MIL-HDBK-291(SH)
26 September 1986
SUPERSEDING
NAVSEA 0900-LP-016-0010
December 1966

MILITARY HANDBOOK

CARGO TANK CLEANING

AMSC N/A
FSC 5430

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362-5101

Cargo Tank Cleaning

1. This military standardization handbook was developed by the Naval Sea Systems Command, Department of the Navy in accordance with established procedures.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. This handbook supersedes information contained in NAVSEA 0900-LP-016-0010. This handbook provides basic and fundamental information on cargo tank cleaning procedures, equipment, and safety precautions approved for use by agencies of the Department of the Navy, the Military Sealift Command (MSC), and as recommended and practiced by commercial interests.

2. This handbook provides instructions for the preparation of cargo tanks which should be studied and followed by all personnel connected with the transport of Government petroleum products by sea in order to avoid serious consequences of contaminated cargoes, tragic loss of life resulting from unsafe practices, and economic loss when cargo tanks do not meet prescribed standards of cleanliness.

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1. SCOPE

1.1 Scope. This handbook provides basic and fundamental information for cargo tank cleaning requirements, safety precautions, equipment and procedures.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and handbook. Unless otherwise specified, the following specifications and handbook of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this handbook to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-C-22230 - Cleaning Compound, Fuel Tank and Bilge.
DOD-P-23236 - Paint Coating Systems, Steel Ship Tank, Fuel and Salt Water Ballast (Metric).
MIL-P-24441 - Paint, Epoxy-Polyamide, General Specification for.

HANDBOOK

MILITARY

MIL-HDBK-200 - Quality Surveillance Handbook for Fuels, Lubricants and Related Products.

2.1.2 Other Government publications. The following other Government publications form a part of this handbook to the extent specified herein.

PUBLICATIONS

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

S9086-CH-STM-030-CH074V3 - Gas Free Engineering (Naval Ships Technical Manual (NSTM) Chapter 074-Volume 3).
S9086-T8-STM-000/CH593 - Pollution Control (NSTM Chapter 593).
S9593-A7-PLN-010 - Shipboard Hazardous Materials/ Hazardous Waste Management Plan.

(Application for copies should be addressed to Commanding Officer, Naval Ship Weapons Systems Engineering Station, Code 5722.3, Port Hueneme, CA 93043.)

DEPARTMENT OF LABOR

Code of Federal Regulations (CFR), Title 29
Part 1910 - Occupational Safety and Health Standards.
Part 33 - US Coast Guard Regulations for Commercial Ships.

(Application for copies should be addressed to the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.)

The side load shall be applied to either side of the wheel and in a direction

(Copies of specifications, handbooks and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Order of precedence. In the event of a conflict between the text of this handbook and the references cited herein, the text of this handbook shall take precedence.

3. DEFINITIONS

3.1 Cold work. Cold work does not involve the use of flame, heat or spark-producing tools. It includes the inspection of tanks and any work which is not classified as hot work by the gas-free engineer.

3.2 Gas-freeing. Gas-freeing is the process of removing all flammable or toxic vapors and their sources from the tanks, piping systems and other associated spaces, rendering them safe for inspection and hot repair work. In some cases (such as a Navy special fuel oil tank) removal of the source is not necessary for inspection or cold work. For gas-free engineering program, see NAVSEA S9086-CH-STM-030-CH074V3.

3.3 Hot work. Hot work involves welding, flame cutting, the use of open-flame equipment or heating metal to or above a red heat. Riveting and any cold work involving the probability of striking sparks are considered hot work except when, in the opinion of the gas-free engineer, circumstances do not require such classification. Hot work also includes all other sources of flames, sparks or intense heat, such as lighted cigarettes, open-flame or electric cooking apparatuses, nonexplosionproof lights and electric motors.

3.4 Not safe for personnel - not safe for hot work. Not safe for personnel - not safe for hot work is the classification used when certifying and labeling (see 5.7.3 and 5.7.5) a space when the following conditions exist:

(a) Personnel are in danger of asphyxiation due to oxygen deficiency (optimum range 20 to 22 percent).
(b) An explosion or fire hazard exists due to the presence of an explosive mixture.
(c) Toxic vapors are present in excess of their threshold limit value (TLV).
(d) Surrounding spaces have not been protected as required.

3.5 Safe for personnel - not safe for hot work. Safe for personnel - not safe for hot work is the classification used when certifying and labeling (see 5.7.3 and 5.7.5) a space when the following conditions exist:

(a) The oxygen content is in the optimum range (20 to 22 percent) for personnel.
(b) Hydrocarbons or other gases in excess of the limits of toxicity are not present and are not likely to be evolved either by personnel entry or the prevailing atmospheric conditions.
(c) There is danger of harm to personnel or of fire or explosion in the presence of hot work due to the existence of flammable or explosive materials.

3.6 Safe for personnel - safe for hot work. Safe for personnel - safe for hot work is the classification used when certifying and labeling (see 5.7.3 and 5.7.5) a space when the following conditions exist:

(a) The oxygen content is sufficient for personnel (20 to 22 percent).
(b) Flammable or explosive materials or vapors have been removed or adequately protected and surrounding spaces have been protected as required.
(c) Toxic gases in excess of their threshold limits are not present and are not likely to be evolved.

3.7 Ventilation. Ventilation is the process of replacing the gaseous atmosphere of a tank with fresh air by natural or mechanical means. In addition to removing hazardous gases, ventilation aids in the elimination of regenerative sources by its drying effect.

4. GENERAL REQUIREMENTS (Not applicable).

5. DETAILED REQUIREMENTS

5.1 Tank cleaning requirements. Requirements for tank cleaning on ships shall be as follows:

(a) Maintenance cleaning.
(b) Cleaning and gas-freeing for tank inspection or minor repairs.
(c) Cleaning and gas-freeing for shipyard overhaul or major repairs.
(d) Cleaning for a change of cargo.
(e) Cleaning after a contaminated cargo.
(f) Gas-freeing in preparation for loading.
(g) Cleaning in preparation for ballasting.
(h) Cleaning prior to inactivation and activation.

5.1.1 Maintenance cleaning. As a result of extended service in carrying certain types of cargo, it is periodically necessary to clean and gas-free the cargo tanks in order for tanks to be maintained in good condition. The frequency and thoroughness required of maintenance cleaning will depend on the nature of the service, the results of tests on previous cargoes, the use or non-use as a ballast tank, and the type of tank coating, if any. Ships in crude service (which alternately run empty or in ballast) will have need for frequent maintenance cleaning since the crude products will result in heavy sludge accumulations further compounded by the corrosive effects of sea water ballast. In contrast, tankers carrying clean products in coated tanks only need flushing and seldom require cleaning for maintenance. (Hereinafter, the term tanker will include oilers and tankers.)

5.1.1.1 Additional benefits. In addition to preservation of the hull, removal of scale deposits makes gas-freeing easier and reduces the chances of cargo contamination. For efficient operation, cargo tanks shall be maintained with a minimum accumulation of sludge in the tank bottoms.

5.1.1.2 Unnecessary cleaning. Unnecessary cleaning is not only costly but results in extra wear on both tanks and equipment; therefore, maintenance cleaning shall be undertaken only when necessary.

5.1.2 Cleaning and gas-freeing for tank inspection or minor repairs. Occasionally tanks must be gas-freed in order to inspect bulkheads or interior piping for leaks or to make minor repairs to valves, extension rods or pipelines. Such gas-freeing shall, as a minimum, be safe for personnel - not safe for hot work (see 3.5).

5.1.2.1 Minor repairs. When affecting a minor repair, the degree of cleaning required will depend on the contamination and involvement of cold or hot work. The cleaning may require a rinsing, a brief spot washing or a complete tank washing. For minor repairs (or inspection), it is usually necessary to gas-free only the tanks to be entered and adjacent spaces. These areas only need to be rendered gas-free during the required periods of inspection and repair. To obtain this gas-free condition, it is usually necessary only to ventilate the tanks by changing the air several times (see 5.3). Frequent testing for gas-free conditions shall accompany any action taken; when personnel are in the tanks, forced ventilation shall be continued at all times for safety and health.

5.1.2.2 Minor repairs involving hot work. Sometimes it is necessary to make repairs by welding or burning or with tools which may cause sparks. When this is the case, all free oil and vapor-generating residues shall be removed from the spaces to be entered and all adjacent spaces. In addition, these spaces shall be ventilated to be safe for personnel - safe for hot work (see 3.6).

5.1.3 Cleaning and gas-freeing for shipyard overhaul or major repairs. A tanker entering a shipyard for overhaul is subject to strict regulations regarding cleanliness and gas-free conditions since these conditions must be maintained over an extended period of time.

5.1.3.1 Certification prior to overhaul. The nature and extent of work normally associated with shipyards involves the extensive use of open flames. Under these conditions, it is usually required that a ship, prior to commencing an overhaul, have all spaces certified safe for personnel - safe for hot work. This certification includes all bunker tanks not in service, foredeeps, fore and after peaks, cofferdams, pumprooms and double bottoms, as well as main cargo tanks and pipelines. To achieve this certification, a thorough gas-freeing involving complete removal of all traces of oil and vapors in the spaces, including all possible sources of their regeneration shall be necessary. The failure to achieve the required state of cleanliness and gas-free conditions before entry into a shipyard can be costly, since it may delay the overhaul or cause the expense of repeating the entire cleaning operation.

5.1.3.2 Overhaul at sea or in foreign ports. When major repairs are made at sea or in foreign ports, all compartments concerned shall be examined carefully and their condition entered in the log before repairs. In foreign ports, regard shall be given to existing local regulations.

5.1.4 Cleaning for a change of cargo. The extent of cleaning required for a change of cargo will depend on the preceding cargoes and the next cargo to be carried. If the change of cargo is a similar product, a routine water washing may be sufficient (see 5.6.2). If upgrading (such as from a black to a refined oil), a more thorough cleaning and gas-freeing shall be required. Since some cargoes have persistent qualities, previous ones other than the last cargo carried shall be considered. The practice of inerting cargo tanks during cleaning on ships so equipped reduces the dangers associated with static electricity.

5.1.5 Cleaning after a contaminated cargo. After a cargo is contaminated, the first requirement for cleaning is to determine the nature and cause of contamination. It is then necessary to institute the required steps to remove the contaminant. For example, contamination may have resulted from an inadequate rinse, failure to use an interim load of a petroleum solvent such as diesel oil, or the entrapment of the contaminating agent behind blisters, scale or faulty doubler plates.

5.1.6 Gas-freeing in preparation for loading. Prior to loading the ship's cargo tanks, the cognizant petroleum inspector and the ship's cargo officer may be required to inspect the tanks and associated piping and valves. As a minimum requirement, the cargo tanks shall be ventilated to achieve the status of safe for personnel - not safe for hot work (see 3.5).

5.1.7 Cleaning in preparation for ballasting. Tanks shall be machine-washed prior to ballasting if ballast is to be brought into port. Discharge of dirty ballast within harbors is in violation of harbor pollution regulations (see 5.2.5). Pipelines used for ballasting and deballasting shall also be cleaned.

5.1.8 Cleaning prior to inactivation and activation.

5.1.8.1 Inactivation. When a tanker is being inactivated, tanks, cofferdams and voids shall be stripped, cleaned and gas-freed prior to preservative requirements. This does not include tanks necessarily used for ballast or tanks specially designed to be used for feed and potable water.

5.1.8.2 Activation. When a tanker is being activated, the extent of cleaning required will depend upon the cargo to be carried.

5.2 Safety precautions.

5.2.1 General precautions. The following safety rules and regulations, assembled over a period of years, are critically important in any tank cleaning operation. Unfortunately, many have been developed as the direct result of tragic casualties. Cleaning and gas-freeing a tanker is hazardous because of the dangerous physical characteristics of the petroleum vapors. Explosive gases may be present. If so, each tank will pass through a nonexplosive condition when it is too rich to explode, then through an explosive condition, and finally through a nonexplosive condition when it is too lean to explode (see 5.2.2.2). Being heavier than air, the gases that are expelled from the tank may accumulate about the deck, creating a hazard in a seemingly safe area. Throughout the entire operation, the ship and personnel may be in jeopardy if there is even a slight variation from the rules. Since most safety problems concern personnel rather than material, proper indoctrination and training is important. But, whenever he considers it advisable, nothing in these rules and regulations shall limit the commanding officer in establishing additional safety precautions (see 5.7.3). It shall be the responsibility of the ship's supervising officer to stop the cleaning operations immediately if any circumstances arise that in his opinion would render such work dangerous. The following general precautions shall be observed.

5.2.1.1 Weatherdeck openings. Ventilators shall be properly trimmed. Doors, portholes, skylights and other openings leading from the weatherdeck to the quarters, engine room, fireroom or galley shall be closed when there is danger from hazardous gases. The fact that these gases can be transported by air currents from a seemingly remote source shall be considered at all times.

5.2.1.2 Hose connections. A buildup of static electricity, which may cause sparks, shall be guarded against at all times. The ship shall be bonded with an approved bonding cable before a ship-to-shore hose connection is made. A galvanometer can be used to ensure that connections at each end of the cable are at the same potential. A seemingly good conductor (necessary for proper grounding) can lose its potential because of a poor conducting hose, a misapplied coating of paint or the formation of rust.

5.2.1.3 Smoking and electrical equipment. The precautions concerning smoking and the use of electrical appliances during hot work shall be rigidly followed. Smoking shall be permitted only in certain enclosed spaces such as quarters, wardrooms and messrooms, and then only with the approval of the commanding officer. However, personnel engaged in the actual tank cleaning process shall be prohibited from carrying matches or lighters. Portable electrical appliances, including radios, shall be used only where and when smoking is permitted. Wireless transmitting and high frequency radar shall be prohibited at all times when explosive vapors are present above deck. (Modern portable radios are approved by U.S. Coast Guard and essential on large tanker decks.)

5.2.1.4 Additional hazards. Gas-freeing shall be prohibited when fires, operating engines or naked, exposed lights are within 200 feet of the tanks being gas-freed. This restriction includes operating engines on other ships as well as proximal electric cars or locomotives. Work shall also be stopped when there is danger of an approaching ship coming within 200 feet of the ship.

5.2.1.5 Oil pollution. Oil pollution regulations shall be followed (see 5.2.5).

5.2.1.6 Cleaning and gas-freeing tanks at sea. This operation shall be carried out with consideration to weather conditions (see 5.6).

5.2.2 Characteristics of military petroleum products. Military petroleum products include aviation gasolines, jet fuels, motor gasoline, kerosenes, synthetic fuels, diesel and Naval distillate fuels, solvents, boiler fuels and lubricating oils. Although their characteristics are varied and some are classified as safer than others, precautions shall be exercised at all times in their presence.

5.2.2.1 Flammable or combustible products. Since all gasolines, naphthas, jet fuel (JP-4) and crude oil are substances that will produce flammable or explosive vapors at 80 degrees Fahrenheit (°F) (27 degrees Celsius (°C)) or below (some vapors may ignite as low as minus 45°F (minus 43°C)), extreme care is required in handling them. Kerosenes, jet fuel (JP-5), diesel fuels, light and heavy boiler fuels and lubricating oils are somewhat safer since they require a higher temperature to produce flammable or explosive vapors.

5.2.2.2 Explosive mixtures. Vapors from petroleum products, when mixed with the proper amounts of air, form highly explosive mixtures. Vapor mixtures of 1 to 14 percent by volume can be explosive; however, gasoline will form an explosive mixture only between 1 and 6 percent by volume in air. The vapor concentration below which a mixture is too lean to burn is called the lower explosive limit. The concentration above which a mixture is too rich to burn is called the upper explosive limit (see figure 1).

5.2.2.3 Vapors with toxic effects. Vapors given off by crude petroleum, gasoline and other petroleum products cause toxic effects when inhaled. Petroleum vapors of a concentration of 0.1 percent by volume may cause slight dizziness at the end of 6 minutes, and a concentration of 0.5 percent may cause a complete loss of balance. Longer exposure or greater concentrations may cause unconsciousness or death. The maximum safe content of petroleum vapors has been fixed at 0.5 percent by volume, which constitutes the danger limit for breathing, rather than 1.0 percent by volume, which is the lower limit of the explosive range. The 0.1 percent concentration pertains to the inhalation of air with sufficient oxygen to sustain consciousness, and does not imply freedom from toxic effects. Any unnecessary exposure by contact or inhalation shall be avoided.

5.2.2.4 Harmful components and additives. In addition to the explosive and toxic effects described in 5.2.2.2 and 5.2.2.3, certain chemical components and additives in petroleum warrant the following special considerations:

(a) Petroleum products contain naturally-occurring compounds, such as sulfur, which can combine with hydrogen and oxygen to form corrosive sulfuric acid. If the product is a sour crude oil, sulfur may combine with hydrogen to form flammable hydrogen sulfide, which is extremely toxic. Fortunately this gas, which has an odor similar to rotten eggs, may be detected at extremely low concentrations.

(b) Organo metallic gasoline additives (such as lead tetraethyl or tetramethyl) vaporize along with the gasoline vapors and can impose a poisonous effect on human physiology. The lead compounds may enter the body through inhalation, skin-absorption and ingestion. Since lead absorption is cumulative, repeated exposures result in a body burden of lethal proportions. Therefore, scale, sediment and sludge, impregnated with gasoline and lead compounds, will constitute a serious fire and poison hazard, unless removed thoroughly by cleaning and gas-freeing. These materials shall be disposed of in accordance with NAVSEA S9593-A7-PLN-010.

(c) Many synthetic fuels are more hazardous than their petroleum analogues because of greater mutagenic, tumorigenic and cytotoxic properties. In addition, synthetically derived fuels may cause sensitization. Contact with or inhalation of synthetic fuels shall be kept to a minimum.

5.2.3 Precautions for entering and working in tanks. Hazards inherent to vapor accumulation cannot be overemphasized, and the utmost precautions shall be taken before a tank is entered for inspection or work. Except in an emergency, personnel shall not enter a tank or other compartments subject to vapor accumulation, until a qualified chemist or ship's officer (designated as

the gas-free engineer) has tested the space, and then only upon direction of the officer-in-charge. If a combustible gas indicator (see 5.5.11.2) shows a vapor content of 0.1 percent or higher, the space is unsafe. In case of an emergency, anyone entering a tank shall be equipped with an air-line mask with a line securely fastened to them. The line shall be tended by reliable personnel outside who shall make sure it remains unfouled and able at all times to extricate a person from the tank. The hose shall be attached to a source of air fit for breathing while slight positive pressure is maintained in the hose and face piece. Since any inadvertent contact between oxygen and oil may result in an explosion, the hose shall not be attached to an oxygen cylinder. For the same reason, an oxygen breathing apparatus (OBA) shall not be used in oil tanks since the canister may explode on contact with a mixture of oil and water and is hazardous to use in the vicinity of petroleum products. The self-contained breathing apparatus (SCBA), an air pack with tank and respirator may also be used in place of the air-line mask when entering tanks.

5.2.3.1 Additional precautions. Additional precautions to be taken shall include the following:

(a) The tanks shall be continuously ventilated while personnel are inside. Controlled, forced ventilation is preferable to natural ventilation.
(b) A reliable person shall stand by the tank top or manhole and keep an accurate count of the number of personnel in the tank or space, maintaining communication with them to ensure their safe condition. In emergencies, he shall assist those in the tank.
(c) Fire extinguishing apparatus shall be provided in the vicinity of such spaces.
(d) Tools, including hose nozzles, scrapers and buckets shall be made of rubber, wood, copper, bronze, brass, aluminum, plastic fiber or other material that will not cause sparks. Possible sources of sparks are arcing motor brushes, grounded or shorted electrical circuits, or the turning on or off of electrical switches or unapproved flashlights. A discharge of static electricity may occur from friction between two rubbing surfaces or a rapidly moving belt. The person in charge shall make sure that no matches, butane or automatic lighters are carried by personnel, and that no steel buttons, belt buckles or shoe nails that might cause sparks are worn.
(e) Clothing shall be changed and washed at the end of each day's work. Only non-sparking clothing such as cotton shall be worn.
(f) When entering gasoline tanks, protective clothing (light-colored material coverall), acid-resistant rubber boots and acid-resistant gloves shall be worn.

Commercial tankers use a tank rescue device fitted over the tank hatch. This is a tripod structure, powered by a small motor winch to extract an unconscious crewmember from a tank. The crew should be trained in its use.

5.2.3.2 Manual washing. The tanks shall be ventilated continuously because of the possible regeneration of gases from the heat of the water. This continuous changing of air will also reduce fogging which endangers the

person's vision. The person doing the manual washing shall stand on the bottom or wherever good footing is available, but not on the pipelines or frames. When adjoining compartments contain bulk cargo, precautions shall be taken to avoid contaminating this cargo or discharging it with the washings. Therefore, all valves in interconnecting lines shall be closed and lashed, if possible. When the adjoining tanks contain gasoline or similar low flash point liquids (see 5.2.2.1), the compartments shall not be washed with water at a temperature above 125°F (52°C).

5.2.3.3 Machine washing. Hot machine washing of tanks when personnel are working in adjoining tanks is ill-advised. However, steaming of tanks interconnected by pipelines to the tanks where men are working is permitted only if the valves are locked shut. Valves and openings between adjoining tanks where personnel are working and those containing an unsafe concentration of oil vapors shall be locked shut.

5.2.3.4 Working near flammable liquids. The handling or transferring of flammable liquids in bulk shall be prohibited when personnel are in the tanks. When flammable liquids in bulk are aboard, personnel shall not be permitted to work in tanks interconnected by oil pipelines unless the pipelines are separated by a blank flange and the valves in the auxiliary lines are locked.

5.2.3.5 Entering closed spaces. Precautions for entering closed spaces which do not normally contain gas-generating liquids are the same for entering tanks. Although these spaces may appear to be gas-free, the same danger exists and the same precautions shall be taken (see 5.2.3). Explosive mixtures may occur from leaks of gas-generating liquids or vapors from adjacent tanks. Additionally, toxic fumes may develop from leaks, painting or oxidation, and oxidation combined with poor ventilation may deplete the oxygen supply.

5.2.4 Temporary lighting precautions. The use of temporary lighting in tanks and spaces subject to vapor accumulation shall not be permitted until such spaces have been certified safe for personnel - safe for hot work (see 3.6) or safe for personnel - not safe for hot work (see 3.5). Even then, use shall be controlled as described in 5.2.4.1 through 5.2.4.3. All electrical equipment used shall be inspected before use by the ships electrical officer.

5.2.4.1 Equipment. Unless the tank has been certified as safe for personnel - safe for hot work, lights shall not be moved into or out of a compartment until first disconnected from the source of electrical supply. Only light globes and flashlights of vaporproof types in first class condition, such as those approved by the National Institute of Petroleum and Energy Research (NIPER) for use in methane and air mixtures, shall be used. Such lights shall be secured with a piece of line, but not by electrical service cables.

5.2.4.2 Personnel. During the period in which portable lighting is being used, an electrician or other qualified person shall be on duty to remove the lights, operate the switchboard, and maintain the equipment in good condition.

5.2.4.3 Additional precautions. If, in spite of certification, gas accumulates, portable or stationary electrical distributing panels and plug fixtures shall not be used in the vicinity of flammable vapors.

