DEPARTMENT OF THE AIR FORCE
Headquarters US Air Force
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AF MANUAL 85-16

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Civil Engineer—General

MAINTENANCE OF PETROLEUM SYSTEMS

This manual provides base and command liquid fuels maintenance (LFM) personnel with guide procedures for accomplishing field maintenance of permanently installed Air Force owned, leased, or controlled petroleum storage and dispensing systems. It also supplements detailed manufacturers' instructions on specific equipment and applies to all Air Force systems and activities for which the civil engineer has maintenance responsibility. This manual applies to all Air Force personnel who have responsibility for the maintenance of permanently installed petroleum systems. If this manual is in conflict with any other Air Force directive, other than Safety and Health requirements published in AFOSH Standards, this manual takes precedence. Immediately notify HQ AFESC/DEMM if this manual conflicts with other Air Force directives. The use of a name of any specific commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

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OPR: HQ AFESC/DEMM (Patrick G. Mumme)
Approved by: HQ AFESC/CC (Col Hisao Yamada)
Writer-Editor: D. Britford
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Chapter 1
INTRODUCTION

Section A—General Information

1-1. Purpose and Scope. The safety of aircraft, and of the Air Force personnel who operate them, depends to a large extent on the delivery of clean, water-free fuel of the correct grade, from all fuel dispensing systems. To do this, the Air Force must operate and take care of its petroleum storage, distribution, and dispensing systems properly.

a. This manual sets up guide procedures for maintenance of systems components by command and base civil engineering management personnel. These people should know, for example, the characteristics of liquid petroleum, because its peculiarities can increase maintenance problems. This manual discusses operation so that these personnel will learn some of the principles of design and function, to provide a sounder basis for maintenance.

b. It emphasizes preventive maintenance to avoid system shutdowns, to prevent the contamination of fuel, and to decrease fire, accident, and health hazards. Periodic inspections and servicing are essential to continue efficient operation with the least possible rehabilitation and repair.

c. This manual is not intended to provide technical guidance for the design and construction of items (for such guidance, see AFM 88-15). For characteristics of liquid petroleum products, see AFM 161-30, volume II, and DOD MIL-Handbook 201 (available as indicated in AFR 0-4).

d. This manual applies to permanently installed petroleum storage and dispensing systems. For specific areas of specialization, consult other Air Force publications.

e. It is Air Force policy that Air Force weapons systems, subsystems, and aerospace ground equipment (AGE) will be operated and maintained by use of TOs, except as specifically authorized by HQ USAF, as in the case of real property installed equipment (RPIE) technical data (see AFR 8-2).

f. All organizations are responsible and must comply with TO 42B-1-23, Disposal of Waste Liquid Fuels and Other Petroleum Products.

1-2. Administrative Responsibility. Administrative details are discussed in AFR 85-1. Functions of the base engineer liquid fuels maintenance shop are described in AFR 85-10. Each major command (MAJCOM) must require subordinate commands and bases to send plans, drawings, and specifications covering proposed maintenance, repair, alterations and minor construction projects involving liquid fuel facilities, estimated at more than $500, for review and approval by the MAJCOM's liquid fuels engineer (see AFR 86-1).

a. Base Fuels Management Officer (BFMO). The BFMO is responsible for the safe and efficient receipt, storage, handling, issuing, and accounting of all aviation petroleum products.

(1) This officer finds out the quality of fuel that is delivered to the system (and handled throughout the system). He or she is also responsible for operational maintenance of petroleum handling and dispensing systems and equipment described in TO 37-1-1. Calibration of permanently installed meters and mobile unit meters are the respsonsibility of the base civil engineer (BCE) and motor vehicle maintenance shop.

(2) The BCE delegates responsibility for the calibration of installed meters to the motor vehicle maintenance shop whenever this is considered an advantage to the Air Force. Meter calibration is scheduled by the agency performing calibration with the BFMO. The Fuel Management Branch will have copies of this manual available at the work center as a reference for fuels operators.

b. BCE Responsibilities. The BCE is responsible for the maintenance of all installed petroleum storage and dispensing systems.

(1) Additional respsonsibilities include providing and maintaining airfield combination static ground rods or tie down anchors; providing adequate meters to ensure accurate metering of all issues of fuels from installed facilities; and maintaining a complete and current file of as-built system drawings, detailed master plans, master certified tank calibration charts, and publications that apply to the system from both military and manufacturer sources.

(2) The BCE is also responsible for maintaining, testing and procuring hoses used on permanently installed fuel systems, that is, hoses on truck or tank car loading and unloading facilities. (Transportation is responsible for fueling trucks and hose carts.)

