outlets. Never force connections that do not fit.

h. Ice Clogged Outlets. In the event that valve outlets have become clogged with ice and it becomes necessary to thaw them out, use warm, not boiling water. Boiling water will melt fusible plugs and vent cylinders.

2-9-50 PAINTING.

a. Frequency. It snall be the responsibility of all ships and commands to repaint cylinders to minimize external corrosion. Repainting shall be done no oftener than is considered necessary for preservation. Navy standard paints are formulated to withstand scrubbing and fading, so that touch-up patch painting is not too obvious. Therefore, touching-up rather than complete repainting shall be done when practicable. Repainting in lieu of cleaning must never be permitted.

b. It is also required that each cylinder be identified, with respect to gases or fluids contained therein, by the color of the paints applied for preservation. The Military Standard Color Code - 101A will be followed on all compressed cylinders and pipe lines used in Navy installations.

* (1) Color code specified for compressed gas cylinders in general use aboard MSTS ships is as follows:

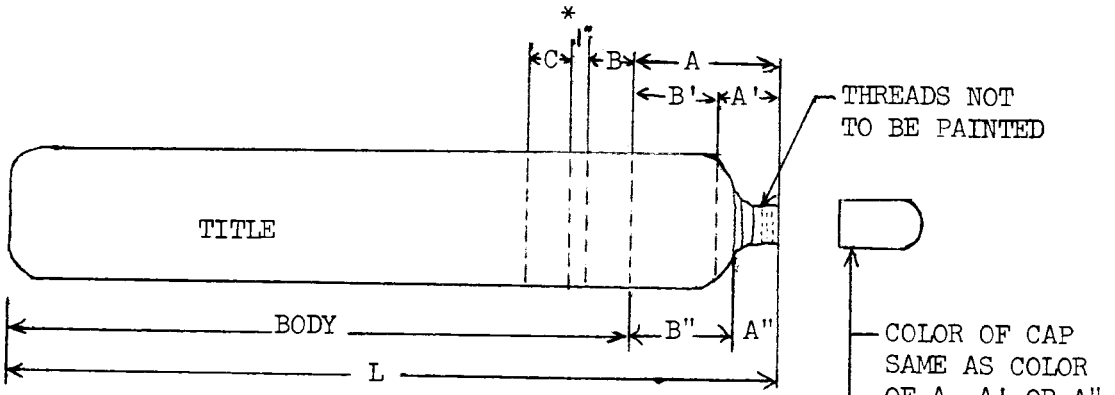
Gas	Location on Cylinder			
	Top A	B and B	B and C	Body
Acetylene	Yellow	Yellow	Yellow	Yellow
Carbon Dioxide (fire only)	Red	Red	Red	Red
F11 Trichlorofluoromethane	Orange	Orange	Orange	Orange
F12 Dichorodifluordmethane	Orange	Orange	Orange	Orange
Helium, oil free or medical	Buff	Gray	Gray	Gray
Helium, oil pumped	Gray	Orange	Gray	Gray

Gas	Location on Cylinder Top A	B and B	B and C	Body
Nitrogen, oil pumped	Gray	Black	Gray	Gray
Nitrogen, Water pumped	Gray	Black	Black	Gray
Nitrous oxide	Blue	Blue	Blue	Blue
Oxygen, medical	White	Green	Green	Green
Oxygen, aviator's	Green	White	Green	Green
Oxygen	Green	Green	Green	Green

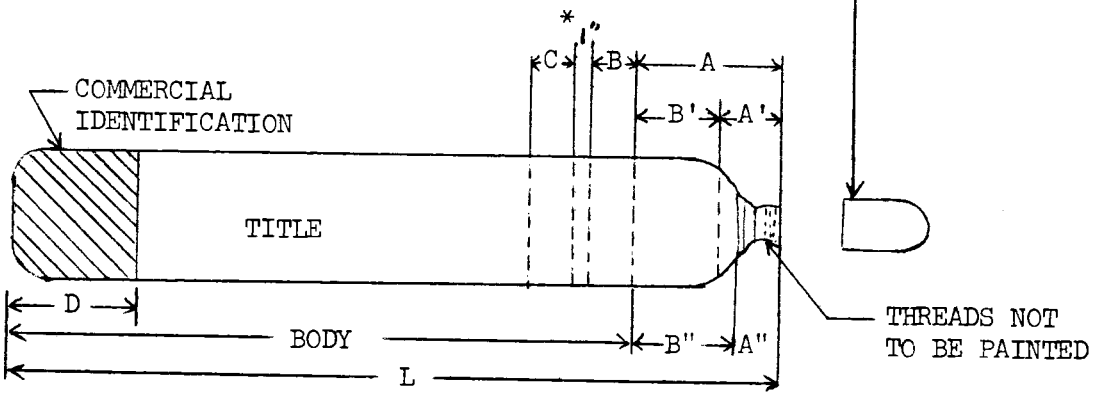
(2) The appearance on the body, top or as a band(s) on compressed gas cylinders of any of the following six colors shall provide a warning of danger from the hazard in handling the type of material contained in the cylinder: *