5.2.5 Discharge of hazardous materials and waste. The discharge of toxic pollutants (petroleum products, petrochemicals or additives as described in 5.2.2.3 and 5.2.2.4) into the marine environment, either at sea or into navigable coastal waters, will have an adverse impact on the marine environment, water craft, human food resources, water supplies, and recreational areas. The U.S. Navy is attentive to these concerns and has embarked on a program to eliminate overboard discharge of oils and oily wastes from Navy ships in particular. Any discharge from Navy ships of these substances, in-port or at-sea, shall be in accordance with the declarations of goals and policies of the Clean Water Act and in accordance with S9086-T8-STM-000/CH593. Hazardous materials and waste remaining after separation techniques shall be disposed of in accordance with S9593-A7-PLN-010 and with Code of Federal Regulations (CFR), Part 33, Chapter 1 which contains U.S. Coast Guard regulations for commercial ships.

5.3 Tank ventilation. Ventilation of a cargo tank for inspection, repair or gas-freeing during a cleaning shall be accomplished with care and thoroughness. Safety cannot be overemphasized; it shall be mandatory that personnel be indoctrinated on necessary precautions. Accurate gas indicators shall be used frequently due to possible regeneration of gases in a tank that has already been tested and declared safe.

5.3.1 Ventilation techniques. Ventilation may be accomplished either by forcing gases out of the tank by blowing or by extracting gases from the tank with suction.

5.3.1.1 Bottom extraction versus blowing. Extraction of the gas by taking suction near the tank bottom is theoretically the most efficient method. This method will draw off the richer accumulation of gases first, since the petroleum vapors are heavier than air and thereby tend to stratify into rich, explosive and lean mixture levels. When these layers are removed separately, the area of the tank subject to possible ignition tends to be lessened. Blowing, on the other hand, creates turbulence with a resultant mixture of the gas concentrations throughout the tank. Thus, at some point the whole tank will tend to be in the explosive range.

5.3.1.2 Efficiency of various methods. The most efficient ventilation procedure (see figure 2) is introducing air at the top of the space and venting from the bottom. The next most effective method is introducing air at the bottom and venting at the top. Although most ships do not have blower attachments to do this, canvas ducts can easily be fabricated and attached to the blower discharge, then led to the tank bottom. If the air is both introduced and vented at the top, the time required to gas-free will be almost double that of the first procedure.

5.3.1.3 Ventilation after tank washing. When ventilating after a tank washing, regardless of the method used, the gases may be removed more efficiently while the tank is still hot and condensation has not yet occurred. This gas-freeing ventilation operation is normally carried out at sea, at an explosive anchorage, or at a pier designated as an authorized cleaning station. Due to static electricity considerations, air being forced into a tank shall be free from foreign matter, such as dust, rain, or snow.

5.3.2 Forced ventilation. Forced ventilation is accomplished by the use of steam-driven or air-driven mechanical blowers, gas exhausters, and air blowers. The use of air or steam as the power source lessens the danger of explosions due to sparks. However, when authorized explosion-proof, electric-driven blowers or fans are sometimes used. Blower units shall have a positive bond to the ship's hull.

5.3.2.1 Coppus blower. The Coppus blower is an extensively used portable ventilation system that is easy to install and operate (see figure 3). The following describes two types available for use aboard either steam or diesel gas turbine ships and installation, operation and lubrication of the Coppus blower:

(a) Steam powered ships. The model C12A is a lightweight unit (60 pounds) which is compact enough to facilitate storage. At a normal operating speed of 3500 revolutions per minute (r/min), it will deliver 4000 cubic feet per minute (ft^3/min) of air, which is sufficient to provide thorough ventilation and rapid drying of the tank. These units are also economical; the steam consumption with 100 pounds of pressure is approximately 150 pounds per hour and air consumption with 80 pounds of pressure is approximately 65 ft^3/min of free air.

(b) Gas turbine and diesel powered ships. The model C12AW is a lightweight unit (63 pounds) which is compact enough to facilitate storage. At a normal operating speed of 3500 r/min, the unit will deliver 5000 ft^3/min of air. With 100 pounds of applied water pressure, the unit will consume 70 gallons per minute of water.

(c) Installation. The blower unit is flanged to fit the existing deck openings used in tank cleaning and can be bolted in place. Flexible hoses are used to connect the turbine drive to the source of power, which is either low-pressure air or steam. When units have an air heater, low-pressure steam is utilized and is led from the turbine exhaust to the air heater by way of a flexible hose connection. It is then vented into the ship's exhaust system or into the atmosphere. A steam throttle valve, supply strainer, exhaust sentinel valve and a drain petcock are installed in this system.

(d) Operation. When the unit is steam-driven, it is placed in operation in the same way as a typical steam pump. The exhaust and drain valves are opened, steam is slowly admitted by opening the throttle valve, and the turbine is brought up to speed. The drains are closed when condensate has ceased being expelled from the drain petcocks. If the exhaust is not lined up properly, it will be indicated by the emission of steam from the sentinel valve. An extra nozzle is installed which may be opened to increase the revolutions per minute of the unit during conditions of low steam supply. Normally, this nozzle is closed; in this position the turbine cannot overspeed. To secure the blower, the throttle valve and the exhaust valve shall be closed and any drains shall be opened. When the unit is air-driven, the throttle valve shall be opened slowly as before. The exhaust will be emitted into the atmosphere.

(e) Lubrication. A grease cup is provided during operation and shall be taken down by one-half turn each week. High quality sodium (or mixed base) ball-bearing grease shall be used. Coppus blowers require little or no maintenance other than routine care in handling and storage. If stored for long periods, it is suggested that the blades be rotated by hand at regular intervals to prevent their freezing in place.

5.3.2.2 Installed dry air vent system. The dry air vent system makes use of a steam turbine-driven blower, an air heater and the main cargo piping to deliver air to the cargo tanks. Operation of the system is extremely simple. The spectacle flange (which isolates the unit when not in use) is changed around, the main cargo lines are drained, and the cargo piping is aligned for the required tanks. The tank gases are vented by the air discharged from main cargo suctions. Excess blower speeds (with resultant high air velocities) or high liquid levels (due to improper stripping) may cause liquid particles to be entrained in the air. This will reduce efficiency and deposit oil particles on the deck surfaces.

5.3.2.3 Gas exhauster or eductor. The gas exhauster or eductor consists of an ejector unit operating on the Venturi principle and utilizing steam, air or water as a motivating element to remove gases from a tank. Steam is most commonly used as the power force. Installation, operation and maintenance of the gas exhauster or eductor are described in the following:

(a) Installation. The gas exhauster or eductor may be flanged for installation directly on the deck opening or for insertion into the main cargo piping system. In the first instance, it shall be bolted in place on the deck opening and a flexible hose connected to a source of power. In the second instance, it shall be connected to a standard expansion joint in the main cargo line, which acts as a swivel joint to allow the discharge end to be pointed in a direction for the wind to carry away the gases. Gases are removed from the desired tank by opening or closing the proper suction valves. In either installation, a strainer shall be installed in the supply line to protect the nozzle from damage due to foreign matter.

(b) Operation. To place the unit in operation, the supply line shall be drained and the throttle valve opened slowly to permit steam or air to pass through the nozzle. This will create a vacuum drag on the air which surrounds the nozzle and, in turn, on the gases which are in the tank.

(c) Maintenance. There are few maintenance requirements because of the absence of mechanical movement in this unit. Gas exhausters or eductors are generally shipyard material.

5.3.3 Natural ventilation. Natural ventilation can be accomplished by means of windsail trimmed into the wind. The windsail consists of a canvas chute which can be hoisted above deck by means of a halyard and a long canvas duct which extends down into the tank. The efficiency of the windsail depends on the force and direction of the wind; in a moderate breeze it is fairly effective. To set up a circulation of air throughout the entire tank, the

lower end of the canvas duct shall be placed near the bottom where the heavy vapors settle. The air caught by the chute is funneled down through the duct to the tank; this allows ventilation through the open tank top.

5.4 Cargo and auxiliary piping systems. In addition to the tank cleaning system, the conventional pumps and piping systems of a tanker are used for gas-freeing and cleaning tanks. Although piping systems aboard different classes of tankers very in specific details, their functions, basic design and operation are essentially the same. Failure to know these systems causes wasted time in lining them up, mistakes that could contaminate other cargo, and danger to both personnel and equipment. A typical shipboard arrangement for each system is described herein.

5.4.1 Cargo system. The cargo system (consisting of pumps, valves and piping) is used for receiving, off-loading or intertank transferring of petroleum. The cargo system is also used for stripping, ballasting and deblasting. A typical fuel tanker (AO), fuel, naval distillate (F-76) and JP-5 cargo piping system are shown on figures 4 and 5, respectively. Aboard tankers carrying both clean and contaminated products, independent cargo systems are provided for each product to prevent contamination from intermingled cargoes.

5.4.2 Stripping system. The stripping system is designed for low suction in the cargo tanks to carry off contaminated cargo or waste fluid from cleaning operations. A stripping suction line with a cutout valve connects each tank to its associated main, from which water or contaminated liquid may be pumped overboard or to other tanks. A typical AO, F-76, and JP-5 cargo stripping and reclamation system are shown on figures 6 and 7, respectively. Flexibility is provided when lines are connected with crossover valves. Stripping pumps are motor-driven, rotary positive displacement pumps which may be used in priming the corresponding cargo pump. In addition to conventional stripping pumps, cargo pumps (when provided with a low suction) may be used. Portable diaphram pumps (such as the Wilden MK 2) are frequently used by personnel in gas-free tanks to dry up residual water.

5.4.3 Auxiliary steam system. Reducing valves, cutout valves and piping are used in this system to supply auxiliary steam to pumps, heat exchangers and strategically located service valves. Steam is piped at line pressure to the steam driven cargo fuel pumps in the pumprooms and at reduced pressure (150 to 160 pounds per square inch (lb/in^2)) to the steam driven stripping pumps. A 150 to 250 lb/in^2 branch line leads to the tank washing heat exchanger. In addition, the 150 to 160 lb/in^2 line is connected to the steam-smothering line, and service outlets on the main deck.

5.4.4 Cargo heating system. Piping with cutout valves is necessary to supply auxiliary steam to the coils in a tank for heating petroleum and, to a lesser degree, to the solution used in a chemical cleaning (see figure 8). Auxiliary steam at 150 to 160 lb/in^2 is admitted to the main heating coil lines on main deck by opening the inlet valves (root valves); then the steam is admitted to the designated tank heating coils by opening individual inlet valves. Condensate is piped to a fresh-water collecting tank or system; an installed trap prevents wasted steam and water hammer. U.S. Navy oilers do not have heating coils in cargo tanks.

5.4.5 Steam-smothering system. In this system, a supply main has connecting lines to each tank (see figure 9). For firefighting, auxiliary steam pressure (150 to 160 lb/in^2) is maintained in the lines up to the tank cutout valves. The system may be used when steaming tanks, however, cutout valves shall be in good condition to prevent leakage and overheating. Modern tankers no longer use steam smothering systems. Foam systems are becoming the primary fire-fighting system.

5.4.6 Carbon dioxide (CO_2) system. The CO_2 system consists of CO_2 cylinders, reducing valves, piping or hoses, and valve connections positioned for the intended service (see figure 10). This system is normally associated with gasoline products and is used for purging hoses, inerting the piping and surrounding cofferdams, and blanketing (snuffing) fires. However, these uses are not restricted to gasoline tanks; adjacent spaces may be inerted with this nonflammable gas to provide a nonexplosive atmosphere for emergency repairs. For purging or inerting, CO_2 from the flasks (usually located in the midship pumproom and a designated CO_2 room) is reduced to a working line pressure of 10 to 15 lb/in^2. Mercury pressure or equivalent gauges shall be provided to check this line pressure and to ensure that the maximum space pressure of 0.5 lb/in^2 is not exceeded. In addition to flasks normally connected to the service main for immediate use, sufficient spares are carried. However, these spares are not connected unless they supply CO_2 to the gasoline cargo hatches for emergency blanketing or snuffing. Care shall be taken when CO_2 is released into a space, since rapid emission may result in CO_2 snow-buildup with an accompanying generation of static electricity.

5.4.7 Vent system. The vent system, consisting of piping, pressure or vacuum relief valves and flame arresters, releases petroleum vapors into the atmosphere safely when tank pressure is excessive. It also allows air to come into the tank when a vacuum is formed (see figure 11). Excessive pressure can result from high air or water temperatures, or possibly from steam leakage from the steam-smothering system. A vacuum can result from a sudden cooling of the outside air or water, causing vapor condensation. An individual line branches from each tank hatch to its associated relief valve manifold located below the 01 level. Normally, forward of midship, vent lines from manifolds lead up the foremast, while others lead up the mainmast. Each pressure or vacuum relief valve is set for automatic lifting of 2 lb/in^2 pressure and 1 lb/in^2 vacuum and is provided with a manual hold-open device in case of malfunction. This shall be operated periodically to ensure movement. Most risers are fitted with relief valves set at 1 lb/in^2, flame arresters and screens. Hose connections are provided for steaming or water flushing the vent lines. U.S. Navy AOE class ships do not have this arrangement for cargo tanks.

5.4.8 Fire and tank washing system. This system uses a pump, salt water heater and associated piping to deliver salt water at the required temperature and pressure for tank washing (see figure 12). A specifically installed fire and tank washing pump, a tanker's conventional fire pump, a general service pump, or a fire, bilge and ballast pump is used to deliver salt water to the heater. The fire pump may have a relief valve set to relieve at system design pressure. A booster pump to bring wash water to desired pressure also has a relief valve set at its design system pressure. The tube and shell type heater consists of two units. The upper unit is the heater proper and the lower unit is the drain cooler. Cold sea water is pumped first into the drain cooler and then into the upper unit. Steam enters the heater shell where it condenses. It

then passes into the drain cooler for further heat release before returning to the drain collecting system. A liquid level control between the heater and the drain cooler regulates the condensate discharge in order to keep the drain cooler flooded. Thus, the sea water is preheated in the drain cooler before passing into the tubes of the upper unit where the heat is raised to the required temperature. A steam-regulating valve maintains the desired temperature by controlling the amount of steam entering the heater. The latest fleet oiler design requires capability to heat 300 gallons per minute of sea water from 29 to 135°F with a pressure of 150 lb/in^2 maximum. From the heater, the water passes to the common fire and tank washing line extending along the catwalk on the main deck. This line is equipped with various fittings, expansion joints and globe-type hydrant valves which can be used as tank washing or fireline hydrants. Pumps, heaters, fittings and valves are tested at 135 percent of system design pressure.

5.5 Tank washing machines. The tank washing machine is a hydraulically rotated nozzle device attached to a hose and inserted in the tank. It is small, self-contained, and constructed of nonferrous metals to eliminate the possibility of spark generation. Pressurized water is supplied to the machine through the hose. As the nozzles automatically turn slowly about the horizontal and vertical axis, their positions change continually during each revolution, causing the streams to strike all surfaces either directly or indirectly. The motion of the jets is controlled with mechanical precision, resulting in a more thorough job than would be possible by hand washing. Furthermore, with hand washing, it is not possible to utilize the high pressure and temperature which can be handled by the machine. The operation and maintenance of various approved models of tank washing machines are discussed herein; however, when possible, the manufacturer's instruction booklet shall be consulted.

5.5.1 Butterworth machine (type K). The type K Butterworth machine (see figure 13) weighs approximately 50 pounds and provides high quality washing with operational reliability. The unit has an enclosed lubricated gear box which is sealed at the factory. Slip clutches, automatically engaged by the water pressure, protect the internal mechanism. No oil bath, lubrication or other maintenance is needed unless the unit is damaged by a very severe blow.

5.5.1.1 Pyrate machines (models E, S, V and L). A Pyrate machine (see figure 14) is coupled to a source of pressurized water which first passes through a strainer to remove any large foreign matter. The water then operates an impeller turbine in the drive unit which forces it out through a nozzle. The early Pyrate model E, still in use, has two nozzles. The more recent models, S, V and L have three nozzles. In all models, the rotating impeller turbine shaft causes the nozzles to rotate vertically and the drive unit to rotate horizontally. This motion is accomplished through a series of gears. The model V Pyrate machine (VP) is a two-nozzle tank washing machine, as follows, which is preferred for use on Navy ships:

VP - major 11 fitted with 11 millimeter (mm) nozzles (7/16 inch) (see figure 15)
VP - major 16 fitted with 16 mm nozzles (5/8 inch) (see figure 16)

No special tools and skills are required for on board servicing of these machines. The cycle time for the VP - major 11 and VP - major 16 are 50 to 20 minutes and 64 to 33 minutes, respectively, at applied water pressures of 60 to 180 lb/in^2 for both machines.

5.5.1.2 Sellers machine (model C). In the model C Sellers machine (see figure 17), pressurized water enters from the hose and is channeled through a guide wheel to the turbine wheel, which forces the water out through the nozzles. The revolving turbine shaft imparts power through a gear reduction (worm and wheel assembly) to the lower housing, which is free to rotate horizontally, and to the nozzles, which are arranged to rotate vertically. The nozzle head is controlled by a slip clutch so that the nozzle may be freely rotated without internal damage to the unit even if it is accidentally dropped. This machine requires no special maintenance other than normal careful handling and storage. If the machine fails to operate, the manufacturer's instruction book shall be consulted.

5.5.2 Tank washing machine hoses. The tank washing machine hoses come in 50-foot and 100-foot lengths and are especially designed to handle hot water under high pressure. Corrosion-resistant, well-protected bonding wires throughout the length of the hoses provide grounding protection against a possible static electrical discharge from the nozzle tips. Fittings and adapters are available to couple together hoses from the same or different manufacturers. Couplings are bronze and the hose fittings are machined for use without gaskets. One exception is the fire line coupling which in some hoses is designed to receive a gasket. Careful handling shall be necessary to avoid leakage resulting from damaged or dirty machined joints.

5.5.3 Deck openings and plates. Openings, 12.5 inches in diameter, are located in the main deck over each tank for inserting a tank washing hose and machine. The number of openings is determined by the size and construction of the tank. The openings are usually located in a central position with consideration given to existing tank obstructions. Bronze or brass plates, bronze nuts and washers, and a gasket are used to seal the openings when not in use. The openings are also used for ventilation. The Coppus blower and certain gas exhausters are flanged to fit the opening and can be bolted in position.

5.5.4 Hosesaddle. A specially designed hosesaddle holds the hose in place and seals the deck opening. It consists of a plate, an attached saddle and a clamp to secure the hose. The plate is fitted to the deck hatch opening and has an opening for the hose.

5.5.5 Internal riggings for tank washing machine. More precise positioning of the tank washing machine, as in spot washing, can be accomplished by the use of lines in conjunction with clamps or blocks (see figure 18). One end of a line or wire cable is attached to the tank washing hose near the top of the machine. The line is led through a temporarily placed clamp or block and then through an ullage hole or deck opening. This allows the machine to be moved to various positions. The clamps, blocks and line or cable are generally shipboard materials.

5.5.6 Pressure relief valve. A 2.5-inch, 250 lb/in^2 relief valve set at 200 lb/in^2 shall be attached to a fire and tank washing hydrant on deck to relieve a sudden high pressure that might occur when the machines are shifted. The water released will alert the operators on deck and prevent serious damage to the equipment. Abnormally high pressure may result in the following:

(a) Unnoticed flooding which may damage any electric motors in the space if the relief valve on the tank washing pump leads to the bilges and not to the pump suction.
(b) Leakage in the heater tubes which contaminates the drains returning to the feed system with salt and causes the heater to be shut down.

5.5.7 Thermometers and pressure gauges. In order that the officer-in-charge can intermittently check and log temperatures and pressure during a tank washing, the fireline shall have a thermometer and a pressure gauge on the forward and after decks. A thermometer installed in the plug hole of the fire and tank washing expansion joint shall register the temperature of the flowing water. A thermometer shall never be installed at a dead end. Since the efficiency of tank washing depends on maintaining a constant temperature and pressure, a positive check shall be kept on these items. The reports of personnel who are not directly concerned with operation shall not be depended on completely. Checking of temperatures and pressures shall be conducted by the officer-in-charge. A pressure gauge may also be installed on the sprinkler system.

5.5.8 Self-cleaning fireline strainers. Standard Navy 2.5-inch, self-cleaning fireline strainers are generally attached to each hydrant supplying water to the tank washing machines to help protect the machines from scale or other foreign matter which can bind and cause excessive wear. This is especially important when the operation is being conducted inside a harbor.

5.5.9 Booster pumps. A booster pump may be used to relieve the operational load on the tank washing or cargo pump during lengthy cleaning periods or when cleaning tanks by chemical recirculation. For either circumstance, a portable, diesel-driven, 1000-gallon per minute centrifugal pump can usually be obtained from a shipyard, since it is standard Navy firefighting equipment. The booster pump also gives the deck officer complete control over the pressure supplied to the tank washing machines. The pressure may be increased or decreased at any time during the operation which permits the primary pump to be run at a steady rate without danger of overload. Two booster pumps can be connected to operate singly or in series. Installation will differ according to the ship's piping arrangement. This information does not apply to U.S. Naval ships.

5.5.10 Heat exchanger. A portable tube-and-shell heat exchanger can be used with the booster pump. A heavy and continuous load imposed on the ship's heater during a major cleaning operation could cause a costly breakdown. As with the booster pump, incorporation of the heat exchanger into the system being augmented will differ according to the piping arrangement of the individual ship. Steam may be supplied to the heat exchanger either from the deck steam line connection (generally located under the catwalk on the after deck forward of the pumproom) or from the after shore steam manifold. A 2.5-inch pipe, fitted with a steam regulating valve, shall be installed to lead from

either of these connections to the steam inlet on the heat exchanger. The steam return line from the heat exchanger shall be a 1-inch pipe connected to a steam trap on the heat exchanger. This information does not apply to U.S. Naval ships.

5.5.11 Gas testing equipment. Gas testing equipment (see 5.5.11.1 through 5.5.11.3) shall be used aboard ship to test tanks and spaces for the presence of oxygen deficiency, combustible and toxic gases (carbon monoxide). Regardless of what instruments are chosen, they shall be approved by the National Institute for Occupational Safety and Health (NIOSH). Recalibration of these instruments shall be requested during each period of shipyard availability. NAVSEA S9086-CH-STM-030/CH074V3 shall also be consulted.

5.5.11.1 Oxygen indicator monitors. There are several models of approved oxygen analyzers. Often the oxygen analyzers are constructed in combination with combustible gas indicators (see 5.5.11.2). Essentially, the instrument consists of a galvanic cell with two dissimilar electrodes. The passage of oxygen over this electrode results in the generation of a current which is proportional to the oxygen partial pressure. The current is then converted to a proportional voltage on a meter. Other instruments with carbon electrodes operate on a depolarization principle.

5.5.11.2 Combustible gas indicator (explosimeter). There are several models of approved combustible gas indicators. Essentially, the operation principle is based on the proportional temperature change that results from the sample gas effect on a heated filament. A temperature increase due to the change in heated filament temperature effects a corresponding change in electrical resistance which is measured by a circuit (Wheatstone Bridge or equal). A sample is drawn through the instrument and over the filament by means of an aspirator bulb. Due to the possibility of the presence of lead vapors (which condense on and foul filaments), only instruments operating at high filament temperatures or with in-line lead inhibitor filters shall be used with aviation gasoline (Avgas).