(3) He or she is also responsible for electrical cords and controls used on permanently installed fuel systems.

c. Motor Vehicle Maintenance Officer. The transportation officer is responsible for all maintenance of mobile fueling equipment except operator maintenance. These responsibilities include installation maintenance; and proper calibration of the fueling unit and hose cart meters; and procuring and testing all fueling hoses installed on mobile equipment.

d. Using Service. The using service is responsible for all operational maintenance listed in TO 37-1-1. Operational maintenance is limited to external cleaning, lubrication of mechanical parts (excluding oiling of motors) and reporting deficiencies. This does not

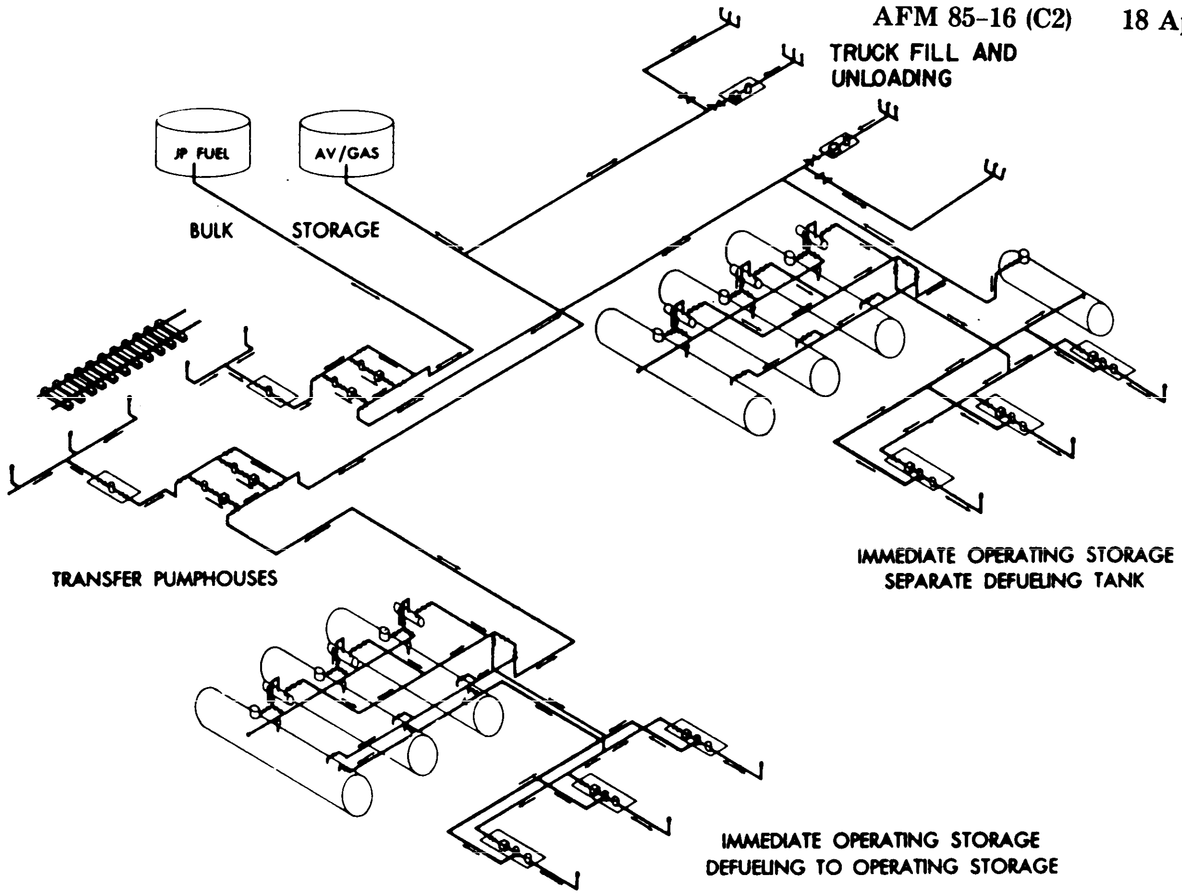


Figure 1-1. Assembled Components of Petroleum Storage and Dispensing System I (Panero).

mean the operating organization and the BCE cannot agree to have the operators perform minor maintenance within their capability when civil engineer maintenance personnel are not present. Civil engineering maintenance personnel may lubricate equipment when they are performing major maintenance on it.

1-3. Assembled Components. The assembled components of a typical petroleum fuel system (as illustrated in figure 1-1) are grouped as follows:

a. Bulk storage area.
b. Immediate operating storage area.
c. Fueling area.
d. Defueling equipment.
e. Truck fill stands.
f. Hydrant outlets.
g. Unloading connections (Tank car and tank truck).
h. Transfer and unloading pumps.
i. Control pits.

1-4. Plans and Equipment Information:

a. Plans. As-built plans of each petroleum system, showing precisely the location of the system elements and the connections from facilities to all tanks, pipelines, valves, and other equipment, with sequence of operations charts, must be filed in the BCE's office and made available to all petroleum maintenance personnel. These plans show the exact location of all equipment, as determined by actual field measurements, and the capacity, size, and type of each component. Plans and charts are kept current; any change in the existing layout must be shown. All directives pertaining to the system are also kept in this file. It is most important that the BCE receive as-built drawings and plans of new systems and changes in existing systems, that are necessary to do maintenance. NOTE: The BCE keeps up-to-date operating manuals on file.

b. Charts. The BCE (Engineering Section with assistance from the Liquid Fuels Maintenance (LFM) shop) prepares charts and illustration panels showing each step in the operation of the existing system. He or she keeps these charts posted prominently and updated whenever system changes or modifications are made.