Class	Standard Color	Class of Materials
a	Yellow	Flammable materials
b	Brown	Toxic and poisonous materials
c	Blue	Anesthetics and harmful materials
d	Green	Oxidizing materials
e	Gray	Physically dangerous materials
f	Red	Fire protection materials

(3) All cylinders shall be painted as specified herein to provide uniform recognition throughout the Department of Defense. Cylinders shall be painted as shown on pages 2-9-22b. and 2-9-22c. and arrangement of colors shall appear as specified in cylinder color code. *



LOCATION OF COLORS ON GOVERNMENT-OWNED CYLINDERS



LOCATION OF COLORS ON COMMERCIAL-OWNED CYLINDERS

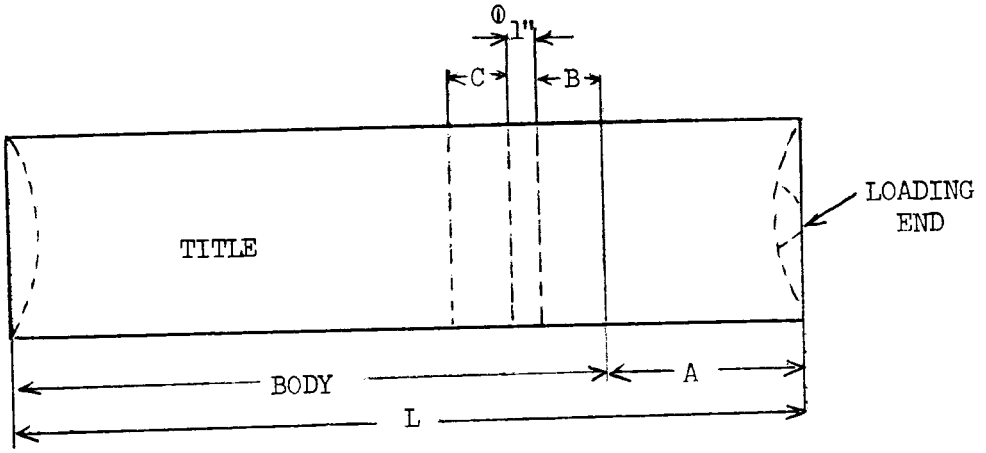
LOCATION DIMENSIONS

ON CYLINDERS FOR MEDICAL GAS MIXTURES, 1" SPACE AND BAND C ARE LOCATED IMMEDIATELY BELOW BANDS B' OR B"

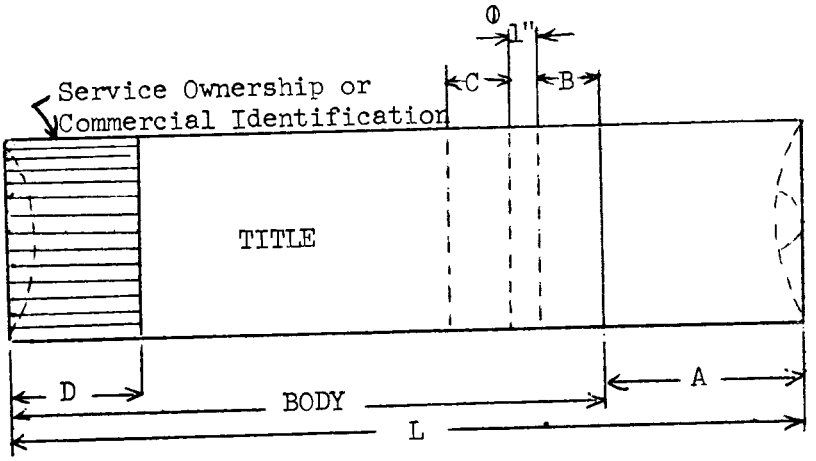
CYLINDERS FOR	OVERALL LENGTH	SHOULDER COLOR(S)			CYLINDER COLOR BAND(S)				COMMERCIAL IDENTIFICATION
	L	A	A'	A"	B	B'	B"	C	D
MEDICAL GAS MIXTURES	over 30"	L/5	3½"	--	--	A less 3½"	--	3"	L/6
OTHER GASES	"	L/5	--	--	3"	--	--	3"	L/6
MEDICAL GAS MIXTURES	30" and under	L/5	--	--	--	--	A less A"	2"	L/6
OTHER GASES	"	L/3	--	--	2"	--	--	2"	L/6