5.5.11.3 Toxic gas detection. Several toxic substances (for example, carbon monoxide, methane and hydrogen sulfide) may be present in tanks. However, instructions are described herein for the most likely toxic gas (carbon monoxide). A gas detector (Draeger multi-gas detector or equal) is used for testing. This instrument consists of a small hand-held pump into which a detector tube is inserted and the gas to be analyzed is drawn through. One squeeze of the pump bellows provides detection of carbon monoxide in a range of 0.01 to 0.3 percent (100 to 3000 parts per million (p/m)). When 10 detector pump strokes are used, the instrument provides a detection range of 0.001 to 0.03 percent (10 to 300 p/m). Prior to inserting the sealed detector tube into the pump, the hermetically sealed ends are broken off in a break-off eyelet. Air metered by an orifice is drawn through the tube over a chemical which develops a brownish-green color band, the length of which is proportional to the concentration of carbon monoxide. The concentration of contaminant gas may be read off the detector tube which is graduated.

5.5.12 Additional materials. The following additional materials required for tank cleaning operations shall be collected and inventoried prior to starting the work. Tools included in this material shall be sparkproof:

(a) Respirators.
(b) Explosionproof flashlights.
(c) Protective clothing.
(d) Buckets.
(e) Rigging lines.
(f) "C" clamps.
(g) Blocks or fairleads.
(h) Rags.
(i) Brooms.
(j) Scoops.
(k) Scrapers.
(l) Extension ladders.

5.6 Methods of gas-freeing and tank cleaning. The gas-freeing and cleaning methods described herein provide effective and safe guidance for the inspection, repair and cleaning of cargo tanks and associated compartments. Selection of method may be governed by the product involved, tank conditions, time allotted and materials available. A successful operation requires proper supervision, planning and indoctrination of the working crews. Equipment and material shall be available and ready for service. Regardless of the method used, the safety of personnel shall be of prime importance.

5.6.1 Preparatory procedures.

5.6.1.1 Testing of lines, valves and pumps. Tank washing piping and heater shall be tested to maximum operating pressure.

5.6.1.2 Preparatory flushing operations. Preparatory flushing operations shall be as follows:

(a) Heating coils. The heating coils, including those which are being removed due to an upgrading of cargo, shall be thoroughly flushed to remove any oil which might have leaked from the tanks. This flushing eliminates any possibility of vapors escaping into the tanks after completion of the cleaning and the possibility of the contamination of future cargoes from the material suspended in the coils. The flushing operation also effectively tests the coils so that leaks can be detected and the necessary repairs can be made prior to loading cargo. The coils shall be flushed as follows:

(1) Close the return line valve to each heating coil to avoid possible contamination of the feedwater system.
(2) Turn on the main steam to the heating coils.
(3) Open the heating coil valves (one tank at a time) to allow maximum steam pressure for cleaning each heating coil line.
(4) Connect a small hose to the heating coil drain valve manifold and lead it into the nearest tank to be cleaned. Open the deck drain valve on the return line to permit steam to pass through the coils and into the tank.

(5) Check for leaks while flushing. This shall be done at the beginning, before the accumulation of steam and high temperature make it difficult to locate possible leaks. Heating coils have been completely removed from U.S. Navy oilers or are disconnected from the ships steam system.

(b) Steam smothering lines. The steam smothering lines to each tank shall be flushed separately by allowing line steam to pass through into the tank. The process should be continued long enough to remove all evidence of oil or suspended vapors from the lines which might enter a gas-free tank through a valve.

(c) Vent lines. The vent lines shall be flushed thoroughly to prevent the escape of oil or vapors into a gas-free tank and also to avoid contamination of future cargo from this source. The flushing shall be accomplished by steaming out the lines or by allowing a sufficient amount of hot water from the fire and tank washing line to pass through the vent lines into each tank in the following manner:

(1) Connect a tank washing hose or a washdown hose from the fire and tank washing line to the connection on the cargo vent system.
(2) Close all pressure/vacuum relief valves on the valve manifolds of the cargo vent system.
(3) Flush the main and vertical vent line to the emergency pressure/vacuum valve on the mast by opening the hydrant valve on the fire and tank washing line and the valve on the vent system at the bottom of the vertical line. Continue flushing until the water is clear.
(4) Open a pressure/vacuum relief valve on the valve manifold which controls the cargo tank vent lines to be flushed. Flush each vent line separately until all visual evidence of oil is removed. A greater volume of hot water can be obtained by opening one pressure/vacuum relief valve at a time.
(5) After flushing each cargo tank vent line, remove the loose scale (if necessary) at its entry into the tank. Check the pressure/vacuum relief valve manifold to be sure that no scale remains on the valve seats. To remove additional loose scale and to allow full ventilation in the main vent lines, remove the blanks on each system.

This information is not applicable to U.S. Naval oilers.

5.6.1.3 Preparatory tank stripping and pipeline circulation. Before a cleaning operation, all associated piping shall be flushed with water, using one tank as a sump. The main cargo tanks and pipelines shall be stripped and dried. Piping arrangements differ between tanks, but the procedures basic to every operation shall be as follows:

(a) Line up the stripping pumps to strip simultaneously or separately through the main cargo line and the stripping line. When using a steam stripper, operate at a reduced rate to ensure a good stripping and to avoid loss of pump suction.

(b) Open associated risers, drops and crossover valves on the main cargo and stripping lines in the pumproom, in the tank and on the deck to allow any free oil suspended in the lines to flow to the pump's suction. Remove the blanks and crack open the header valves on the deck amidship and the hydrant valves on all deck drop lines to eliminate a vacuum in the pipelines which would allow oil to remain suspended.

(c) In preparing for the stripping operation, check all valves. Leave open all master valves on the main cargo and stripping lines. Close tightly all suction valves, thus eliminating a possible source of suction loss and helping to relocate other possible sources of such loss.

(d) Begin with a tank at the forward end of the ship and strip through a main cargo line. Open the main suction valve as little as possible to avoid losing suction without starving the pumps.

(1) Strip the tank through the main cargo line to remove free oil from the main cargo suction line.

(2) Strip through the stripping line by opening the stripping suction valve. Do not open this valve more than one and one-half turns, as most stripping valves are nonreturn up to that point. This eliminates the possibility of the oil running back into the tank if the pump should lose suction. It also strips the tank down to a minimum of oil and removes free oil from the stripping line.

(e) Continue the procedures outlined in 5.6.1.3(d), working from forward to aft to remove free oil from the fore-and-aft pipelines as well as the athwartship pipelines on the main cargo and stripping lines.

(f) After the tanks and pipelines are stripped, the strainers on the stripping pumps shall be opened, inspected and cleaned (if necessary). If the pump strainers are cleaned before the wash is started and kept clean during the operation, stripping will be improved and one cause of a reduced stripping rate will thus be eliminated.

5.6.1.4 Gauge lines. Pressure and vacuum gauge lines from the main cargo and stripping pump in the pumps shall be drained.

5.6.1.5 Extension rods (reach rods) and handrails. When upgrading from a black to a clean product, if the cargo valve extension rods or ladder handrails in the main cargo tanks are hollow, 1/4-inch holes shall be drilled at the upper and lower ends for drainage purposes. The heat in the tanks during the tank washing will aid in the drainage, evaporation, and washing away of free oil and suspended oil. Authorization shall be obtained to replace hollow handrails and extension rods with solid ones if the tank is being shifted over permanently to clean oil products. U.S. Navy ships do not carry black oil.

5.6.1.6 Log book. A log of the starting and stopping time of each step and any other factors pertinent to a cleaning operation shall be maintained. This provides the officer-in-charge and other watch officers with a record of what has been accomplished on each watch.

5.6.1.7 Gas-free condition. This gas-free condition of the tanks or compartments shall be posted by the certified gas-free engineer or the certified gas chemist. Entry shall be made in the deck log.

5.6.2 Routine machine washing. A routine machine washing consists of washing tanks with streams of water under pressure by means of tank washing machines to clean and gas-free the tubes. It also consists of a proper waste disposal in accordance with existing oil pollution regulations and NAVSEA S9086-T8-STM-000/CH593 (see 5.2.5).

5.6.2.1 Temperature and pressure. Temperature and pressure demands for machine washing will vary with the cargo product and the physical nature of the tanks to be cleaned. Although hot salt water may be necessary for some cleaning operations, its use shall be kept to a minimum due to its corrosive characteristics. Temperature and pressure shall be maintained as follows:

(a) For an uncoated tank, a minimum temperature of 135°F (57°C) and a minimum pressure of 150 lb/in^2 shall normally be maintained. The water temperature can be raised for stubborn heavy oils and can be lowered for clean oil tanks, depending on the physical condition of the tanks and the extent of cleaning necessary.
(b) For coated tanks, the water temperature is normally limited to 125°F (52°C) and the pressure will depend on the particular coating involved. U.S. Naval ships use cold water washing.
(c) For a surface coated with a film of wax, the use of cold water at the beginning of the washing period can be very effective. An initial application of hot water may remove the light oil from the wax and leave a residue which is difficult to remove. Maximum temperature of 100°F and maximum pressure of 150 lb/in^2 shall be maintained for cargo tanks adjacent to magazines when they contain ammunition. Maximum temperature of 120°F and maximum pressure of 150 lb/in^2 shall be maintained for gasoline tanks that are not adjacent to magazines.
(d) Since gasoline tanker (AOG) class ships do not have the facilities to provide temperature and pressure control, cold water at the best pressure obtainable is used for machine washing.

5.6.2.2 Personnel organization. The success of a machine washing operation depends on personnel performance. It is highly advisable to instruct crews properly in the various stages, giving reasons for performing each step; this technique results in a more efficient operation. During the machine washing operation, a normal engine room crew is employed. Following the routine machine washing, special crews will be needed for mucking and hand hosing. To perform a routine machine washing by using two machines continuously, the following personnel are recommended:

(a) An officer-in-charge to supervise the entire operation.
(b) A qualified officer or chief petty officer in charge of each watch.
(c) A qualified pumpman on each watch to be responsible for the operation and maintenance of the ship's pumps, as well as for keeping the tanks being washed as dry as possible at all times.
(d) A petty officer on each watch to supervise the machine washing.

(e) A crew consisting of four seamen to handle the machine washing equipment.

5.6.2.3 Standard equipment and material. When preparing for a routine machine washing, the items required will depend on whether the tanks are to be machine washed individually or simultaneously and on the number of machines to be employed in each tank. When using two machines to wash and two machines to enable immediate shifting to the next scheduled tank, the following equipment shall be required:

(a) Four tank washing machines with adapters and spare parts kits.
(b) A minimum of 10 lengths of tank washing hose, including two spare lengths.
(c) Five 2.5-inch bronze or brass male hose couplings.
(d) Four hosesaddles or quadrants.
(e) Four portable air-driven or steam-driven blowers (such as the Coppus blower), a set of windsails, or a gas exhauster if ventilators of this type are to be used.
(f) Two 36-inch pipe wrenches.
(g) Four 15-gallon buckets for use as oil and water containers. U.S. Naval oilers are provided with three tank cleaning machines and six Coppus blowers.

5.6.2.4 Additional equipment. To provide more accurate, safely controlled machine washing, it shall be necessary to have the following additional equipment which has been assembled and tested in advance to allow time for replacements:

(a) One 2.5-inch, 250-lb/in^2 relief valve.
(b) Two 300-lb/in^2 pressure gauges.
(c) Two 300°F thermometers.
(d) Four 2.5-inch, self-cleaning line strainers.

5.6.2.5 Washing schedule. A regular washing schedule shall be made to take full advantage of the transfer of heat from tank to tank (see figure 19). The importance of a regular washing schedule is indicated by the fact that a full 1/2-hour is usually needed to heat a cold uncoated cargo tank to the point where machines are working efficiently. Once the pattern has been formulated, a sketch showing the tank arrangements and the sequence to be followed shall be posted to keep all concerned personnel up-to-date and ready for the next step. A system of symbols or letters can conveniently be used to indicate the stages of the cleaning in progress or those stages which have been complete. For example, MW may stand for machine washing, H for handhosing, and M for mucking. Sometimes unfavorable conditions warrant change in the formulated pattern. For instance, when performing the tank washing at sea, it may be necessary to transfer ballast from tank to tank, making it difficult to abide by the pattern. In such cases, the best advantage of heat transfer should be taken. A proven pattern is as follows:

(a) Begin the cleaning of the number 1 port and starboard or the most forward set of wing tanks to be washed, operating one machine in each tank simultaneously.
(b) On completion of the number 1 wing tanks, shift to the number 1 center tank, whose longitudinal bulkheads have been heated by washing the wing tanks.

(c) On completion of the number 1 tanks, start two machines simultaneously in the number 2 center tank, whose forward bulkheads have already been heated from the washing of the number 1 tanks.

(d) After completing the number 2 center tank, simultaneously operate one machine in the number 2 port and one in the number 2 starboard wing tanks. As before (see (b)), the longitudinal bulkhead of each tank has already been heated from the washing of the number 2 center tank.

(e) On completion of the number 2 wing tanks, clean the number 3 port and starboard wing tanks simultaneously, using one machine in each tank. Again, the forward bulkhead of each tank has already been heated from the washing of the number 2 wing tanks.

(f) Continue in similar fashion or by other patterns which take full advantage of the heat transfer from adjoining tanks.

5.6.2.6 Drop schedule. A schedule of drops shall be made to clean the tanks in accordance with the type of cleaning being performed and the pattern formulated as specified in 5.6.2.5 (see figure 20). Tanks being cleaned and gas-freed may require washing only at levels of approximately 10, 20 and 30 feet. If the tanks were being converted from black oil to clean oil, a more complete cleaning shall be required. The following drop schedule is recommended: It shall be performed through each deck opening. If the number of openings is considered insufficient, the ullage opening may be used for insertion of a machine. The time periods for the washes in this recommended drop schedule are approximate and could be increased or decreased according to the condition of each tank and the nature of the last cargo. However, they have proven sufficient for the average cleaning operation. The drop depths are also approximate and will vary, depending on the positions of the ladders, ladder platforms, supporting angles and other tank obstructions that could interfere with the placing of the machines. The officer-in-charge shall familiarize himself with the inner tank structures to prevent fouling or damaging of the machine. This is especially important while undertaking a tank washing operation at sea when the movement of the ship could produce an additional hazard to the operation of the machines. As will be noted in the drop schedule, because of the cooling effect of the water in which the ship floats, the bottom requires more time for proper washing than other parts of the tank. The recommended drop schedule shall be as follows:

(a) Begin with the tank washing machines placed approximately 30 feet below the deck, and operate machines in this position for 30 minutes. This will preheat the upper part of the tank and break-up and remove heavy sediment or free oil from the bottom, thus providing good bottom drainage.

(b) Raise the machine to 10 feet below the deck and operate machine in this position for 30 minutes. This section has been preheated during the preceding low-level wash.

(c) Lower the machine to 20 feet below the deck and operate machine in this position for 30 minutes.

(d) Lower the machine to 30 feet below the deck again and operate machine in this position for 30 minutes.

5.6.2.7 Procedure for machine washing. After the pattern of the drop schedule has been established and preparatory steps have been completed, the procedure for machine washing shall be as follows:

(a) Hook up four sections of hose (two lengths to a section) to self-cleaning strainers on the fire and tank washing line hydrants.
(b) Connect a tank washing machine to each of the four sections of hose.
(c) Hook up a relief hose from the fire and tank washing line and lead hose over the side.
(d) Remove the plates from the deck openings over the first tanks to be washed.
(e) Lower two machines through the deck openings to the desired level. Position the hosesaddles.
(f) Lower the other machines into the next tank to be washed. These reserve tanks will serve not only as a relief if a breakdown requires a change of machines in the tank being washed, but will also provide continuity of operation.
(g) Prior to starting the machine washing operation, close the tank tops to conserve heat and prevent explosive vapors from escaping onto the deck. After the tank tops have been closed tight with a dog (clamp), remove the dog to permit the top to be raised and allow the escape of pressure in the event of an explosion. When the cargo vent manifold valve is opened, accumulated vapor may escape through the mast cargo vent.
(h) Notify the engineroom to start the tank washing pump and heater to supply water at the required temperature (135°F (52°C)) and pressure (150 lb/in^2). Be sure that the hydrant valves leading to the machines are closed. Open the valve to the relief hose, allowing the cool water to discharge over the side until the heater has raised the temperature of the water to at least 135°F (52°C) on deck, keeping the pressure at 150 lb/in^2. Then close the relief hose while simultaneously opening the hydrant valves to the two machines in the tank. Keep a constant check on the temperature and pressure on the fire line. Adjust pump discharge pressures and heat exchanger controls as necessary to approach (as nearly as possible) the required optimum pressures and temperatures. When it is necessary to change from one machine to another, always open the hydrant valve on one machine as the other is being shut off. This keeps the pressure constant during the changeover, and the fluctuation of temperature and pressure is reduced to a minimum at the heater and pumps.
(i) After a tank has been ventilated and cooled to permit entry and gas indicator shows it is safe for personnel, inspect tank to determine whether additional cleaning is necessary. If so, cleaning should be done while the tank is still warm.

5.6.2.8 During-operation inspections. During the operation, the officer-in-charge shall make frequent inspections, noting his findings in a tank cleaning log, to ensure the following:

(a) The temperature and pressure of the wash water shall be maintained at rates suitable to the type of cleaning being done. Washing is less effective for each degree of temperature and each pound of pressure lost.

(b) The drops shall be carried out on schedule. Improper drops will leave contaminated areas and require additional cleaning.

(c) The machine shall operate properly. If a single machine is operating within a tank, the periodic fluctuation of steam escaping in puffs around the hosesaddle will indicate the machine is functioning properly. However, if the volume of steam escaping around the saddle is constant, it is probable that the machine is not turning. As you become familiar with the operation of a tank washing machine, your ear will become trained in recognizing the sounds emitted when the machine is functioning properly. This is an important detail since it is impossible to watch the machine while it is in operation, and halting the cleaning to examine the machine means a delay in operation. When a machine is operating at a low level far down within the tank or when two machines are in operation, it is difficult to be certain of proper functioning; therefore, you should listen at an adjoining tank for the sound of the water streams hitting the tank surfaces. In case a machine is not operating properly, the relief machine shall be turned on and the malfunctioning machine shut off immediately so that vital parts will not be further damaged by the continuous high pressure of the water. The malfunctioning machine shall be replaced as soon as possible to provide continuous operation.

(d) A close check shall be maintained on the discharge rate of the stripping pump since the wash water should be removed at approximately the same rate at which it accumulates in the tanks.

5.6.2.9 Tank stripping during wash. During the wash period, the stripping pump shall remove the accumulated wash water at a rate which will allow the streams of water to effectively break up the oil sludge and sediment on the bottom and wash it to the tank suction. Stripping also drains the bottom of oil, water and washings which have drained down from the upper sections of the tank. Tankers may use a 6 to 10-foot drag to allow water to flow aft and a list to collect it around tank suction. When water builds up in a tank, the oil will float on the water's surface and leave a coating on the sides as the tank is pumped dry. This will lower the effectiveness of the machine washing and additional cleaning shall be required. The number of stripping pumps to be used will depend on their individual capacities and on the number of discharge rates of the tank washing machines in use. In addition, consideration shall be given to the loss in pump capacity due to scale accumulation in the strainers, the use of hot water and the condition of the pump. Cargo stripping pumps operate at 200 to 400 gallons per minute at 150 lb/in^2. To provide an efficient stripping operation, the following procedures shall be observed:

(a) Clean the strainers at regular intervals. This is an important factor in keeping the tank bottoms relatively dry, because it enables the stripping pumps to keep up easily with the wash water discharged through the machines. When a reduction in

be considered as cause for rejection of a projective lot. When a

the discharge rate is noted, the stripping pump vacuum gauges shall be checked. If a strainer has become clogged, the gauge will indicate an increase in the vacuum. By comparing this reading with normal vacuum when the strainers were known to be clean, clogging may be noted immediately.

(b) Lead a separate discharge hose from each stripping pump over the side or over the deck into a slop tank. This permits the officer-in-charge to watch the discharge flow. If a pump loses suction or reduces its discharge rate, it will be noticed immediately.

(c) When machine washing inside a harbor or within the 100-mile limit (see 5.2.5), it is advisable to use a center tank to accumulate the slop from the stripping pump and then discharge it ashore with a main cargo pump when a slop line or barge is available.

5.6.2.10 Pipeline cleaning. Simultaneously with the machine washing operation, the lines shall be cleaned by stripping each tank separately through both the main cargo and stripping suction. The main cargo lines shall be used for approximately 75 percent of the time and the stripping lines for the remainder. On completion of the routine machine washing, hot water shall be circulated through all main cargo and stripping lines and headers. This can be accomplished by pumping the hot water from the fire and tank washing line through a jumper hose to the hydrant valves on the deck drop lines to the main cargo and stripping lines. The water shall be circulated by using hose loops at the cargo headers until clean water is discharged. On completion of this circulation, the main cargo and stripping lines shall be stripped dry a second time. This will remove any remaining free oil while the temperature is high enough to loosen it. Drops, lines, manifolds, pumps and risers are usually flushed prior to and after machine washing.

5.6.2.11 Ventilation after machine washing. After machine washing, the tanks shall be ventilated by either forced or natural methods as described in 5.3. When tests indicate a safe condition for entry or personnel (see 5.2.3), the tank shall be inspected to determine the success of the machine washing and the extent of followup necessary to complete the cleaning. Followup measures include additional routine washing, spot washing, hand hosing and mucking.

5.6.3 Mucking. Mucking consists of removing scale sediments and sludge accumulated on the tank bottoms or internals prior to and during routine machine washing. Although the process appears to be simple, the time involved can be lengthy, depending on the condition of the tanks. Required steps will help prevent the regeneration of vapors (after a tank has been gas-freed), reduce bottom corrosion, cut down cargo loss, reduce the time needed for stripping (in conjunction with the discharge of cargo) and facilitate future gas-freeing. Before the mucking operation, the tanks shall be ventilated until the combustible gas indicator reads 0.1 percent or less.

5.6.3.1 Procedure for mucking. Mucking is generally accomplished by scraping, sweeping and then shoveling the scale, sediment and sludge into buckets for disposal. When available, eductors and large capacity vacuum pumps are sometimes used to remove the bulk of the waste material more rapidly as follows:

(a) In a black oil ship, bottom accumulations consisting largely of oil residues and salt water mixed with sediment and scale, are usually the major problem. Bottom accumulations often contain substances which promote corrosion and shall be removed, especially on tankers carrying sour crude oil or fuel oil derived from sour crude oil. If sludge has accumulated to any extent and formed a mud-like mass, mucking shall be supplemented by manually washing the accumulations to the tank suction by using hot pressurized water and operating a stripping pump continuously to remove the wash water.

(b) In a clean oil ship, the major problem is scale which contains volatile liquids from which flammable or explosive vapors could generate. Scale generally accumulates in the upper parts of the tanks. The heat and pressure of the routine machine wash will remove most of these volatile liquids from the surface scale, but not necessarily from beneath the scale blisters which remain after the wash is completed. A gas-free tank may return to a gaseous condition when the volatile liquids under the scale seep out. Heat from the sun or other sources will hasten a return to the gaseous condition, therefore, these blisters shall be removed by scraping during this phase of the cleaning operation.

(c) Scale, sediment and sludge, inpregnated with gasoline and volatile organic lead compounds, constitute a serious fire and toxic hazard. Therefore, whether scraped or accumulated on tank bottoms, these deposits shall be removed entirely. A high rate of ventilation shall be maintained and proper precautions taken to avoid lead poisoning during the removal of these accumulations. The scale, sediment and sludge are usually removed to the deck by means of a bucket, block and tackle (see 5.2.5).

5.6.3.2 Mucking equipment. The amount of equipment required will vary according to the size of the working crew and the condition of the tanks. Equipment shall be made of sparkproof materials and shall consist of the following:

(a) Eight vaporproof extension lights.
(b) Eighteen whisk brooms.
(c) Six corn brooms.
(d) Twelve scoops or small shovels.
(e) Twelve hand scrapers.
(f) Six long-handled scrapers.
(g) Six 3- to 5-gallon buckets.
(h) Block and tackle equipment as required.
(i) Several bales of lint-free wiping rags.

5.6.3.3 Omission of mucking. When possible, a mucking process should follow a machine washing. In some instances when gas-freeing for tank inspection or minor repairs, mucking can be omitted, provided there is continuous ventilation and no chance for gases to be regenerated.

5.6.4 Spot washing. Spot washing is a more precise application of routine machine washing and is used when the routine washing is inadequate or when the cleaning is difficult or inaccessible. Contaminated areas revealed during the postmachine wash inspection or uncovered during the mucking procedure can be cleaned by positioning the machines to provide a more direct impingement of the wash water. The additional time and effort spent on mucking and spot washing can be the key to a successful tank cleaning operation.

5.6.4.1 Organization of personnel. As in routine machine washing, the success of a spot washing operation depends on personnel performance. A watch section, as used for routine machine washing (see 5.6.2.2), should be sufficient to perform this operation. The personnel concerned shall be informed of additional instructions on the rigging of the machines inside the tank and the expected results from further cleaning.

5.6.4.2 Standard equipment and material. The routine machine washing equipment and material can be used when two machines are used for the spot washing operation. In addition, C-clamps (or blocks) and line shall be available for rigging the machines inside the tank.

5.6.4.3 Preparatory operations. Preparatory flushing, tank stripping and pipeline circulation requirements shall be effected (see 5.6.1) if the spot washing has not been preceded by a routine machine washing.

5.6.4.4 Schedule. After the gas-free state has been attained, each tank shall be inspected and a pattern developed for the additional tank cleaning required. A method for this is to divide each tank into areas and outline the washes required to remove the remaining contamination from areas not previously reached by routine machine washing.

5.6.4.5 Procedure for spot washing. The tank washing machines shall be rigged in accordance with a formulated drop schedule and spot washing shall be as follows:

(a) Rig the machines with C-clamps or blocks. A machine may be lashed in an exact position to get behind vertical and horizontal obstructions such as web stiffeners, web frames, girders, longitudinals and pipelines. If a section of the tank is unclean, because of its distance from the deck openings, the machines may be rigged by the use of clamps and guy wires to cover these areas properly.

(b) Set up a drop schedule. The number and duration of the drops will depend on the location of the contaminated area and the extent of cleaning required. The machine shall be operated at the lowest level (a few feet above the bottom longitudinals) for 30 minutes to break up bottom sediment and accumulations, permit better drainage of washings from higher levels and preheat the upper part of the tank. If possible, the progressive drops shall begin at the after section of a tank because the water in this section tends to build up first, thus reducing the washing effect on the bottom tanks. Then, as in routine machine washing, progressive 30-minute drops at 10, 20 and 30 feet shall be made (see 5.6.2.6). This drop schedule is

usually sufficient to clean the tanks. However, areas below the waterline, especially on the skin longitudinals, may be difficult to clean. This is partly due to the cooling effect of the water in which the tanker floats. When the cleaning of these areas is unsatisfactory, it may be necessary to wash them again until the residue is removed. To locate a machine advantageously, the officer-in-charge shall be familiarized with the interior structures of the tanks.

(c) The tanks shall be stripped as described in 5.6.2.9.

(d) Piping, valves and pumps shall be cleaned as outlined for routine washing and flushed with hot water after the washing.

(e) Although the tanks have been ventilated in conjunction with the routine machine washing, they should be reventilated after the spot washing is completed because the hot water from the machines heats oil remaining in the tanks, thus regenerating gases.

(f) The mucking operation, which should be undertaken upon completion of spot washing, follows closely the procedure used after a routine machine washing operation; however, a greater degree of cleanliness is required (see 5.6.3).

(g) Frequent inspections of temperature and pressures, depth and duration of drops, operation of the machines, and the stripping pump operation shall be made.

5.6.5 Hand hosing. Hand hosing may be used to spot wash when machines are not available or as an aid to the mucking process. A standard 1.5-inch hose with a rubber nozzle can be used. Usually, a water pressure of 100 lb/in^2 at a temperature of 125°F (52°C) is acceptable. Pressure and temperature shall be governed by conditions prevailing in each case, especially with regard to the safety of the tank cleaning personnel. Personnel shall not enter a tank for hand hosing if it adjoins a tank being hot machine washed or if the hazardous vapor content of the tank exceeds 0.1 percent on the combustible gas indicator (see 5.2.3). Personnel engaged in hand hosing a tank should not stand on frames or pipelines; they should stand on the bottom, a platform or wherever stable footing is available.

5.6.5.1 Cleaning the tank bottom. The cleaning of the tank bottom is similar to the cleaning of a dirty sidewalk or cement floor. Some of the particles of dirt will remain after the areas have been scraped and swept. For a thorough cleaning, a hose shall be used to wash away the mud of the fine granulated scale and sweepings. The mucking crew does the preliminary work of scraping and sweeping, but personnel doing the hand hosing shall ensure that loosened particles of scale are removed. The process shall continue, alternating between mucking and hand hosing, until the tank bottom is sufficiently clean. If an oil solvent, such as diesel oil, has been sprayed on areas to loosen scale during mucking, the solvent shall be removed during hand hosing.

5.6.5.2 Washing the tank bottom. When washing bottoms, workers shall begin at the forward end of a tank, to allow all sediment to wash toward the stripping suction. To continuously remove the wash water and sediment from the bottom, a stripping pump shall operate during the entire manual hosing or washing. When the tank bottoms are clean, the wash shall continue to flush out the cargo stripping line. When the bottom accumulations are heavy, usually

from viscous cargoes, it may be advisable to hand hose before mucking so that part of the scale and sediment is removed with the wash water. However, since scale increases the wear and tear on pumps, manual removal (if time permits) is recommended.

5.6.6 Chemical cleaning. Various chemical agents can be used to assist in the tank cleaning process and are applicable for difficult cleaning assignments, such as required for an upgrading in cargo or spot washing. As there are various methods of using these chemicals, determination of the suitable method shall be governed by the type of cleaning required, equipment available and time allotted. For example, the use of cleaning compound in accordance with MIL-C-22230 shall be restricted to black oil tanks (see 5.6.6.1). Regardless of the method used, a thorough final rinse shall be applied to the tank to prevent contamination of the product. Personnel shall be thoroughly briefed in the safe handling of chemical solvents or emulsifiers to be used.

5.6.6.1 Machine washing with chemicals. This method of chemical cleaning is used most effectively when a fast upgrading is necessary and especially when the allotted time for the conversion does not permit the loading of an interim higher grade product. However, this particular process shall be restricted to conversions from a fine to a finer product since the amount of chemicals required for a conversion from a black to a clean product would usually be uneconomical. Machine chemical cleaning consists of a cycle in which a preheated chemical solution (instead of plain, hot salt water) is pumped to the tank washing machines. A permanent system (see figure 21) may be installed; however, a cargo tank, peak tank or cofferdam is normally used as a mixing tank (see 5.6.6.1(d)) and the solution is returned to the mixing tank for reuse. An additional booster pump and heat exchanger may be installed to help alleviate the burden on the tank washing pump and heater. The same personnel can be used as in a routine machine washing operation (see 5.6.2.2), except that two additional personnel are required for handling equipment in each section when machine washing is also in progress in another tank. Personnel shall be thoroughly briefed in the safe handling, mixing and storage of chemicals.

(a) Necessary equipment. The standard and special equipment and the amount of chemical required for this type of cleaning will vary with the number of machines in use, the extent of cleaning required, and the piping arrangement for each class of ship. Important equipment shall include the following:

(1) Four tank washing machines with adapters and spare-part kits. (U.S. Naval ships have three machines.)
(2) A minimum of 10 lengths of tank washing hose.
(3) Five 2.5-inch bronze or brass double-hose couplings.
(4) Four hosesaddles or quadrants.
(5) At least four portable air-driven or steam-driven blowers or other means of ventilation.
(6) Sparkproof tools for making connections.
(7) Special equipment, such as an additional pump and heat exchanger (if necessary) and jumper hoses or connections for routing the chemical lines.
(8) Chemicals, such as cleaning compound in accordance with MIL-C-22230 and other approved chemicals.
(9) Relief valves, pressure gauges and thermometers.

(b) Supply lines. The installation of temporary chemical lines or a booster pump and heat exchanger (if used) will depend on the ship's piping and pumping arrangements, the purpose of the cleaning, and the possibility of water washing being performed simultaneously. Basically, the 4-inch fire and tank washing line or the heating coil main can be connected to the after port main cargo header and the port main cargo pump used for delivering the solution. When connecting to the fire and tank washing line, a section forward of the after pumproom is removed and the after flange blanked off, then 4-inch hoses are installed to connect the cargo header to the fire and tank washing line. When upgrading, the heating coil main is particularly useful as a supply line, since the coils in each tank are normally removed during this operation. In this case, the coils are allowed to remain in one tank or, more conveniently, in two wing tanks (usually number 9 wing tanks) for heating the solution. One main coil line section forward of the tanks is removed. After the tank coil connection is blanked off, a jumper line is used to connect the cargo header to the main coil line and 2.5-inch tees and 2.5-inch, 300 lb/in^2 hose valves are installed in the main line. An alternate supply uses the fire and tank washing pump and heater by a hose connection between the cargo main and the pump suction or by a connection between the pump suction and the after peak tank. Regardless of the arrangement, the supply line shall be flushed before the operation and regularly during the operation. In addition, the solution shall not be overheated since solids may form. Situations vary, but the temperature usually shall be not higher than 170°F (77°C).

(c) Additional supply pump. To relieve the operational load on the tank washing or cargo pump, install a booster pump. If the pump is used to augment the tank washing pump, remove an aftersection of the fire and tank washing line to allow for a loop connection to the booster pump suction and from the booster pump discharge back to the line. If used to augment the cargo pump, make connections from the cargo header to the fire and tank washing line or the heating coil main, whichever is being used. If chemical and machine water washing are to be performed simultaneously, a booster pump may be installed for each system (for example, one for the fire and tank washing line and one for the heat coil main). In conjunction with the booster pump, a portable heat exchanger may also be installed.

(d) Reuse of the chemical solution. For subsequent use of the chemical solution, connections shall be made from the stripping pump discharge line on deck or the mixing tanks. The following method may serve as a guide:

(1) Connect the 4-inch steam stripper discharge with the 6-inch fuel oil transfer line on the after deck, using the regular crossover and spectacle flange (if installed), or install a 4-inch gate valve to make the connnection. When the vessel lacks the means of making such a crossover, the same purpose may be accomplished by making a loop connection amidship between the bunker header on the port

or starboard side and the starboard 12-inch main cargo header. This is possible only when the 4-inch steam stripper discharge leads into this main cargo header.

(2) Connect two 4-inch hoses from the port and starboard after bunker-line headers and lead them through the deck openings into the number 9 port and starboard wing tanks.

(3) Before using as a chemical return line, flush the fuel oil transfer line with hot water. Install blank flanges in the filling lines to avoid contamination of the bunker tanks.

(e) Testing the system. When completely lined up, the system (including the pumps) shall be hydrostatically tested.

(f) Procedure. The chemical solution shall be mixed in a clean tank according to instructions for the chemical being used (see 5.6.6.1(d)). For example, when using cleaning compound in accordance with MIL-C-22230 (55-gallon drum), mix 2 gallons of the chemical with each 1000 gallons of water and heat to 140 to 160°F (60 to 71°C). If a lower temperature (100°F (38°C)) is necessary because of a nearby hazard, such as an adjacent magazine, mix 1 gallon of the chemical with each 100 gallons of water to provide a stronger solution. After preparatory water washing and thorough stripping, the cleaning shall proceed as for routine machine washing (see 5.6.3). Cleaning shall be followed by a complete pipeline flushing, hand hosing and rinsing.

(g) Additional cleaning. Difficult cleaning may require spotting the tank washing machines or applying the chemical solution with hand hoses. Care shall be taken to avoid possible skin irritation from the chemical solution.

5.6.6.2 Chemical spot washing with portable units. Chemical spot washing can effectively be accomplished using commercially available portable units, which basically consist of a drum (55-gallon), pump, hose and hand lance. These easily assembled units deliver a high-velocity jet stream that penetrates difficult and remote cleaning areas. Normally, depending on the model, a hydraulic jet unit (see figure 22) or an air-motor-driven pump (see figure 23) delivers the chemical solution from the drum to the hand lance. For better velocity control, lance spray tips of different orifice size are available. After application, a short soak is recommended.

5.6.6.3 Brush application of chemicals. When the spot washing is not extensive, the chemical mixture can be applied by brush (paint, scrub). In this case, the solution is mixed in a drum and then transferred to a bucket for convenient handling. Care shall be taken to avoid possible skin irritation from the chemical solution.

5.6.6.4 Chemical cleaning by the ballast and soak method. The ballast and soak method consists of ballasting, adding chemicals and soaking. It shall be restricted to black oil tanks and shall be further restricted to small tanks, bilges and large tank bottoms. As with all tank cleaning procedures, the operation shall begin with a complete flushing and testing of the piping, flushing of the tank, stripping and mucking (as circumstances permit). The tank shall be ballasted with sea water and heated for 12 hours

or to a maximum temperature of 160°F (71°C). Normally, the temperature of a flooded tank will not exceed 100°F (38°C) because of heat loss. The ballast shall then be pumped overboard, if permissible (see 5.2.5), and the tank stripped. (This step can be omitted when discharge of the ballast is not feasible.) The cleaning compound shall then be introduced and the tank reflooded. The ballast shall be heated as high as the nature of adjacent spaces will permit (see 5.6.8.1(c)), and this temperature shall be maintained for 36 hours. When rolling is anticipated, the tank shall be filled to 80 percent capacity; and at dockside, it shall be filled to full capacity. If the ship's movement is not producing enough agitation of the solution, steam or compressed air may be introduced. The tank shall be vented. After soaking, the tank shall be emptied, stripped, and the process repeated using one-half the initial concentration of the chemical. The heat shall be maintained for 24 hours; then, the tank shall be emptied, flushed several times (including piping), stripped, machine washed or hand hosed with cold salt water, mucked and inspected.

5.6.6.5 Mixing the chemicals. The chemical (see 5.6.6.1(a)(8)) shall be introduced into the tank through the sounding tube or manhole. When using cleaning compound in accordance with MIL-C-22230, 2 gallons of chemical for each 1000 gallons of tank capacity shall be used. This concentration shall be increased for difficult cleaning.

5.6.7 Bottom flush and line circulation with solvent. Upon completion of a chemical cleaning, the bottoms and associated piping of a tank can be flushed with a petroleum product which is lower in quality than, but similar to, the intended cargo. The flushing agent will act as a solvent and will effectively remove any remaining contaminants which may otherwise be picked up by the next cargo. The solvent can normally be reclaimed or reused as a flushing agent and shall therefore be pumped to the settling tank rather than disposed.

5.6.7.1 Procedure. Two 1000-barrel lots of high flashpoint petroleum solvent (such as diesel oil), which have been designated as first and second washes, shall be loaded into separate tanks on the tanker. The first wash shall be pumped from tank to tank throughout the ship, using both the main cargo and stripping lines, so that practically all the 1000-barrel lot is loaded into and discharged from each cargo tank. Upon completion of the first wash, the second wash shall be started, following the same pattern. To obtain the best results from the solvent washes, it is recommended that a main cargo pump be used along with two stripping pumps. One stripper shall be used to pull off the vapors from the tip casing of the main cargo pump to permit it to maintain a suction under lift. The other shall be used to strip each tank dry, removing excess water which will prevent action of the solvent. A main cargo pump shall be used to expedite the transfer of the solvent between the tanks.

5.6.7.2 System lineup. To perform the bottom wash effectively, the following shall be carefully observed:

(a) The glands on the main cargo pump shall be tight to maintain a good suction.
(b) The main pump shall be operated at a moderate speed to maintain a good suction.

(c) The adjacent stripper shall be hooked up to take a suction from the top of the main cargo pump casing and discharge into the discharge header amidship.

(d) A 12-inch valve on the discharge line aft of the amidship headers shall be closed sufficiently to build up a head of 75 lb/in^2 on the discharge line.

(e) Upon completion of each solvent wash, the solvent shall be circulated through the main cargo lines, stripping lines and all main cargo and stripping pumps at the full capacity of the main cargo pumps.

5.6.8 Steaming and manual washing. Steaming and manual washing to clean a tank shall be used only when other means are not available. Since introducing live steam into a gaseous tank may create an electrical charge, an explosion hazard is present. In addition, there are other serious disadvantages. Specifically, the safety of the ship is endangered by thermal strains on the hull and greater quantities of gases which are discharged on deck. Also, steaming increases the burden on the boilers and reduces the average speed of steam ships.

5.6.8.1 Operational precautions. To ensure that the tanks are heated gradually and pressure does not become excessive, the following precautions shall be taken:

(a) Excessive pressures. To avoid building up excessive pressures, the ullage hole covers shall be weighted but unpinned. Hatch dogs shall be engaged; however, if ullage hole covers are not weighted, they shall be pinned and the hatch dogs disengaged. If equipped with a vent system, the valves in the vent lines shall be opened to provide an unobstructed vent to the atmosphere.

(b) Danger of hand hosing. Tanks shall not be manually washed by a hose from the deck unless the vapor content of the tanks is 0.1 percent or less as shown by the combustible gas indicator (see 5.2.2.3). Free fall of the water through the vapor space might produce static discharge and cause an explosion.

(c) Overheating adjacent compartments. Tanks adjacent to paint lockers or other tanks containing low flashpoint liquids shall be steamed carefully. Temperatures in surrounding compartments shall be frequently checked. The temperatures of tanks containing gasoline or similar low flash point liquids shall not be raised above 125°F (52°C) or within 20°F of the flashpoint of the liquid, whichever is lower. Tanks adjacent to magazines containing ammunition shall not be steamed.

(d) Overheating liquidometer systems. On ships fitted with distant reading liquidometer gauges, the temperature in the tanks shall be limited to 180°F (82°C); otherwise, the lines to the gauges shall be disconnected. The gauges have been compensated by the manufacturer for expansion of the liquid in the closed hydraulic circuit for temperatures up to, but not exceeding 230°F (110°C). The hydraulic system shall not be exposed to temperatures above 180°F (82°C).

(e) Personnel working in adjoining tanks. When personnel are working in tanks, steaming shall be prohibited in adjacent tanks. In the case of nonadjacent tanks interconnected by piping, the valves on the interconnecting pipelines shall be tightly shut and tagged "Keep Valve Closed: Personnel Working in Tanks."

5.6.8.2 Procedure. Procedure for steaming and manual washing shall be as follows:

(a) Ventilate the tank thoroughly; then, perform preparatory testing and flushing requirements.
(b) Close and dog the tank tops; close the ullage plugs, but do not dog them.
(c) Open the vent manifold valves to the tanks to be steamed.
(d) Begin steaming the tank; gradually raise the temperature over a period of 6 to 12 hours, depending on tank condition.
(e) After steaming, open the tank tops and ventilate them (see 5.3) until the gas indicator reads 0.1 percent or less (see 3.5 and 3.6).
(f) Begin manual washing with a hose from the deck. Wash all accessible surfaces using as high a pressure and volume as possible. However, during this, keep in mind weather conditions and personnel safety. For best results, wash water temperature should be 125°F (52°C).
(g) On completion of the manual hosing from the deck, continue ventilation until the tanks have cooled sufficiently for personnel to enter.
(h) Test the tanks again with a gas indicator. A reading of 0.1 percent or less is required prior to personnel entering the tanks. If, after ventilating, the gas indicator reads in excess of 0.1 percent, additional ventilating, steaming or hosing may be necessary.
(i) With hot water, hand hose all accessible surfaces from the ladder platform and then the lower sections of the tank from the bottoms concentrating on areas under the skin longitudinals and on horizontal surfaces which are covered with oil, residue or sediment.
(j) Keep a stripping pump operating during all washes to provide continuous removal of wash water, oil and sediment.
(k) Muck out the bottoms of the tanks as required for routine machine washing (see 5.6.3).

5.6.9 Gas-freeing spaces other than main cargo tanks. Often in a shipyard, while the main cargo tanks have been properly cleaned and gas-freed, other tanks or spaces such as deep tanks, cofferdams, double bottoms or pumproom bilges have been overlooked. In such cases, the ship is usually subject to costly delays while these spaces are gas-freed.

5.6.9.1 Fore and after peaks and double bottoms. These tanks usually carry fresh water and seldom contain toxic gases. They are, however, often closed for long periods of time during which oxidation of the iron depletes the supply of oxygen. Since there is no odor or visible means of detecting such a condition, no one should enter such a tank until it has been properly

ventilated and tested for oxygen content (see 5.5.11). But, if there is any possibility of toxic gases remaining (see 5.2.3.5), a gas indicator shall be used. If the tanks contain water, they shall be pumped dry and then thoroughly ventilated. If forced air ventilation is not available, a stream of cold water shall be played against the sides within the tanks to clear the atmosphere in the tank.

5.6.9.2 Bunker tanks and deep tanks. Bunker tanks and deep tanks, which are normally used as reserve bunker spaces, shall require the same treatment for cleaning and gas-freeing as main cargo tanks. This includes testing and flushing, a thorough hot water washing, mucking, hand hosing and pipeline cleaning. If the deep tanks are used as water tanks, the same procedure as described in 5.6.9.1 shall be followed.

5.6.9.3 Cofferdams. Cofferdams which adjoin main cargo or bunker tanks are often a source of trouble, especially when the bulkheads leak. The following methods for gas-freeing cofferdams shall apply:

(a) Gas-freeing cofferdams with tight bulkheads. When the cofferdam bulkheads are tight, permitting no leakage from adjoining tanks into the cofferdams, the following steps shall be required:

(1) Vent off tank pressure, if necessary.
(2) Open the tank tops.
(3) Flush the steam-smothering lines as outlined in 5.6.1.2(b).
(4) Pump all water from the bottoms.
(5) Ventilate.
(6) Test with a combustible gas indicator (see 5.2.3) and leave the tank tops open to permit continuous airing.