FROM CYLINDER TOP TO BOTTOM OF NECK RING

* 1" space to be omitted if bands B & C are of different colors



LOCATION OF COLORS ON GOVERNMENT-OWNED CYLINDERS



LOCATION OF COLORS ON COMMERCIAL-OWNED CYLINDERS

LOCATION DIMENSIONS

OVERALL LENGTH	CAP AND SHOULDER COLOR	CYLINDER COLOR BAND(S)	COMMERCIAL IDENTIFICATION
L	A	B & C	D
OVER 30"	1/4 of L	3"	1/6 of L
30" and UNDER	1/4 of L	2"	1/6 of L

① 1" space to be omitted if bands B & C are of different colors.

2-9-51 REPAIRING CYLINDERS AND VALVES.

a. Maintenance. Cylinders shall be repaired only by ships or by personnel who are specifically authorized to perform such work. To assure that all cylinders aboard ship are in satisfactory and serviceable condition, periodic inspections should be made and cylinders found with any of the following defects should be relieved of pressure in accordance with paragraphs b, c, and d below and turned into the nearest naval supply point in exchange for other cylinders:

(1) Severely dented, gouged, or corroded.

(2) Evidence of fire damage (carbon deposits on valves or safety plugs of cylinders containing acetylene or other flammable gases).

(3) Bulges (deformation of cylinders from internal pressures).

(4) Damaged, split, or leaking seams (low-pressure cylinders containing flammable gases such as acetylene, etc.)

When it is impracticable to bleed defective cylinders, they may be surveyed and jettisoned at sea. An approved survey report should be turned in as required for surveys of ship's materials.

b. Valves. In general, cylinders with leaking or defective valves (stripped threads, bent stems, etc.) shall be turned in to the nearest naval supply point for overhaul. Leakage from valves may be caused by the presence of dirt or foreign particles in the valves or the valve seat. The leakage may sometimes be corrected by partially opening and then closing the valve, to blow out the foreign material. If the leakage continues, the cylinders should be removed to a safe place (in the open if possible) and drained by opening the valve. The cylinders should then be tagged and turned in for overhaul and recharging.

c. Draining Cylinders. Cylinders containing combustible or toxic gases (acetylene, hydrogen, chlorine, etc.) should be drained through pressure regulators and their rates of discharge controlled so that dangerous accumulations of these gases will not occur.

d. Toxic Gases. The utmost caution should be exercised in draining cylinders containing chlorine, sulphur dioxide, anhydrous amonia, and other toxic or irritant gases. Cylinders containing these gases should be discharged to atmosphere only under conditions assuring the prompt dispersal of these gases without hazard to personnel or property to leeward. Personnel engaged in draining these cylinders should be equipped with the necessary protective clothing, goggles, and breathing masks.

2-9-52 CARE AND TESTING OF CYLINDERS.

a. Quinquennial-Tests. Interstate Commerce Commission regulations require that practically all cylinders with the exception of those containing acetylene be retested every five years. Regulations specify that cylinders for which prescribed retests have become due must not be charged and shipped until such retests have been properly made. However, cylinders which have been charged prior to the expiration of their retest period are satisfactory for shipment and use subsequent to the date of expiration.

b. Refilling. Do not refill cylinders unless such action is specifically approved by the bureau concerned and then only in accordance with instructions.

c. Designated Gas. Do not fill any cylinder with a gas other than that gas for which the cylinder has been specifically designated. Explosive mixtures may readily be formed when cylinders containing residual combustible gases such as hydrogen, propane, or acetylene are charged with air or oxygen. The reverse of this procedure is equally hazardous.

d. Changing Markings. Do not remove or change the numbers or marks stamped into cylinders without the specific approval of the cognizant bureau or supply demand control point.

e. Improper Marking. Do not use any gas cylinder which is improperly marked (color of paints, name or gas stenciled on cylinder and valve, etc.). Return all such cylinders to the nearest naval supply depot.

f. Specific Use. Never use cylinders for rollers, supports, or for any purpose other than to carry gas.