(b) Gas-freeing cofferdams with leaking bulkheads. When the cofferdam bulkheads leak, allowing oil from the main cargo or bunker tanks to enter the cofferdams, the following steps shall be required:

(1) Vent off tank pressure, if necessary.
(2) Open the tank tops.
(3) Flush the steam-smothering lines.
(4) Pump the tank dry.
(5) Wash down the cofferdams with hot water from the deck. At the same time pump it out through the cofferdam suction, removing as much oil as possible.
(6) Ventilate until it is safe for personnel (see 3.5 and 3.6).
(7) Send personnel down into the cofferdams to remove sludge and sediment from the bottoms. Maintain ventilation at all times while personnel are in the cofferdams.
(8) Test again with a combustible gas indicator (see 5.2.3); leave the tank tops open to permit continuous airing.

5.6.9.4 Pumproom bilges. Leaky pump glands, valves and loose connections often result in accumulations of oil and heavy waste matter in pumproom bilges. This condition is further compounded because much of the bilge space is inaccessible due to piping and equipment foundations. Nonetheless, these spaces shall be as clean and gas-free as the cargo tanks. The bilge cleaning process consists

of flushing, reflushing, mucking and hand wiping while maintaining continuous ventilation. The use of standard cleaning compound in accordance with MIL-C-22230 (see 5.6.6.1) will materially assist in this process. If such chemical agents are used, the mixture of oil, water and chemical shall be agitated to create as much turbulence as possible so that all hidden and obscure pockets of oil may be completely emulsified. As in cleaning other spaces, a gas indicator shall be checked to ensure a gas-free condition is the final step (see 3.5 and 3.6).

5.7 Tank testing. When a tank or compartment is to be opened for inspection, repair or maintenance, tests shall first be conducted to ensure the complete safety of these areas. The danger to personnel may involve toxic gases, oxygen deficiency or highly explosive gas mixtures. An examination shall be conducted for all conditions within the tank where gas regeneration might occur.

5.7.1 Gas-free engineer. Aboard each ship, an officer who is knowledgeable in the use of the gas indicators and the procedure required to achieve a gas-free condition (see 3.2) shall be designated the gas-free engineer. The gas-free engineer shall be certified and be responsible for declaring a tank gas-free before personnel are permitted inside, organizing a program to educate the personnel in safety precautions, and notifying the commanding officer or other responsible authority of any conditions which may endanger the crew or work effort.

5.7.2 Testing procedures. Testing shall be first conducted in the tanks where the safety of personnel is involved or where hot work may be performed, and then in all adjacent areas. Before any testing, the tanks shall be thoroughly ventilated (see 5.3). The testing shall be conducted first for explosive gases, then for toxic gases, and finally for any oxygen deficiency. A change in sequence or an omission of any one of the following tests could result in disaster:

(a) The initial testing for explosive gases shall be conducted at the open hatch of the tank. Following the testing of the gases leaving the tank, the sampling hose shall be lowered in stages, and tests shall be conducted at the various levels. The final sampling and test of the atmosphere shall be made on the bottom of the tank. The hose shall be long enough for the operator to remain in the gas-free area and still sample the full depth of the tank. If the combustible gas indicator reads less than 0.1 percent, the space may be considered safe from toxic as well as explosive gases.

(b) Further tests of the entire bottom area shall then be conducted inside the tank. If the tank has been ventilated thoroughly and proper ventilation is maintained, a test for toxic gas will not be necessary. But, if the ship is equipped with an inert gas system, a test shall be made with a carbon monoxide indicator. Tests for explosive dangers shall be made throughout the tank with a combustible gas indicator. An inspection shall be made for oily sediments, scale blisters or other sources of gas regeneration. Tank cleanliness will determine the period of safety in the tank and the necessary frequency of testing. In any case, testing shall continue periodically. Oxygen in a tank may become

deficient, especially if hot work has been performed, and periodic tests with an oxygen indicator (see 5.5.11) as well as observance of proper ventilation shall be required.

(c) Areas adjacent to the tanks (cofferdams, adjacent tanks or open pipes connected to the tanks) shall be checked.

5.7.2.1 Unsafe areas. If tests indicate that an area is unsafe, all work shall be stopped immediately. However, in an emergency, when it is necessary to send personnel into a space not certified as gas-free or not containing sufficient oxygen, the personnel shall be equipped with an air-line mask and an attached safety line, which shall be tended by reliable personnel outside the tank (see 5.2.3).

5.7.3 Safety test certificate. Upon completion of the tests, the gas-free engineer or a representative will post a label or tag near the entrance of the space indicating its condition. A complete record showing the condition of each space tested and inspected shall be maintained (see figure 24). NAVSEA S9086-CH-STM-030/CH074V3 shall be consulted to determine the appropriate category of certification.

5.7.4 Contractor operations. The Navy (shipboard or land-based) gas-free engineer shall not certify spaces for contractor operations of their personnel, except under conditions of extreme emergency or endangerment of personnel and property. NAVSEA S9086-CH-STM-030/CH074V3 shall be consulted for gas-free certification when contractors are involved in maritime/nonmaritime confined space operations.

5.7.5 Calibration of testing instruments. Testing instruments, such as gas indicators, shall be frequently calibrated, carefully handled and properly stored to prolong their accuracy. Instruments suspected of inaccuracy shall be tagged as unsafe and removed from use. An accurate record of calibration shall be maintained by the person having cognizance of the gas indicators and the record shall be regularly examined by the damage control and cargo officers.

5.8 Guide for the preparation of cargo tanks. The approved tank cleaning procedures which shall be applied under stipulated conditions and requirements are described herein.

5.8.1 Inspections. To obtain acceptable standards of tank cleanliness, it may be necessary to repeat or prolong the prescribed procedures. For example, after machine washing a black oil tank, an inspection may indicate that a solvent flush (see 5.6.8) or a manual hosing (see 5.6.6) of the bottom is required to loosen adhering accumulations.

5.8.2 Coated tanks. The cargo tanks on some tanks on AO tankers are coated with epoxy coatings in accordance with MIL-P-24441 and are primarily used in transporting clean products. In emergencies, however, coated tanks may be assigned to lift black petroleum but shall require upgrading before carrying clean products. This upgrading is not too difficult, since the black oil is less likely to adhere to the smooth coated surfaces. U.S. Naval oilers do not have capability to carry black oil.

5.8.2.1 Gas-freeing coated tanks. The procedures and safety precautions outlined for cleaning and gas-freeing regular cargo tanks shall be followed, except that the water shall not normally exceed a temperature of 125°F (52°C) or a pressure of 150 lb/in^2. However, water up to 175°F (79°C) may be used when upgrading from a black to a clean product.

5.8.2.2 Cleaning coated tanks to carry clean product cargo after carrying black oils. To clean coated tanks for upgrading the cargo from a black to a clean product, the following procedures shall be observed:

(a) Discharge all black oil and strip tanks thoroughly. Drain all piping, pump casing, strainers, valves and manifolds to the maximum extend possible.
(b) Machine wash tanks at temperatures up to 175°F (79°C) and pressure not exceeding 150 lb/in^2. Strip tanks alternately through the stripping and cargo lines. Open crossover valves as necessary to ensure purging of entire piping system. Flush cargo vents. Gas-free and muck tanks, perform necessary repairs, and remove heating coils if tanks are to remain in clean product service.
(c) Hot water flush piping at high velocity and hot water clean tanks by machine washing. Hot flush entire piping system, flushing toward the tanks until assured that all piping components and dead ends have been purged. Use the stripping pump to drain tanks. Clean and muck tanks until inspection indicates adequate cleanliness for clean products cargo.
(d) Flush piping and tank bottom with diesel oil (using approximately 5,000 to 10,000 gallons), flushing to each tank in turn. Continue flushing until all lines are free of black oil residue or other contaminants. Repeat flushing if any residue is found. Strip tanks.
(e) Flush tanks and piping using machine wash procedure. Strip tanks.
(f) Rinse cargo lines and tank bottoms with clean F-76. Test the flushing F-76 as required to ensure cleanliness of system.
(g) Machine wash tank and flush piping to remove F-76. Strip tanks and drain piping.

5.8.2.3 Gas-freeing JP-5 tanks. Usually JP-5 tanks only need to be gas-freed with Coppus blowers which shall be operated without heaters before manual cleaning and with heaters after cleaning to dry the tanks. All AOs are equipped with Coppus blowers. Newer AO classes do not have heaters.

5.8.3 Procedures for special classes of tankers. On fast combat support ships (AOEs) and other replenishment ships, a water temperature below 100°F (38°C) shall be maintained during tank cleaning to prevent ammunition stored near the tanks from deteriorating. Tests indicate that sea water at a temperature of 100°F (38°C) and a pressure of 150 lb/in^2 can satisfactorily be used.

5.8.4 Solvent emulsifiers. Solvent emulsifiers, such as cleaning compound in accordance with MIL-C-22230 (see 5.6.6.1(a)(8)) are used only in cleaning uncoated black oil tanks. The cleaning of JP-5, gasoline, and diesel oil tanks with this chemical shall not be permitted. Chemical cleaning of coated tanks, regardless of product, shall not be authorized.

5.8.5 Critical contamination factors and possibilities. The contaminating effects of a preceding cargo upon a succeeding cargo are described in table I.

TABLE I. Critical contamination factors and possibilities.

Succeeding cargo	Preceding cargo and effect of contamination
Gasolines	- White or black diesel fuel, lube oil: As little as one-third of a barrel of any of these oils can contaminate 8000 barrels of gasoline by increasing gum content. - Dyed kerosene: Some commercial kerosenes may be dyed after loading. The dye power will adhere to bulkheads and impregnate the scale above the liquid level and thus impart a color to subsequent white products.
Kerosenes	- Gasoline: Small quantities will affect the flashpoint. - Black oils: Very small quantities will impart a color (see dyed kerosenes under gasolines).
Jet fuels: JP-4	- Diesel fuel: Small quantities will affect the freezing point. - Black oils: Since jet fuels are good solvents, small quantities of black oils will increase gum content. - Gasoline: Small quantities may affect the flashpoint and explosibility.
JP-5	- Black oils: Small quantities will precipitate sludge in JP-5 fuel; even minute traces of black oil will reduce the water-separating ability of JP-5. - Gasoline: Small quantities will affect the flashpoint and explosibility.
Diesel fuels	- Gasoline jet fuel and kerosene: Small quantities will affect the flashpoint. - Black oils: Small quantities of some black oils will precipitate sludge in diesel fuel; even minute traces of black oils will reduce the water-separating ability of diesel fuel.

TABLE I. Critical contamination factors and possibilities. - Continued

Succeeding cargo	Preceding cargo and effect of contamination
Boiler and burner oils	- Gasoline: Very small quantities will affect the flashpoint and explosibility.
Lubricating oils	- Special precautions are necessary in cleaning prior to loading bulk lubricating oils. Such cleaning should be accomplished under the supervision of the cognizant petroleum inspector in accordance with MIL-HDBK-200. For effect of contamination of lubricating oils see MIL-HDBK-200.

5.8.6 Chart for cargo tank cleaning. The chart for cargo tank cleaning (see figure 25) shall be a guide to the proper tank cleaning operations to be carried out between cargoes. It shall not, however, relieve the ship's officers of the responsibility of exercising good judgment or observing safety. The following conditions shall be observed while using the chart for cargo tank cleaning:

(a) Each cargo tank shall be proven gas-free (see 5.7.1) prior to the entry of personnel. Safety precautions concerning the personnel working in tanks and compartments shall be strictly enforced.

(b) To avoid delays at a loading port, all necessary cleaning of cargo tanks, pipelines, vent lines and heating coils shall be accomplished prior to arrival. Tank tops shall be ready to open for inspection. Only tankers with clean ballast shall be permitted in port, except those in black oil service.

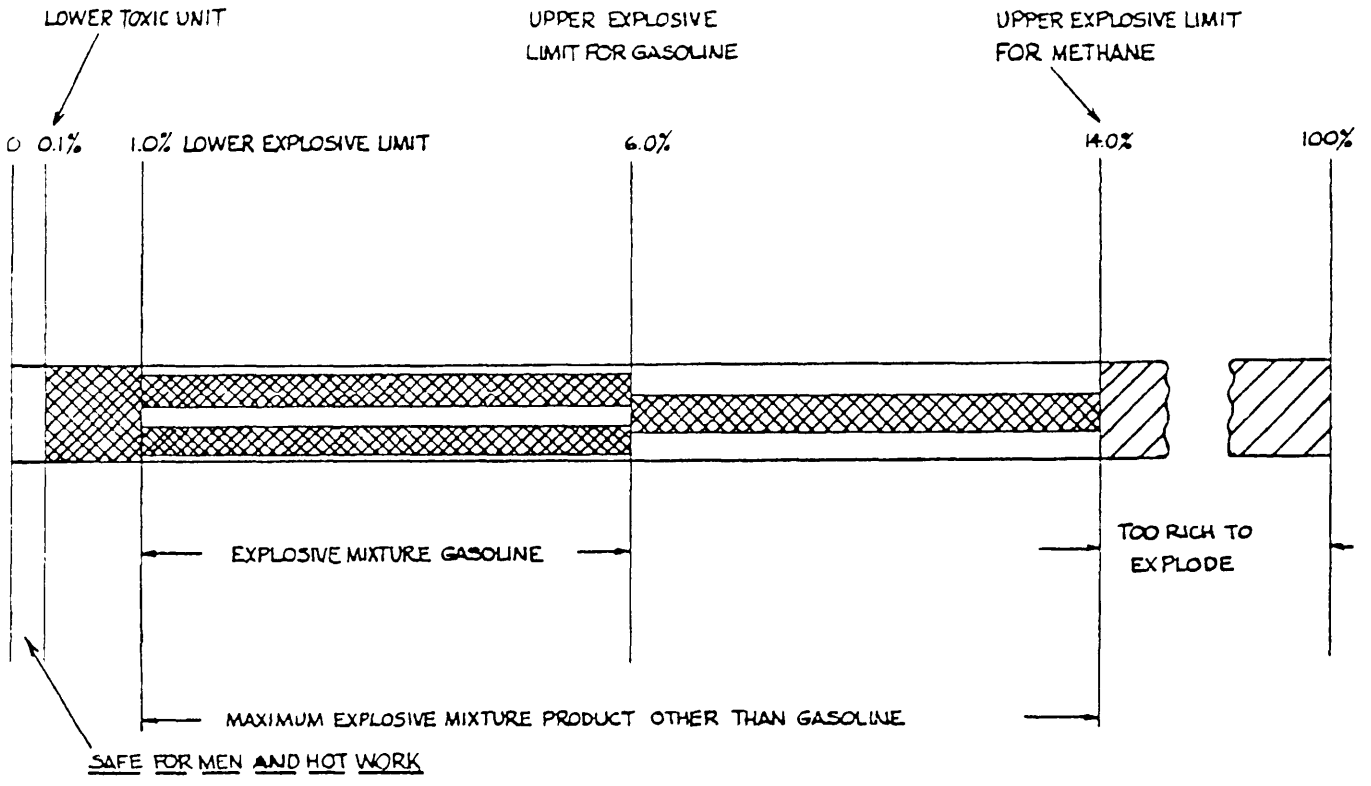
(c) During loading and discharging, tank cleaning or gas-freeing operations, officers shall investigate for leaks which may develop in bulkheads, pipelines, valves or heating coils. To avoid any delay, this information, which will directly affect the ship's cargo nominations and cargo segregation plans, shall be given immediately to the home office, as well as to military inspectors and oil company field representatives boarding the ship.

6. NOTES

6.1 Subject term (key word) listing.

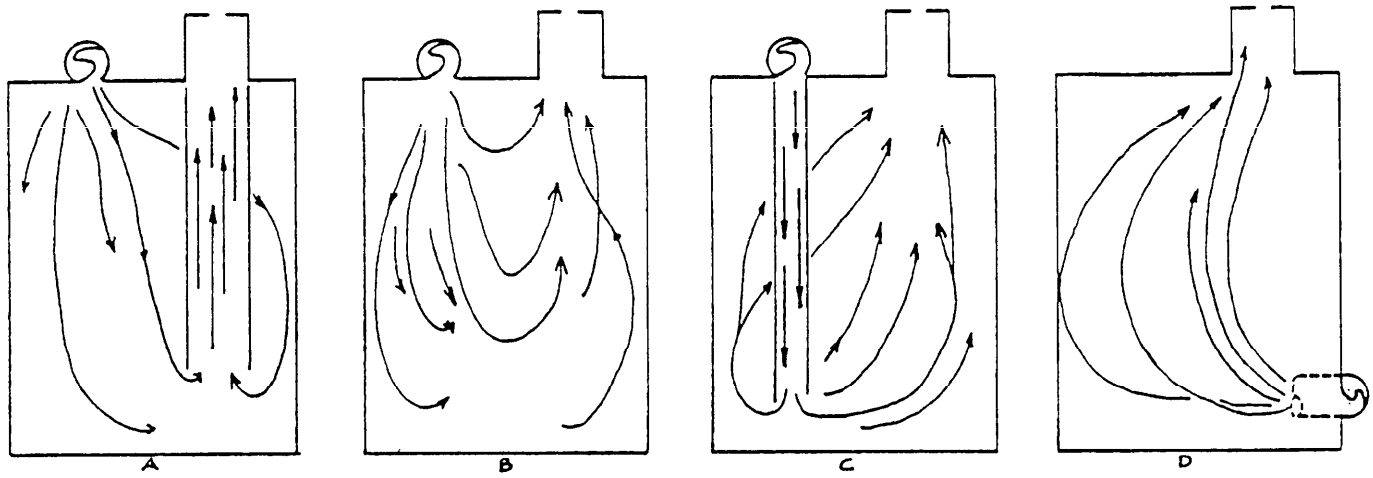
Cargo
Cleaning
Piping
Safety precautions
Tanks

Preparing activity:
Navy - SH
(Project 5430-N148)



SH 13091

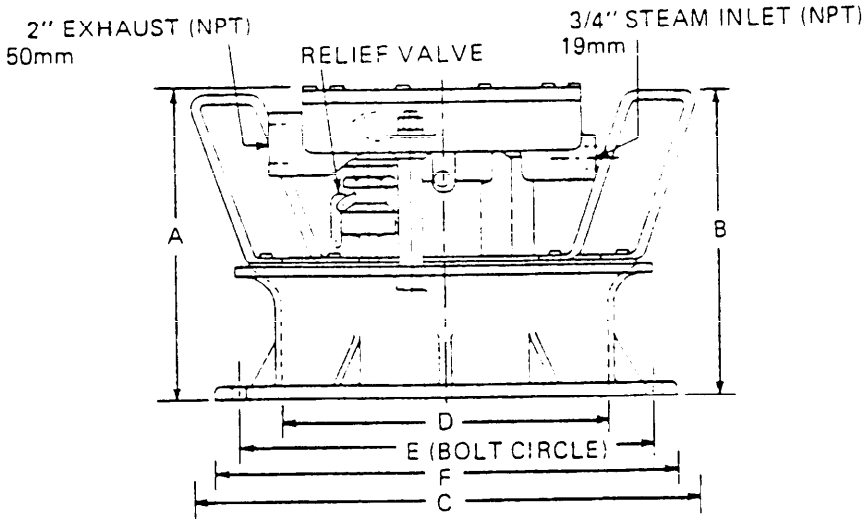
FIGURE 1. Maximum permissible content of petroleum vapors in air.



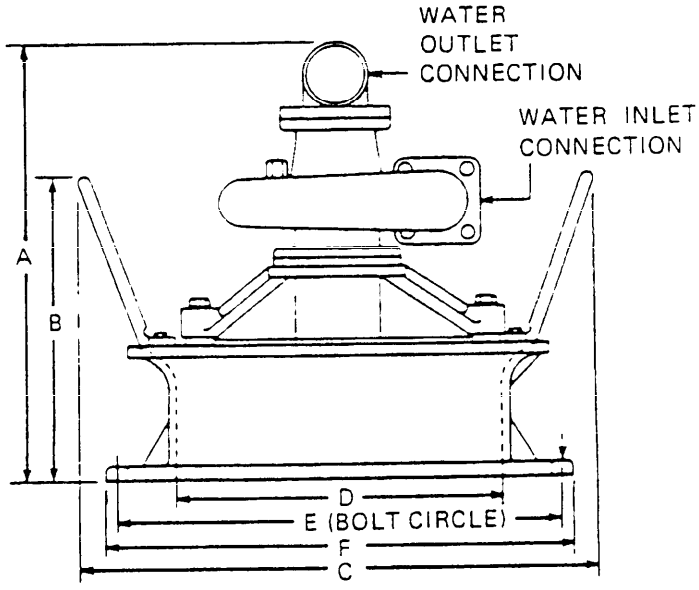
SH 13092

FIGURE 2. Ventilation techniques.

DIMENSIONS



Model	A	B	C	D	E	F	Bolt Slots		Net Wt.
							Size	No.	
C-12A	12.62" 321mm	14.25" 362mm	20.50" 521mm	12.50" 318mm	15.31" 390mm	16.81" 427mm	.93" 24mm	10	100 lbs. 45kg
C-15A	14.38" 366mm	14.25" 362mm	22.25" 565mm	15.25" 387mm	20.50" 521mm	21.50" 547mm	1.12" 29mm	8	120 lbs. 54 kg
C15AW	21.06" 535mm	14.25" 362mm	24.50" 622mm	15.25" 387mm	20.50" 521mm	21.50" 547mm	1.12" 29mm	8	120 lbs 54 kg



NOTE: Driver can be air or water or steam.

SH 13093

FIGURE 3. Coppus blower.

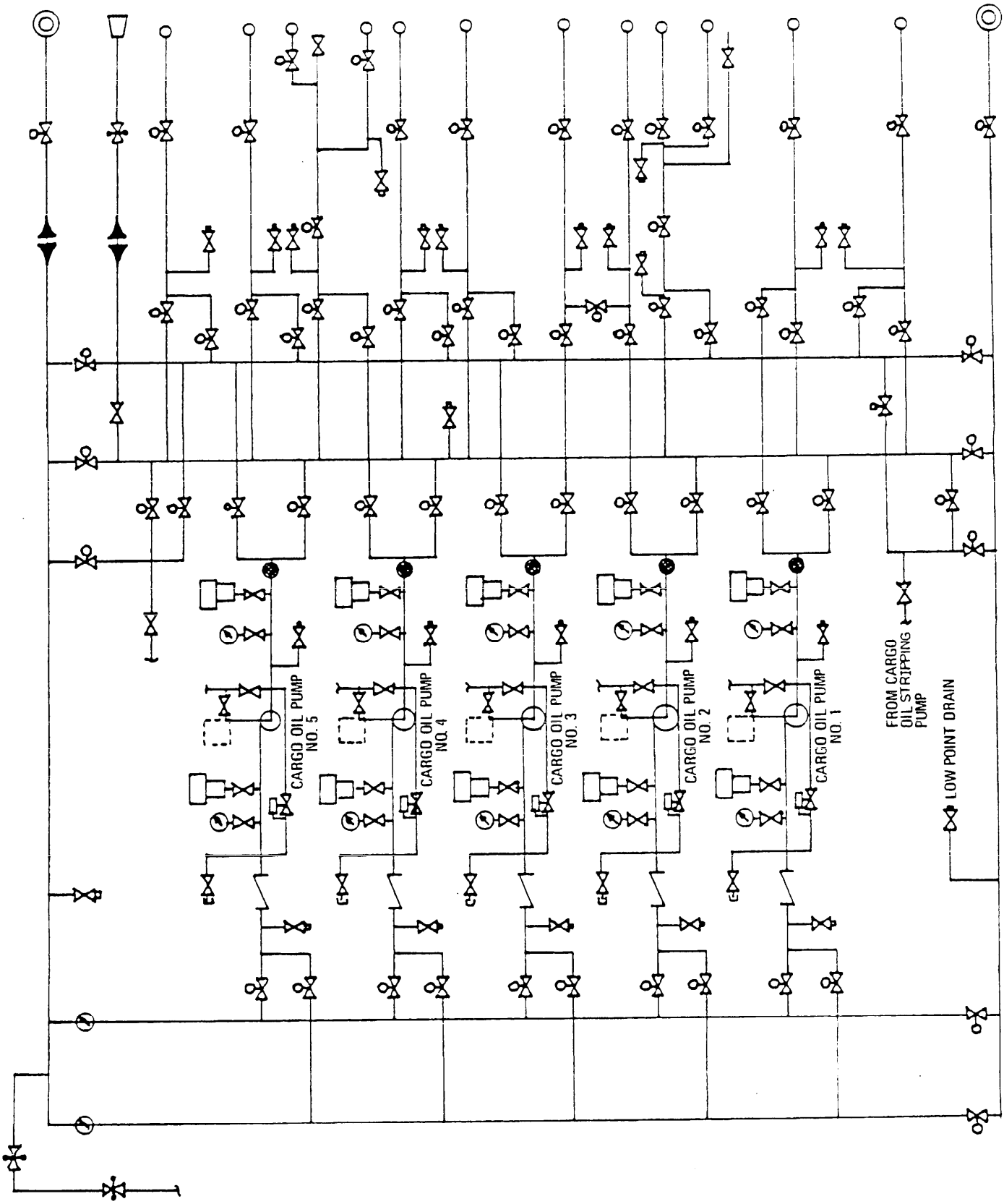


FIGURE 4. Typical F-76 pump room piping.

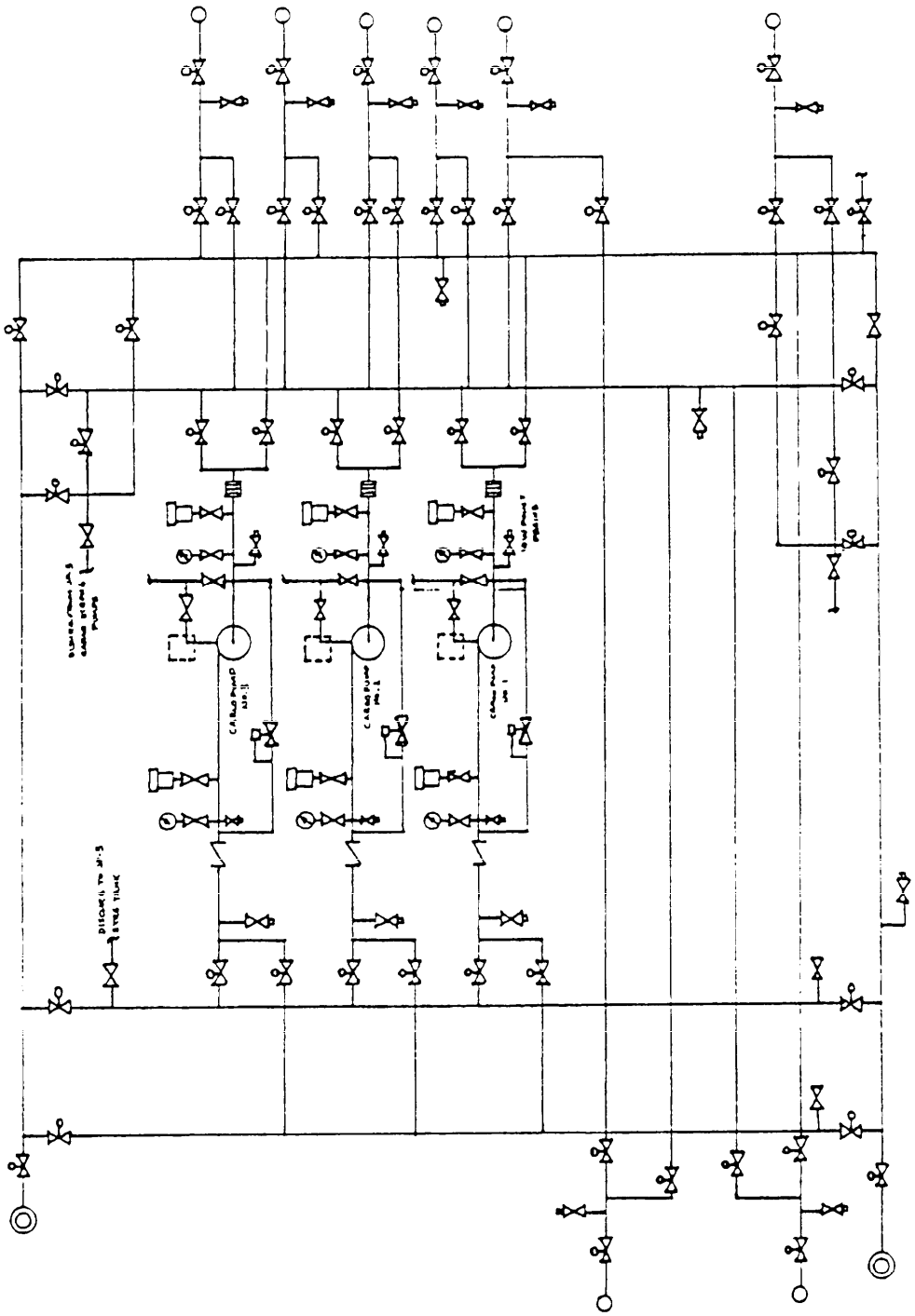
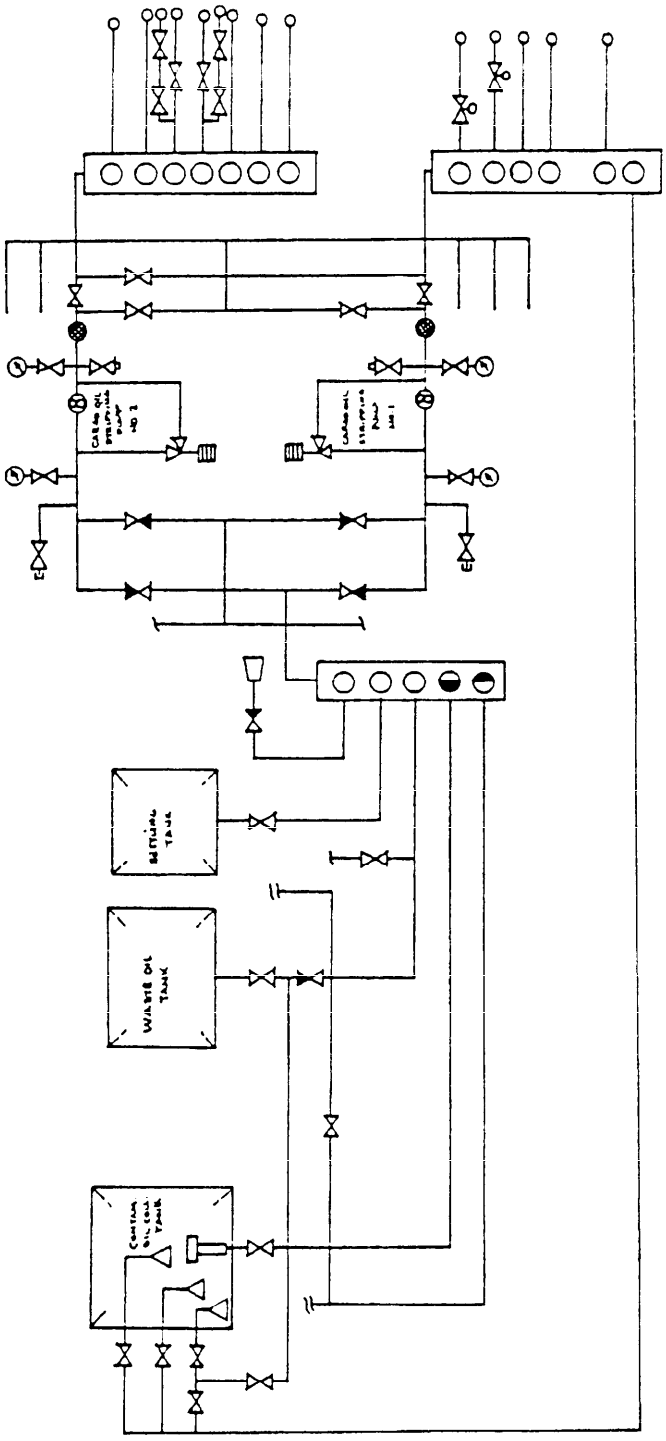


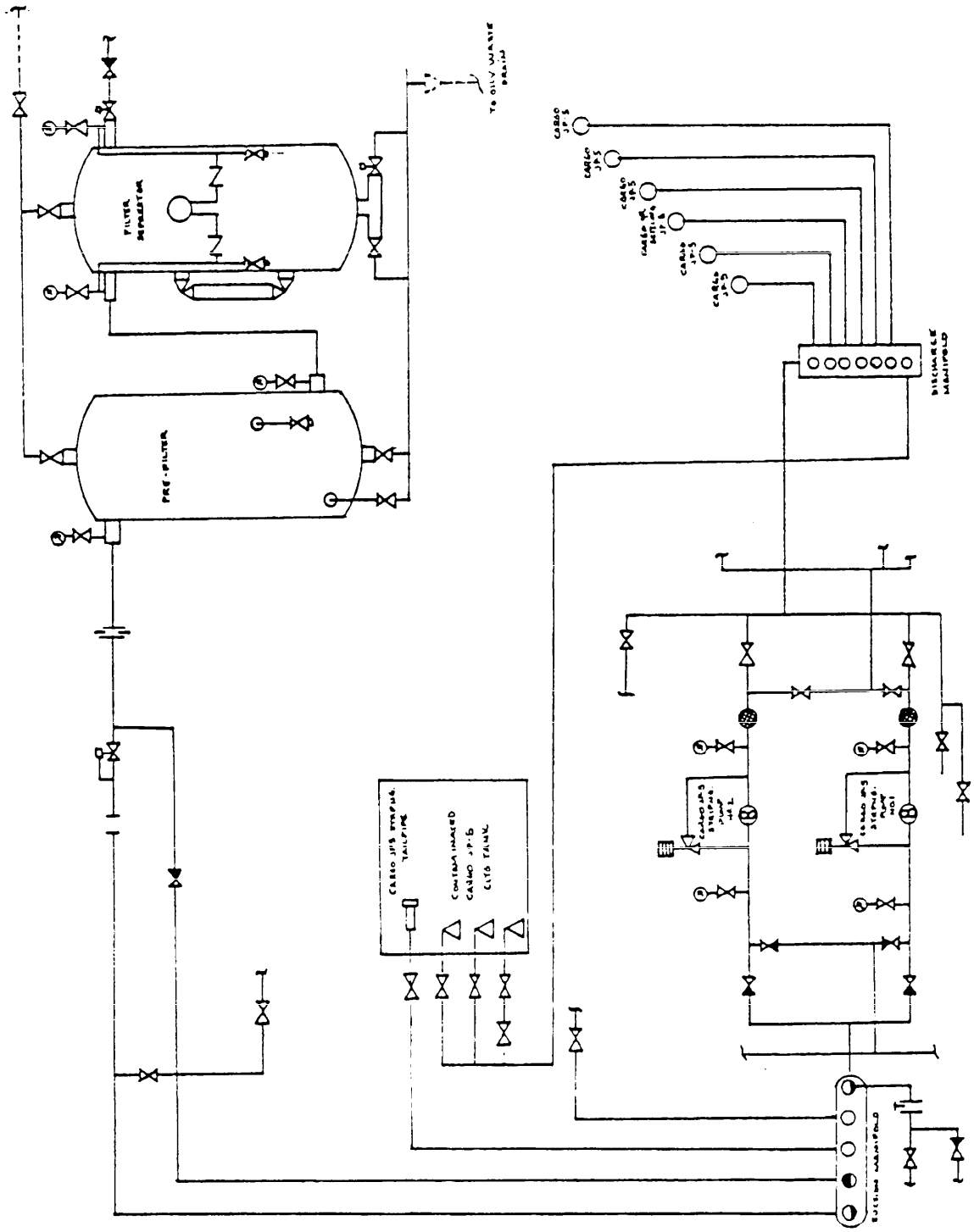
FIGURE 5. Typical JP-5 pump room piping.

SH 13095



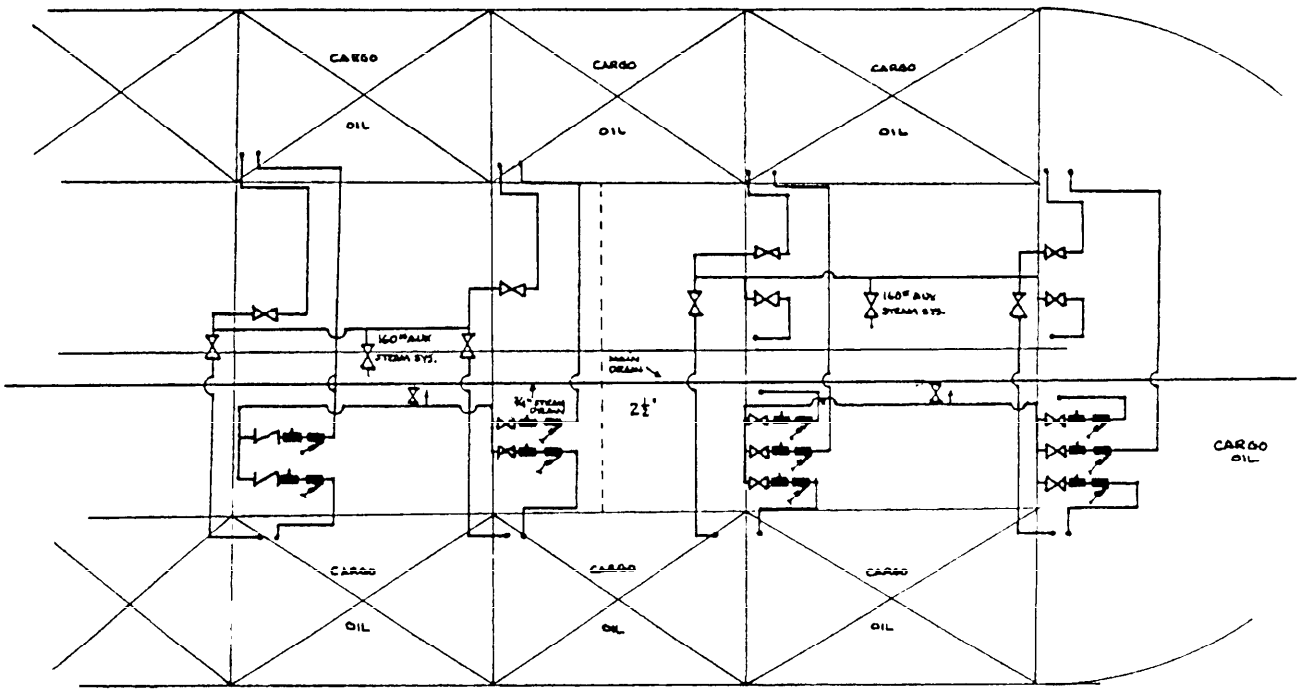
SH 13096

FIGURE 6. Typical F-76 cargo oil-stripping and reclamation.



SH 13097

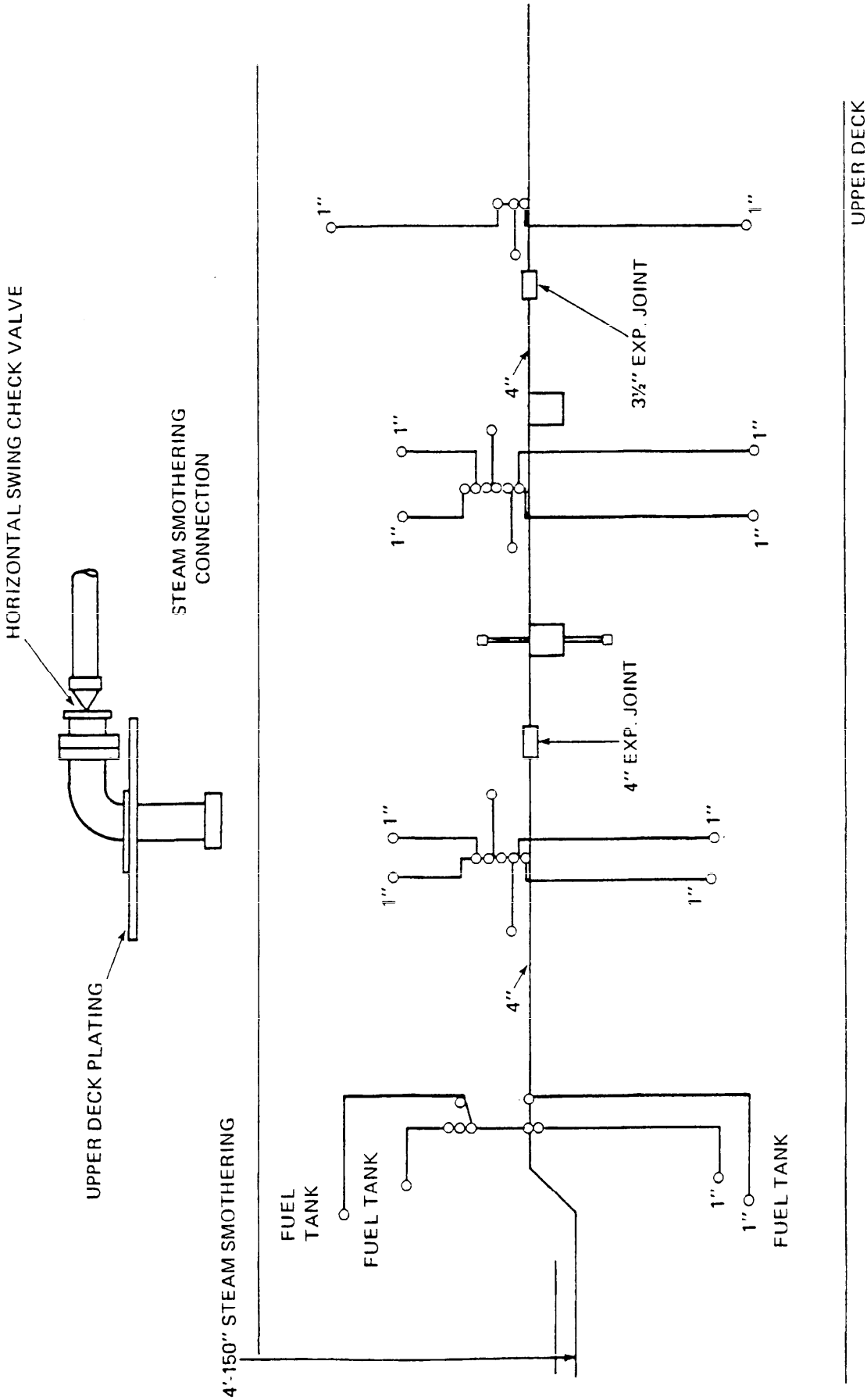
FIGURE 7. Typical JP-5 cargo systems stripping and reclamation.



(Not applicable to U.S. Navy ships)

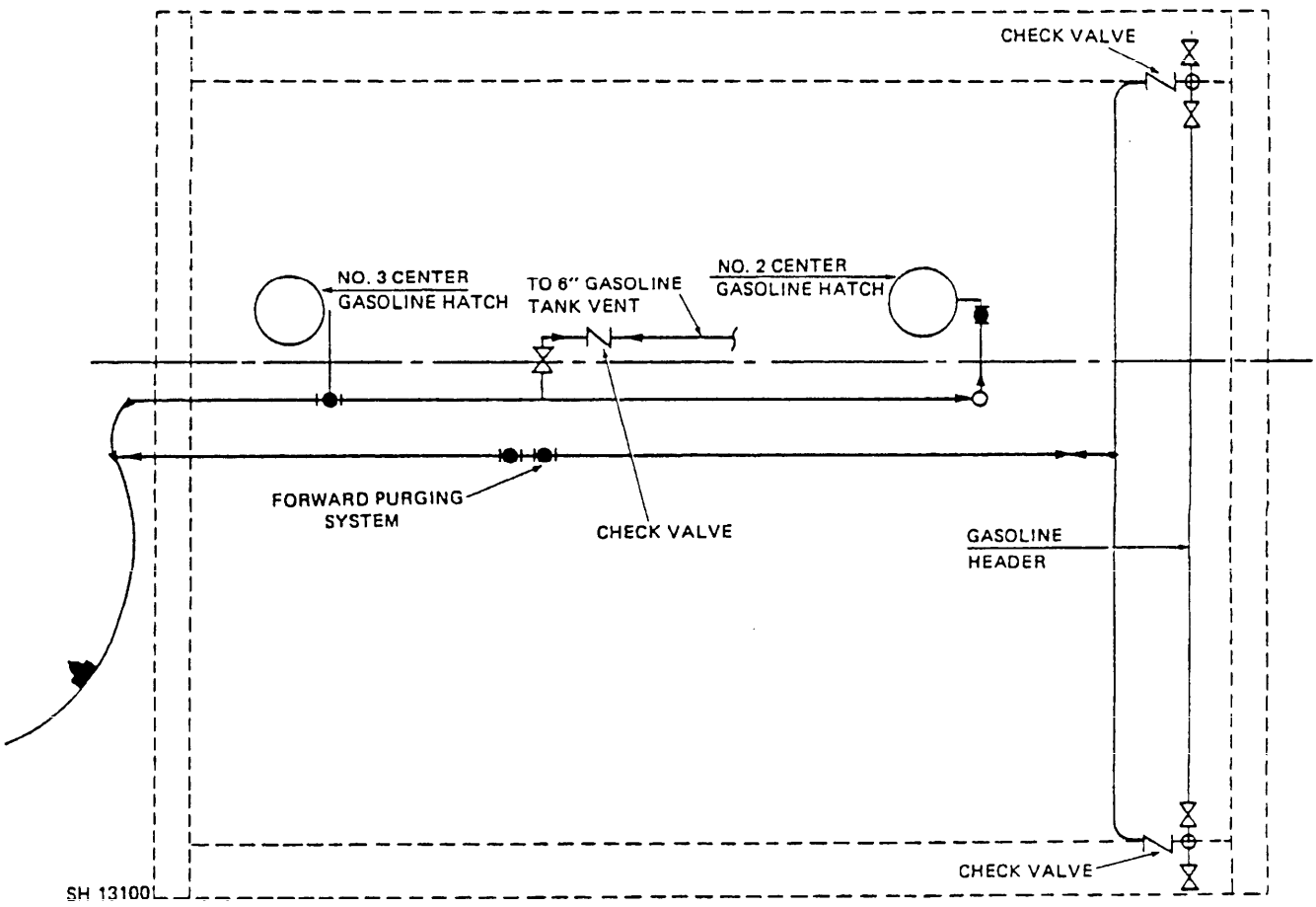
SH 13098

FIGURE 8. Auxiliary steam supply and drainage piping for fuel oil heating coils.