g. Regulators. Do not use regulators, pressure gages, manifolds, and related equipment which are provided for a particular gas on cylinders containing different gases.

h. Protection From Heat. Do not subject compressed gas cylinders, either in storage or in service, to a temperature in excess of 130° F. A direct flame should never be permitted to come in contact with any part of a compressed gas cylinder.

i. Protection From Abrasion. Be careful to protect cylinders from objects that will produce a cut or other abrasion in the surface of the metal.

j. Testing for Leaks. When testing for leakage from gas cylinders, use soapy water. Keep the scene of operations well clear of open flames and other sources of potential ignition, such as unshielded lamps, switches etc.

2-9-53 STOWAGE AND HANDLING DEFINITIONS.

a. Stowage. As used herein, the term "stowage" refers to articles under the cognizance of the supply officer, in general stores, to be drawn on for the ship's own use; or articles of cargo being transported. It does not refer to articles removed from stores or cargo and transferred to shops or other locations for use.

b. Ready Service. The term "ready service" means articles that have been transferred from store and are physically located in a shop or elsewhere, regardless of whether they are actively being used at a given moment or are being held in reserve in the interim

between periods of actual use or in anticipation of a need for immediate use.

2-9-54 HANDLING CYLINDERS.

a. Handle With Care. Cylinders that contain flammable and/or explosive gases shall be handled with particular care. Every effort should be made to avoid their being dropped or allowed to strike forcefully against each other or any other object. Every precaution shall be taken to prevent bumping or striking the discharge valves during handling operations.

b. Caps in Place. The cylinder valve outlet cap and the cylinder valve protecting cap shall both be in place when cylinders are being handled. Unless ready service cylinders are secured in a special portable rack, regulators shall be removed and caps replaced before the cylinders are moved to a new location.

c. Transporting Cylinders. When loading or transferring cylinders, especially when using ship cargo gear, the cylinders shall be secured in a cradle, suitable platform, rack, or special container (such as a sand bag, stock 24-B-1062). Neither a sling (line or chain) nor electromagnets shall ever be used. A cylinder moved by hand should be tilted slightly and rolled on its bottom edge, without dragging or sliding. Hooks or lines through valve protection cap shall not be used for hoisting cylinders.

d. Fixed to Deck. Cylinders frozen to the deck or otherwise fixed shall not be pried loose with crowbars or similar tools.

e. Hand Trucks. When cylinders are transported by hand truck, they shall be securely held in position by chains, steel strapping or other means that will prevent falling from the truck. Hand trucks used by welders for holding cylinders of welding gases shall conform in general to the requirements of Specification Mil-T-19259, Truck, Hand 2 Wheel, Welding Cylinder Rack, Double Handle Type, Solid Rubber Tires.

2-9-55 STOWAGE OF COMPRESSED GASES, GENERAL.

a. Location. In general, weather-deck stowage will be provided for flammable and explosive gases. However, in specific cases, below-deck stowage is approved depending on the particular type, mission, and arrangement of the vessel. In such cases, these approved locations are shown on the plans of the vessel. (See BuShip Technical Manual, Chapter 23.43)

b. Separating Flammable and Oxidizing Gases. Combustible gases shall never be stowed with oxidizing gases. A fire wall shall

separate such stowage compartments. However, the inert gases such as helium, nitrogen, carbon dioxide, or argon may be stowed with either flammable or oxidizing gases. Typical oxidizing gases are oxygen, chlorine, etc.

c. Fire Apparatus and Oxygen Tanks. Fire extinguishers employing gases, fire-extinguishing cylinders permanently connected to fixed fire-extinguishing systems, and gases and chemical canister for oxygen-breathing apparatus may be stowed in the vicinity in which they are used.

d. Compartments. Compressed gases aboard all vessels, except cargo vessels, shall be stowed only in compartments designated in applicable plans for the vessel.

(1) Necessary steps shall be taken to prevent the maximum temperature of the stowage compartment from exceeding 130° F.

(2) When provisions are made for mechanical ventilation, this ventilation shall be operated in accordance with the damage control classification assigned. The classification for closure of this system shall be "Z" or "W".

(3) Compartments containing compressed gases shall be ventilated for 15 minutes prior to entry, in event ventilation has been closed down, and a suitable sign to this effect shall be prominently posted on the outside of the access door.

(4) Other flammable materials, especially grease and oil, shall be kept out of all stowage spaces, and stowage space shall be kept clean.