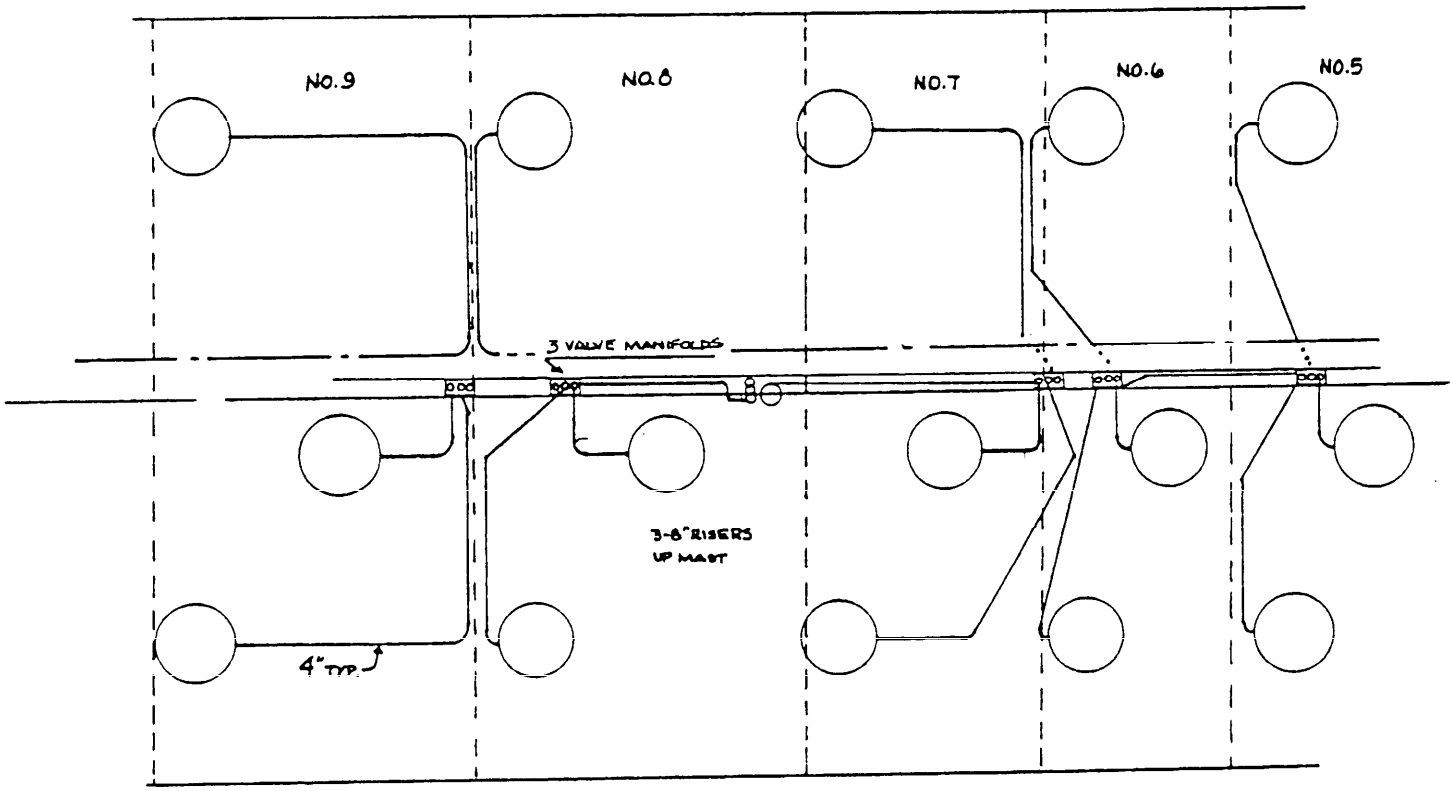
SH 13099

FIGURE 9. Piping arrangement of a steam-smothering system.



SH 13100

FIGURE 10. Piping arrangement of a CO_2 system for gasoline tanks.



SH 13101

FIGURE 11. Vent system piping arrangement.

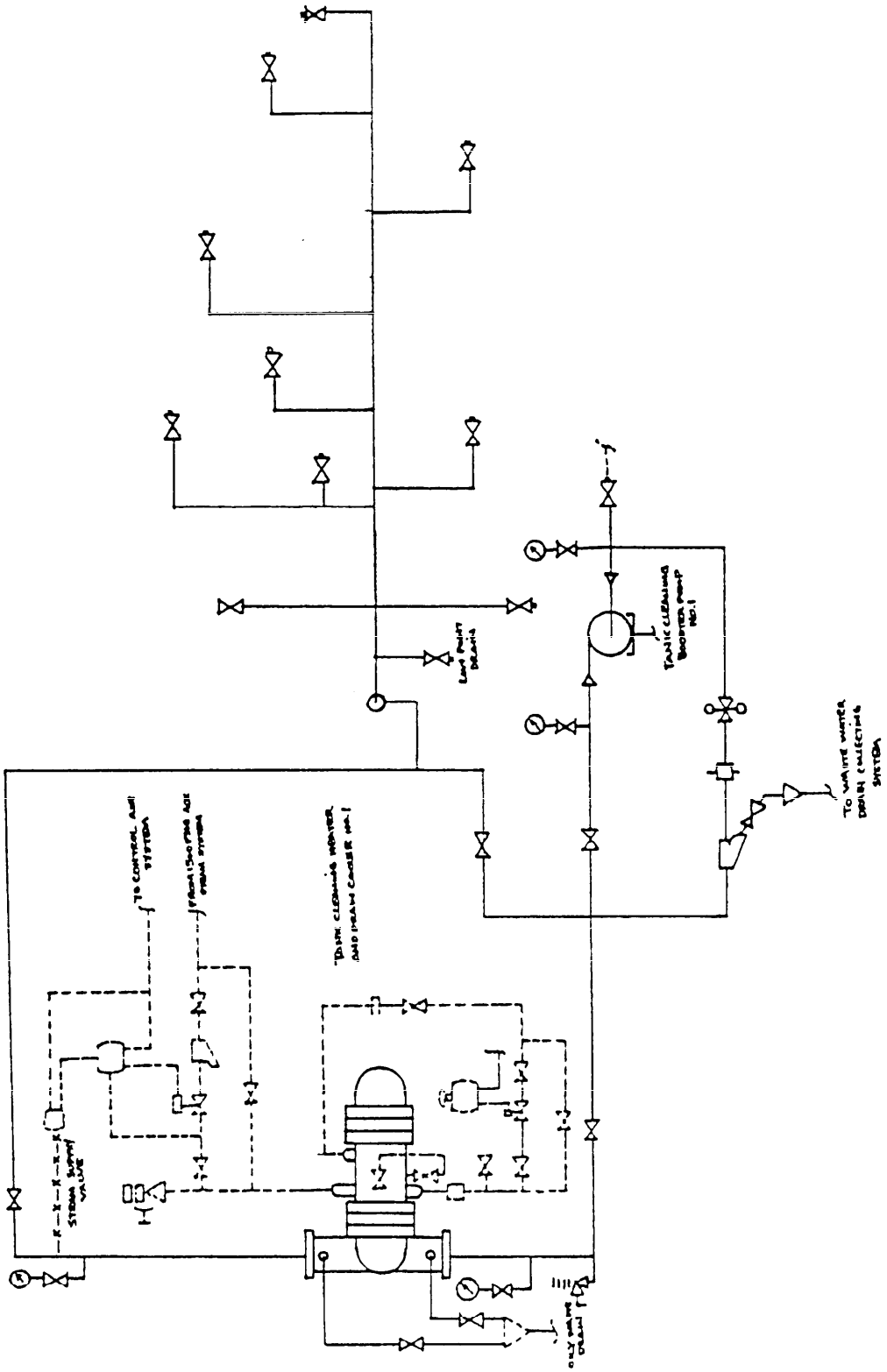
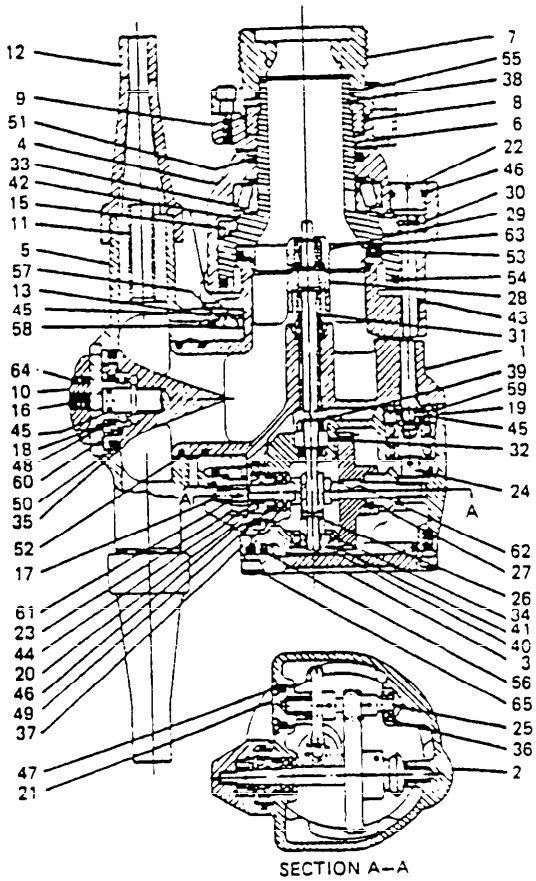


FIGURE 12. Cargo tank cleaning and gas-freeing.

SH 13102

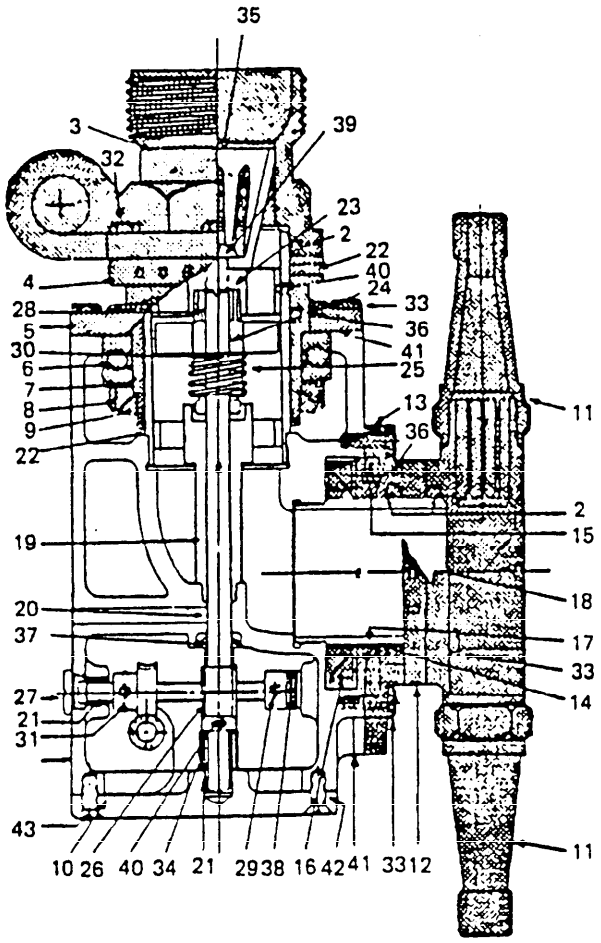


SECTION A–A

DET. NO.		DESCRIPTION
65		SOCKET HEAD CAP SCREW, 1/4 - 20 x 1/2
64		SOCKET SET SCREW, NO. 10 - 24 x 3/8
63		FLAT HEAD SCREW, NO. 8 - 32 x 1/2
62		KEY, WOODRUFF WHITNEY STD. NO. 213
61		ROLLPIN, 1/8 x 15/32
60	O RING SEAL	NOZZLE BEARING
59		MITER GEAR BEARING LOCK NUT
58		NOZZLE CLUTCH
57		NOZZLE
56		COVER
55		INLET
54		BEARING SLEEVE
53		GUIDE VANE
52		L-HEAD (INNER)
51		BEARING HOUSING
50		L-HEAD (OUTER)
49		L-HEAD
48		NOZZLE BEARING LOCK NUT
47		WORM GEAR SHAFT CAP
46		CAP AND LOCK NUT
45		MITER GEAR SHAFT
44		NOZZLE DRIVE SHAFT
43		L-HEAD DRIVE SHAFT
42		GEAR RETAINING RING
41		WORM SHAFT BRG. RET. RING (OUTER)
40		WORM SHAFT BRG. RET. RING (INNER)
39		WORM SHAFT RETAINING RING
38		BEARING SLEEVE NUT RET. RING
37		NOZZLE DRIVE SHAFT BEARING
36		WORM GEAR SHAFT BEARING
35		NOZZLE BEARING
34		WORM SHAFT BEARING
33		ROLLER BEARING
32		WORM SHAFT SEAL
31		IMPELLER SHAFT SEAL
30	SUBASSEMBLY	L-HEAD DRIVE SHAFT AND PINION
29		GUIDE VANE AND BUSHING
28		IMPELLER AND MITER GEAR
26		WORM SHAFT
25		WORM GEAR AND PINION
24		MITER GEAR SHAFT
23		NOZZLE DRIFT SHAFT PINION
22		L-HEAD DRIVE SHAFT CAP
21		WORM GEAR SHAFT CAP
20		NOZZLE DRIVE BEARING LOCK NUT
19		MITER GEAR BEARING LOCK NUT
18		NOZZLE BEARING LOCK NUT
17		NOZZLE DRIFT SHAFT
16		NOZZLE BEARING SHAFT
15		BEARING SLEEVE GEAR
14		DRIVE RING
13		NOZZLE GEAR
12		NOZZLE TIP
11		NOZZLE TUBE INSERT
10		NOZZLE NUT
9		INLET COLLAR
8		BEARING SLEEVE NUT
7		INLET
6		BEARING SLEEVE
5		NOZZLE
4		BEARING HOUSING
3		COVER
2		GEAR HOUSING
1		L-HEAD

SH 13103

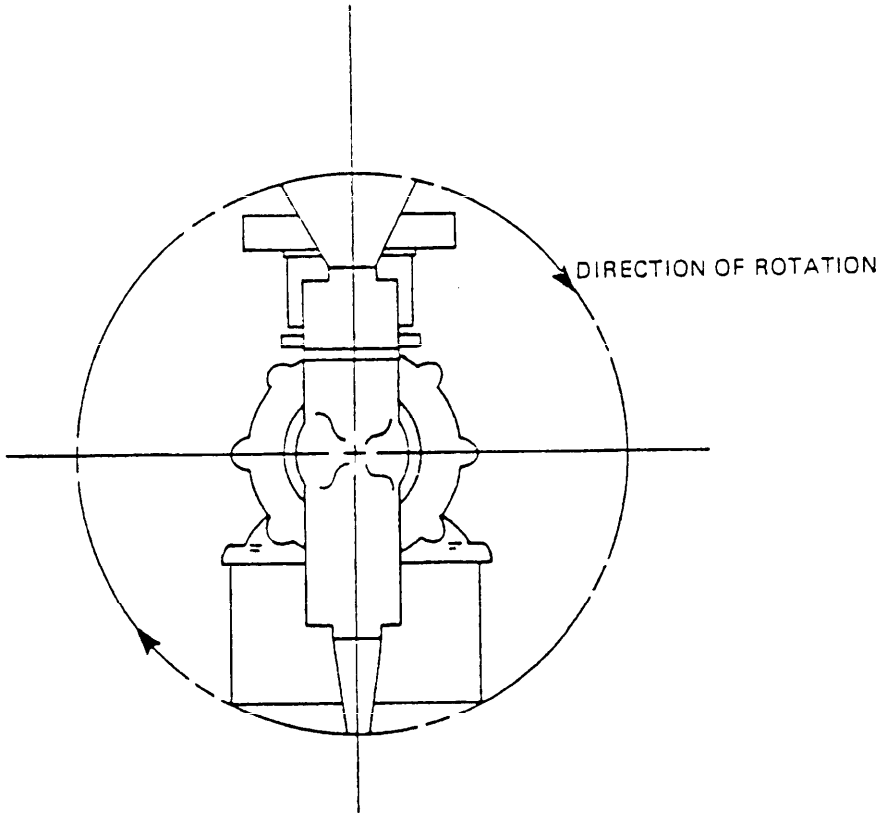
FIGURE 13. Butterworth machine (type K).



DET NO.	PYRATE AUTOMATIC TANK WASHER BILL OF MATERIAL – MODEL "E"
1	MAIN HOUSING
2	"O" RING GRC-27-35
3	WATER INLET
4	TOP COLLAR
5	TOP COVER
6	BEARING ANDREW #2914
7	SPACER
8	INLET-DRIVE RING GEAR 69 TEETH
9	CLUTCH CONE
10	BOTTOM COVER PL.
11	NOZZLE TIP
12	SIDE COLLAR
13	SIDE COVER
14	BEARING RACE
15	BALL CAGE
16	NOZZLE-DRIVE RING GEAR 70 TEETH
17	OUTLET TUBE
18	NOZZLE CARRIER
19	TURBINE SUPPORT
20	TURBINE DRIVE SHAFT 3/8 DIA.
21	BUSHING 5/16 I.D. x 1/2 O.D. x 3/8 LONG
22	INLET TUBE
23	SCROLL
24	IMPELLER TURBINE
25	SHAFT SEAL CRANE #375 F-SD-1003A-1
26	WORM DOBULE LEAD
27	CAP SCREW 5/8 x 18
28	BUSHING INSIDE SCROLL 3/4 x 1/2 L.
29	5/16 COLLAR
30	TURBINE FIN 1/8 x 13/16 O.L.
31	WORM GEAR DOUBLE LEAD 5/16 HOLE
32	HEX. HD. MACH. BOLT 1/4 - 20 x 7/8 LONG
33	HEX. HD. MACH. BOLT 1/4 - 20 x 3/4 LONG
34	SPACER FOR TURBINE SHAFT
35	STRAINER
36	"O" RING PRP. 6230-12
37	OIL SEAL C/R 3687 3/8 SHAFT
38	BEARING FT-08 5/16 SHAFT
39	RD. HD. MACH. BOLT 3/8 - 16 x 3/8 LONG
40	SET SCREW 10 - 32 x 3/16 LONG
41	GASKET TOP AND SIDE .025 TICK.
42	GASKET BOTTOM PLATE .025 TICK.
43	FL. HD. MACH. SCREW 1/4 - 20 x 3/4 O.L.

SH 13104

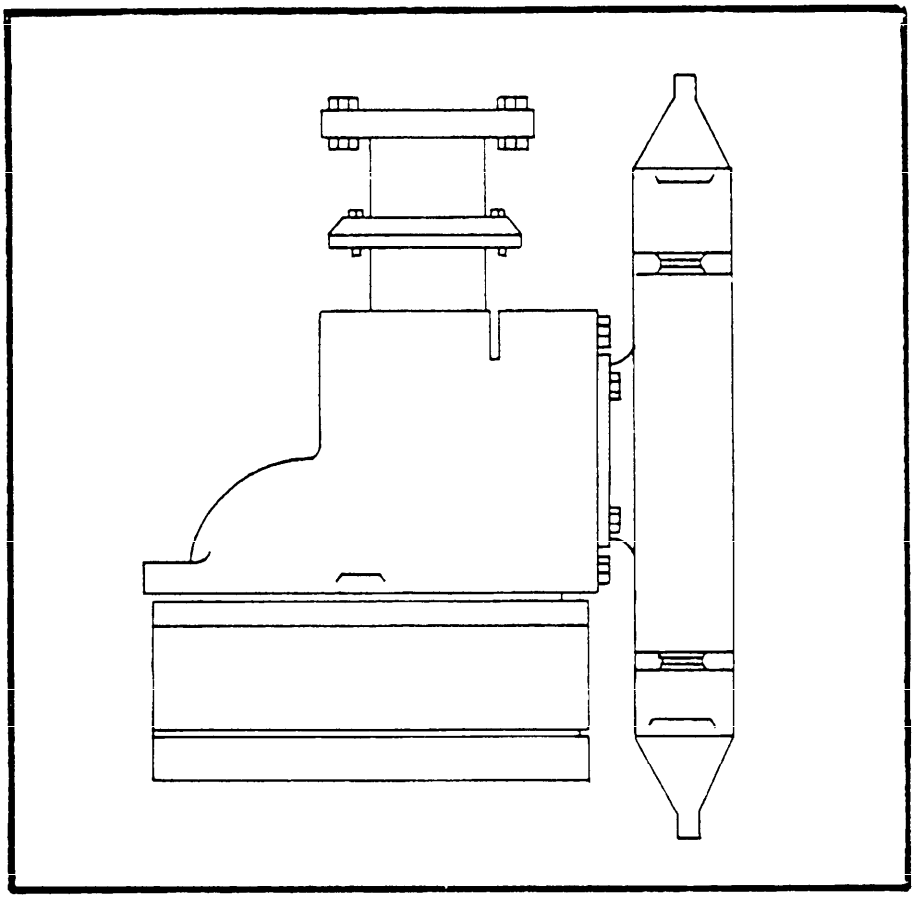
FIGURE 14. Pyrate model E.



VARIOUS FLANGE SIZES AVAILABLE							
FLANGE SPECS:	PIPE BORE	D FLANGE	b FLANGE	c NO. HOLES	K P.C.D.	d_1 HOLES	d_2 BOLTS
J.I.S. 16K-65	65	175	20	8	140	19	M16
DIN 2533NP16	65	185	20	4	145	18	M16
ASA 2"–150	2"	6"	3/4"	4	4-3/4"	3/4"	5/8"
ASA 2-1/2"-150	2-1/2"	7"	3/4"	4	5-1/2"	3/4"	5/8"

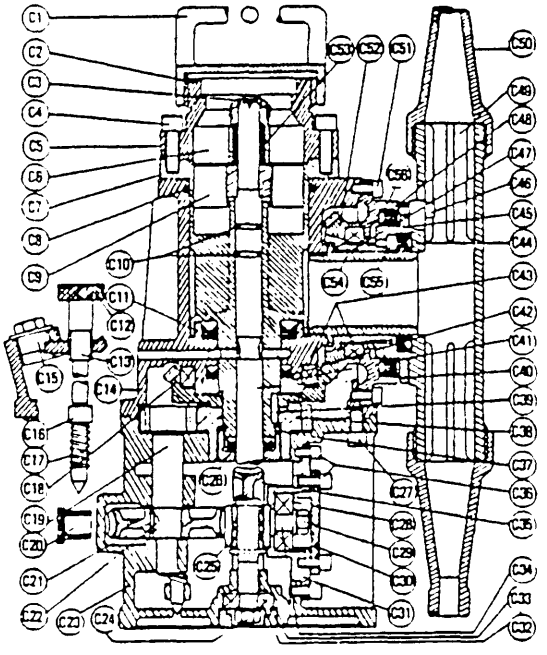
SH 13105

FIGURE 15. Pyrate model VP major 11.



SH 13106

FIGURE 16. Pyrate model VP major 16.



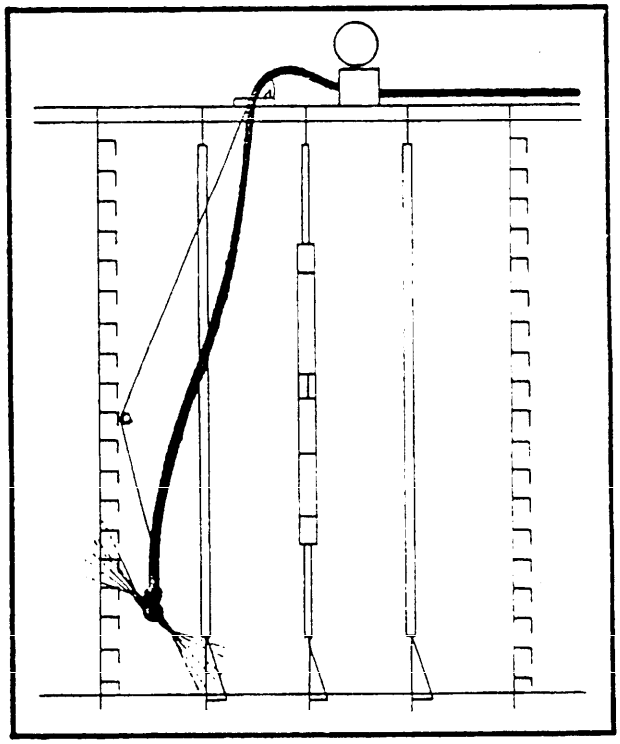
C1	1	COVER
C2	1	TOPCOVER
C3	1	NUT for GUIDE
C4	8	SCREW
C5	1	TOPCOVER
C6	1	GUIDE WHEEL
C7	1	TURBINE CASING
C8	1	SEAL
C9	1	TURBINE WHEEL
C10	2	SEAL
C11	1	SEAL
C12	1	HANDWHEEL
C13	1	VALVESTEM
C14	1	ADAPTER
C15	1	SCREW PLUG
C16	1	VALVE CONE
C17	1	SPRING
C18	1	CONICAL PINION
C19	1	CYL. PINION
C20	1	BUSHING
C21	1	WORM GEAR WHEEL
C22	1	KEY
C23	1	GEARBOX
*C24	1	NUT & WASHER
C25	1	WORM
C26	1	SEAL
C27	4	SCREW
C55	1	LOCKING SCREW

C28	1	BALL BEARING
*C29	1	NUT & WASHER
C30	1	BEARING CAP (outer)
C31	1	BEARING CAP (inner)
C32	1	BALL BEARING
C33	1	PLUG
C34	1	WORM SHAFT
C35	1	WORM GEAR WHEEL
C36	7	SCREW
C37	1	NUT
C38	1	CYL. GEAR WHEEL
C39	1	KEY
C40	1	TURBINE SHAFT
C41	1	LOCK RING
C42	1	SEAL
C43	2	THRUST BEARING
C44	1	SEAL
C45	1	CARRIER DISK
C46	4	SCREW
C47	1	CLUTCH BUSHING
C48	1	COVER for pos. C14
C49	1	JET PIPE
C50	2	SPRAY NOZZLE
C51	8	SCREW
C52	1	CONICAL GEAR WHEEL
C53	1	BUSHING
C54	1	GUDGEON
C56	1	SEAL

*NOTE: Nuts C24 and C29, left hand thread.

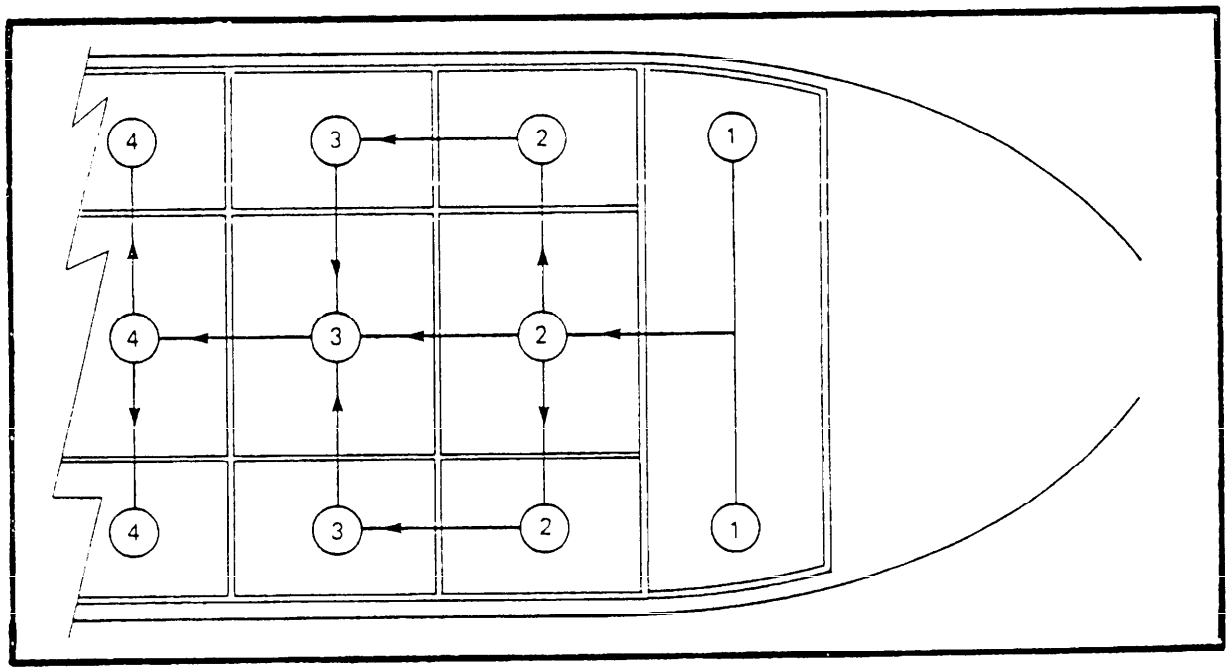
SH 13107

FIGURE 17. Sellers machine, model C.



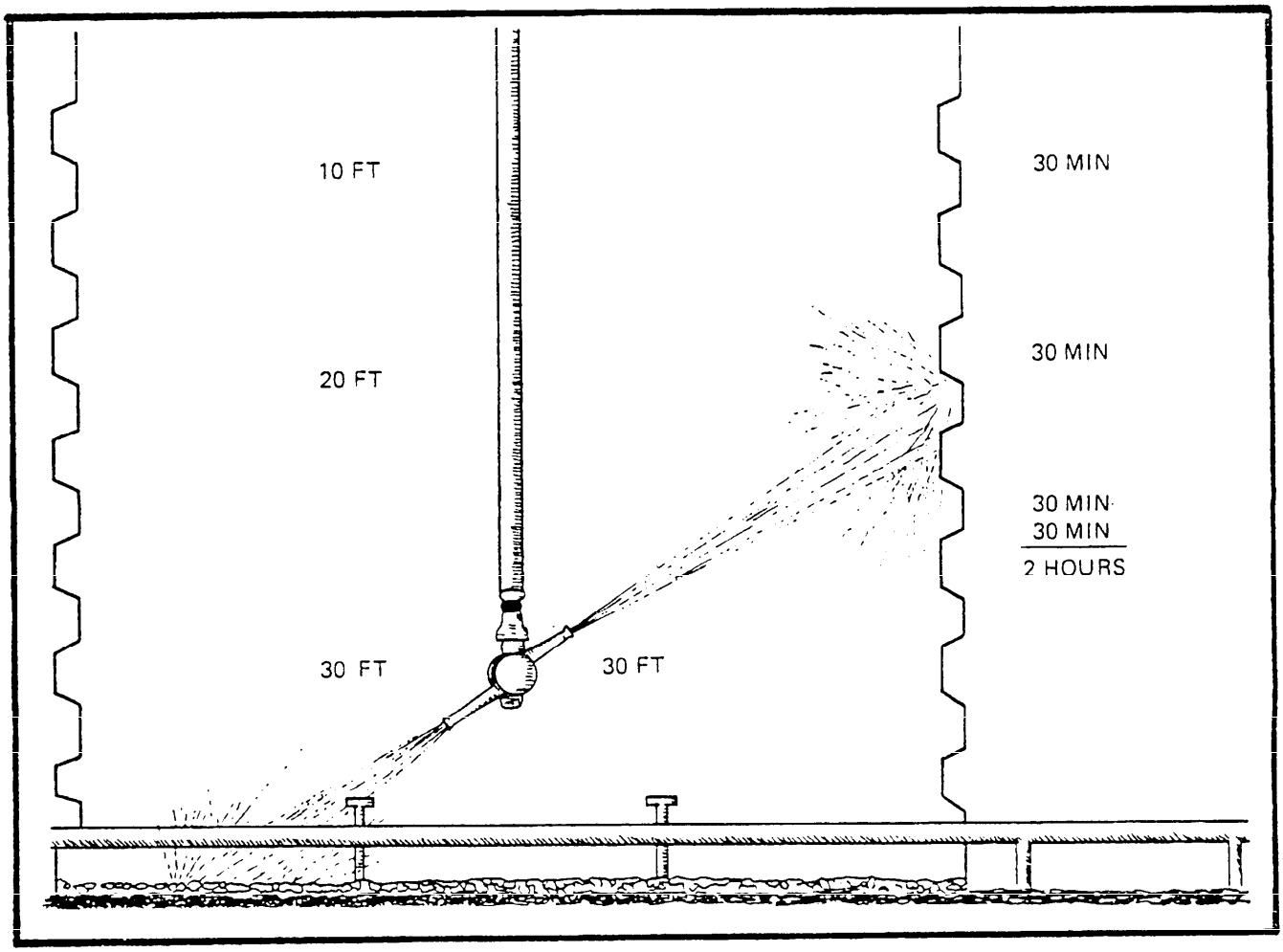
SH 13108

FIGURE 18. Rigging machine for spot washing.



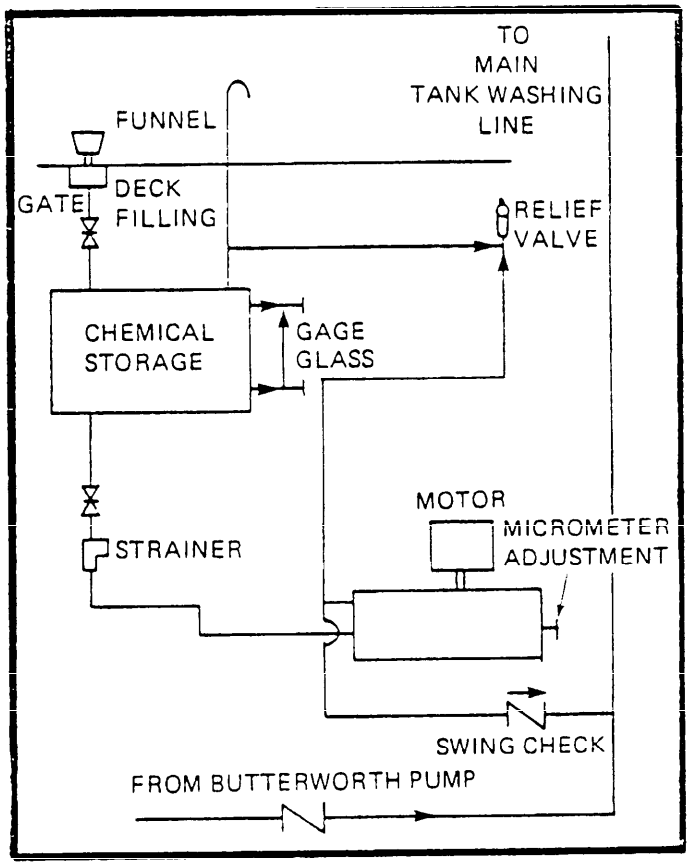
SH 13109

FIGURE 19. Sample tank washing schedule for efficient heat transfer.



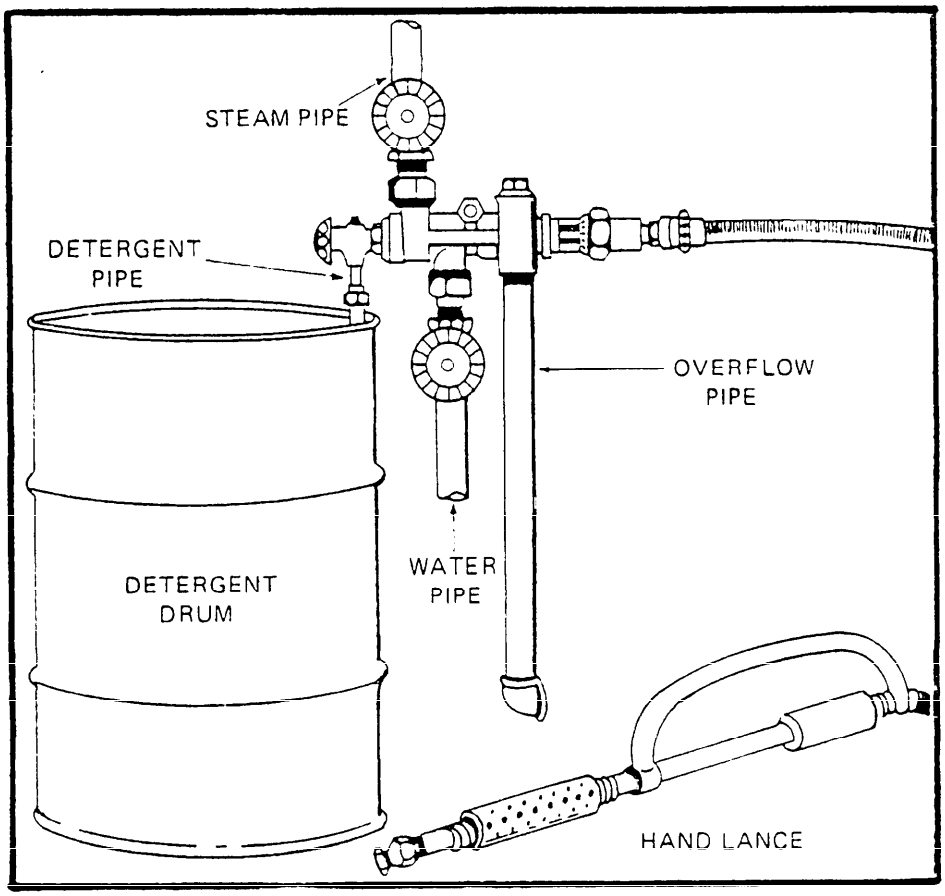
SH 13110

FIGURE 20. Typical drop schedule.



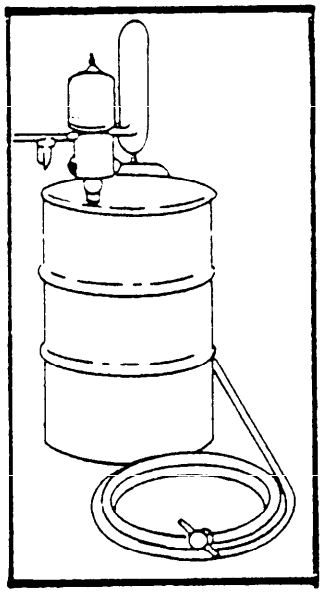
SH 13111

FIGURE 21. Chemical cleaning unit installed on main deck.



SH 13112

FIGURE 22. Hydraulic jet unit.



SH 13113

FIGURE 23. Air-motor-driven pump.

NAVY GAS FREE CERTIFICATE

Initial Date of Test: hr. _____ day _____ mo. _____ yr. _____

Initial Expiration: This certificate expires · hr. _____

day _____ mo. _____ yr. _____

GFE Personnel Signature _____

Re-test/Update Time _____ Date _____ Expires _____

GFE Personnel Signature _____

Re-test/Update Time _____ Date _____ Expires _____

GFE Personnel Signature _____

Ship/Unit/Activity _____

Item/Compt./Space _____

Type of Operation
To Be Conducted _____

This certificate indicates the conditions that exist at the time tests were conducted.

☐ NOT Safe For Personnel · Not Safe for Hot Work

☐ NOT Safe For Personnel Without Protection · NOT Safe For Hot Work

☐ SAFE For Personnel · NOT Safe For Hot Work

☐ SAFE For Personnel · SAFE For Hot Work

☐ INERTED · NOT SAFE For Personnel INSIDE · Safe For Personnel and Hot Work OUTSIDE _____

Remarks:

SH 13114

FIGURE 24. Sample gas detection report form.

PRODUCT TO BE LOADED →				MILITARY CARGOES										
				CLEAN PRODUCTS									BLACK PRODUCTS	
LAST PRODUCT CARRIED	MILITARY PRODUCTS	COMMERCIAL PRODUCTS	COLOR & LEADING	AVGAS MIL G 5572 LEADED & DYED	WHITE GAS MIL F 2116 VV G 109 CLEAR	MOGAS MIL G 3056 VV G 76 LEADED & DYED	KEROSENE VV K 211 CLEAR	DIESEL MIL F 16884 VV F 800 STRAW COLOR	JP 4 MIL J 5624	JP 5 MIL F 5264	BURNER FUEL OIL VV F 815 1 & 2	LUBE OILS	BOILER FUEL OIL MIL F 859 BLACK	BURNER FUEL OIL NO 6 5 4 VV F 815 BLACK
CLEAN PRODUCTS	Avgas MIL G 5572	Leaded Aviation Gasoline	Leaded & Dyed	A	BDEF	A	BDEF	BDEF	BDEF*	BDEF*	BDEF	BDDEF*	BDEF	BDEF
	White Gas MIL F 2116 VV G 109	White Gasoline	Clear	A	A	A	BDEF	BDEF	BDEF*	BDEF*	BDEF	BDDEF*	BDEF	BDEF
	Mogas MIL G 3056 VV G 76	Motor Gasoline	Leaded & Dyed	A	BDEF	A	BDEF	BDEF	BDEF*	BDEF*	BDEF	BDDEF*	BDEF	BDEF
	Jet Fuel MIL J 5624	JP 4		A	A	A	BDEF	BDEF	CF*	BDEF*	BDEF	BDDEF*	BDEF	BDEF
	Jet Fuel MIL J 5624	JP 5	Straw Color	A	A	A	A	A	CF*	CF*	A	BDDEF*		A
	Lube Oils			BDDEFH	BDDEF	BDDEF	BDDEF	BDDEF	BDDEFH*	BDDEFH*	BDDEF	A	A	A
	Kerosene VV K 211	Water White or Standard State Kerosene	Clear	A	A	A	A	A	CF*	CF*	A	BDDEF*	A	A
	Burner Fuel VV F 815 OIL 1 & 2	Grade 1 & 2 Fuel Oil	Straw Color	BDDEF	BDDEF	BDDEF	BDDEF	A	BDDEF*	BDDEF*	A	BDDEF*	A	A
		Dyed Kerosene	Dyed	BDEF	BDEF	BDEF	BDEF	BDEF	BCEF*	BCEF*	BCF	BDDEF*	BCF	BCF
	Diesel Fuel MIL F 16884 VV F 800	Diesel Gas Oil	Straw Color	BDDEF	BDDEF	BDDEF	BDDEF	A	BDDEF*	BDDEF*	A	BDDEF*	A	A
BLACK PRODUCTS		Diesel Oil Commercial Diesel	Black or Dark	BDDEFG	BDDEFG	BDDEFG	BDDEFG	BDDEFG	BDDEFG*	BDDEFG*	BDDEF	BDDEF*	A	A
	Boiler Fuel Oil MIL F 859		Black	BDDEFG	BDDEFG	BDDEFG	BDDEFG	BDDEFG	BDDEFG*	BDDEFG*	BDDEF	BDDEF*	A	A
	Burner Fuel Oil No 6 5 4 VV F 815	Bunker Oil or "Bunker C Fuel Oil"	Black	BDDEFG	BDDEFG	BDDEFG	BDDEFG	BDDEFG	BDDEFG*	BDDEFG*	BDDEF	BDDEF*	A	A
		Crude Oil	Black	BDDEFG	BDDEFG	BDDEFG	BDDEFG	BDDEFG	BDDEFI*	BDDEFG*	BDDEFG	BDDEF*	BDDEF	BDDEF
		Molasses, Linseed Waxes Cotton Seed Oil		BDDEFH	BDDEFH	BDDEFH	BDDEFH	BDDEFH	BDDEFH*	BDDEFH*	BDDEFH	BDDEF*	BDDEF	BDDEF
		Grain		BDEF	BDEF	BDEF	BDEF	BDEF	BDEFH*	BDEFHI*	BDEF	BDEF*	BDEF	BDEF

SH 13115

FIGURE 25. Cargo tank cleaning requirements.

Notes to figure 25.

1. Explanations for symbols for cargo tank cleaning requirements (see figure 25) are as follows:

A - No specific preparation is required if lines have been dropped and tanks have been stripped.

B - Blow out steam-smothering lines and any heating coil lines.

C - Bottom wash cargo tanks; after dropping lines, hand hose the tank bottoms.

D - Clean vent lines, machine wash, and gas-free cargo tanks. Close relief valves, fill vent lines with water, and open one valve at a time to flush each line into its respective tank; then, remove all end flanges and allow entire vent line system to drain. Wash each tank with cold water by machine or with other approved system. Open tank tops and ventilate to permit entry for removing scale and hand hosing the bottom. Give particular attention to tanks which previously contained products that were dyed after loading; some dye powder may adhere to bulkheads and underdecks and will contaminate subsequent white product cargoes. After cleaning, strip all tanks and lines. Flush all vent lines between clean cargoes.

DD - Same as "D" except that hot water shall be used instead of cold. If tank interiors are coated, water temperatures shall not normally exceed 125°F (52°C) unless upgrading from a black to a clean product. A water temperature of 175°F (79°C) may then be used (see 5.8.2.2).

E - Remove all loose sediment, sludge, and scale. Hand hose tank bottoms in conjunction with removal of sediment, sludge, and scale.

F - Flush cargo pipelines and pumps. Clean pump strainers. Pump clean water through each pump and pipeline for a minimum of 20 minutes. Carefully remove any oil which may remain at low spots or in bypasses in the pipeline, valves, and strainer boxes. While flushing, use main and stripper pumps simultaneously, opening and closing crossover and bypass valves several times. Clean cargo pump strainers frequently. Flush cargo lines and pumps before and after tank cleaning. Drain all cargo lines upon completion of flushing and dispose of all drainage liquids before loading. (Cargo lines are not coated.)

Notes to figure 25. - Continued

G - Unless imperative, when converting from black to clean service, do not carry gasoline or jet fuel in a black oil tank without first carrying diesel oil for at least two voyages. If the tanks are coated, however, they may be cleaned for clean oil service immediately after black oil has been carried. Do not load black oil into clean oil vessels unless absolutely necessary. This necessitates a lengthy cleaning procedure before the vessels can be returned to clean oil service.

H - Reject any products which would cause contamination of the succeeding cargo unless, after cleaning, the tanks have carried at least two cargoes of light commercial products and are satisfactory to Government petroleum inspectors.

I - Ships shall not go directly from grain to JP-5 service.

2. Remove all traces of water after cleaning tanks.
3. All safety regulations shall be followed.

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(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-HDBK-291	CARGO TANK CLEANING

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ OTHER *(Specify)*: _____

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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