(5) In compartments designated for the stowage of flammable or explosive gases, the installation of portable electric wiring and equipment shall not be permitted.

(6) Each individual cylinder shall be securely fastened in the vertical position (valve end up) by means such as metal collars.

2-9-56 WEATHER-DECK STOWAGE. When compressed gas is stowed on the weather deck, the following precautions shall be observed.

a. Fuel and Oxidizing Gases. Oxygen and chlorine cylinders stowed on the weather deck shall not be in close proximity to fuel gas cylinders.

b. Protection From Elements. Cylinders containing compressed gases should be so stowed that they will be protected insofar as practicable. During winter, cylinder valves shall be protected

against accumulation of snow and ice. Warm (not hot) water shall be used to thaw ice accumulations in cylinder valve caps and outlets. During summer, cylinders shall be screened from direct rays of the sun.

c. Corrosion. Every effort shall be taken to prevent corrosion of threaded connections of cylinders which have been in stowage for extended periods of time. The use of grease or flammable corrosion inhibitors on oxygen cylinders is not permitted.

d. Area. The stowage area shall be as remote as practical from navigating, fire control, and gun stations.

2-9-57 TOXIC HAZARDS.

a. Leaking Cylinders. Particular attention should be given to location of cylinder stowage to prevent fumes from leaking cylinders entering ventilating air intakes leading to spaces where personnel may be affected or flammable gases cause explosions.

b. Chlorine and Ammonia. Chlorine and ammonia are toxic and will produce fatal results if breathed in large quantities. In small quantities they are irritants and cause acute distress by attacking the tissues of the lungs.

c. Inert Gases. Helium, nitrogen, carbon dioxide, and argon are nonflammable gases and may be stowed with flammable gases. Although the inert characteristics of these gases are a fire protection, they will not support respiration, and sufficient concentration in a closed space will cause asphyxiation. Aerosol insecticide and carboxide are also nonflammable; however, where concentrations are present these gases are toxic. Freon likewise is nonflammable but in the presence of fire or red hot metal will decompose into phosgene gas, which is toxic.

2-9-58 EMPTY CYLINDERS.

a. Pressure. Though empty cylinders, with valves securely closed and valve protection caps in place, are comparatively less hazardous than full cylinders insofar as stowage is concerned, the former shall be handled and stowed with the same precautions as used with full cylinders. This is important since it is specified elsewhere that cylinders of some gases are not to be completely exhausted but should be considered empty when the gas pressure falls to about 25 p.s.i. gage.

b. Labeling. Empty cylinders should be tagged as "Empty" and segregated from full cylinders.

c. Valves Closed. Valves should be tightly closed and valve

protection caps securely fastened to assure the return in good condition of empty cylinders to suppliers.

d. Rotation of Cylinders. Full cylinders should be used in rotation as received from the source of supply.

e. Disposition. Empty cylinders should be delivered to the nearest naval supply depot with valves closed and under some positive pressure, except where the design of the valve does not permit closing, as is the case with fire extinguishers. This is necessary to prevent condensation of atmospheric moisture in cylinders and in the case of acetylene cylinders to prevent loss of the solvent (acetone) and/or entry of air, should the cylinders cool considerably below the temperature at which they were discharged.

f. Drying of Cylinders. Cylinders used for aviators' breathing oxygen, dry nitrogen, dry argon, dry helium, or dry air, which are found to have open valves and/or a positive internal pressure of less than 25 p.s.i. gage, should be tagged "Dry Before Refilling."

2-9-59 ACETYLENE. See Chapter 2-8 for description of hazards and safety precautions.

2-9-60 CARBON DIOXIDE.

a. Characteristics. Carbon dioxide is a dangerous asphyxiant because it is not detectable by odor or by color when present in hazardous quantities. It is heavier than air and gives little if any warning to personnel exposed to it until they are completely overcome. The inhalation of carbon dioxide will produce various effects, depending on the length of time the carbon dioxide is breathed.

b. Treatment When Exposed. The treatment of exposed personnel consists of artificial resuscitation, administering oxygen, and keeping the patient warm and quiet.

c. Entering Contaminated Compartment. Do not enter an area or compartment containing hazardous amounts of carbon dioxide without being equipped with a breathing mask and an independent supply of oxygen, or if this is not practicable and the case is urgent, enter only when equipped with lifelines and with assistants standing by outside the area or compartment.

2-9-61 CHLORINE.

a. Contamination of Atmosphere. Chlorine should be used only by experienced and properly trained personnel. Where chlorine