(1) To facilitate operation and maintenance of fuel storage systems, fuel lines on charts must be marked to identify the contents according to MIL-STD-161. All operating components of the system are numbered and properly identified on the drawing and charts.

(2) Make sure all valves are identified on the charts as well as being identified on the valve itself (either by tag or stenciling). One suggested method of valve identification is as follows:

(a) All valves operated manually by FMO personnel to control the direction of flow have a prefix of the capital letter "O" (for operating) followed by a number. For example, "O-1", "O-2", etc. When the system is not in operation, these valves are usually open, "NO" or usually closed "NC." The complete valve designated would then be either "O–1–NO" or "O–1–1NC", "O–2–NO" or "O–2–NC", etc.

(b) All manually operated valves, operated by LFM personnel, who are doing maintenance only, are usually open, except during a maintenance test. These valves have a prefix of the capital letter "M" (for maintenance) followed by a number. For example, "M–1", "M–2", etc.

(c) All automatic valves that require no manual operation have a prefix of the capital letter "A", such as "A–1", "A–2", etc. These valves would include check valves, pressure relief valves, and automatic diaphragm type valves.

(3) Revise operational checklists to show the valve numbering system used.

c. Equipment. A file of manufacturers' catalogs, maintenance and repair manuals, and equipment data will be kept in the LFM office for reference.

1–5. Standards for Maintenance of Military Liquid Fuel Facilities:

★a. General Policy:

(1) All petroleum fuel facilities that the Air Force controls are to be maintained in a way to protect the government's interest and are kept in a safe and proper operational condition. The nature of government maintenance on leased petroleum fuel facilities is affected by the terms of the lease. In determining the degree of maintenance required at these facilities, cognizance will be taken of their known short-term use, but the Government's investment will be protected at all times.

(2) The standards of maintenance established will be the minimum for an active installation. When the installation is in an inactive or surplus status, the standards of maintenance will be reduced to a point consistent with the anticipated mission.

b. Maintenance Objectives. Regardless of location, type, or magnitude of a military petroleum fuel facility, or the nature of the petroleum products handled, the facility exists primarily to receive, store, handle, distribute, and issue petroleum products with the following attendant factors:

(1) The quality of all products involved is consistent with its military specification requirements as received (that is, no product will be contaminated by deficiencies in the operation or design of the facility).

(2) The facility is operated and maintained according to the prescribed and accepted standards, to eliminate the loss of government fuel, and to ensure the highest degree of safety at all times.

(3) The facility is maintained and operated to fulfill the assigned military mission.

c. Quality Surveillance of Product. The BFMO is responsible for making sure that petroleum products delivered to the base storage facility have not been contaminated during the handling and transportation of the product (see TO 42B–1–1 and Military Handbooks in the 200 Series). Proper maintenance of fuel facilities receives first priority, being one of the most important factors in maintaining quality control. The standards for maintenance of fuel facilities should, therefore, take cognizance of the various causes for contaminating products. If fuel contamination problems occur, the MAJCOM is notified immediately. If necessary, the BFMO will request assistance of the POL Technical Assistance Team (see AFR 74–7). The command civil engineer must be represented on any survey involving installed fuel facilities.

d. Fuel Facilities. The following divisions of components usually encountered in whole or in part throughout the military establishment, are included within the category of maintenance standards prescribed here. Frequent periodic inspections of these facilities, followed by immediate remedial actions on deficiencies found, are essential for an uncontaminated fuel supply:

(1) Receiving and Dispensing Facilities:
- (a) Piers, wharves, and offshore facilities.
- (b) Tank car loading and unloading facilities.
- (c) Tank truck loading and unloading facilities.
- (d) Drum filling plants.
- (e) Unloading and transfer pumps.
- (f) Cross country pipelines.

(2) Storage Facilities:
- (a) Tankage (above ground).
- (b) Tankage (below ground).
- (c) Tank accessories.
- (d) Berms, inclosures, and tank foundations.

(3) Distributing Systems:
- (a) Piping.
- (b) Pumps.
- (c) Control equipment.
- (d) Filter separator and filter facilities.
- (e) Hydrant fueling systems.

e. Preventing Corrosion. Preventing destructive attack on the various components of fuel facilities constitutes one of the most important phases of proper maintenance. Chapter 9 outlines various methods of controlling corrosion.

f. Safety. Safety measures at fuel facilities are important to preserve life and government property. The pursuit of measures for safe operation and maintenance of fuel facilities is a matter of constant attention. Breaches of the prescribed safety standards set forth in this paragraph and chapter require disciplinary action. The following points are set forth for attention:

(1) Static and Electrical Grounding. Bonding and grounding components of petroleum fuel facilities are of primary importance in preventing fire and explosion. All components in the fuel system must be bonded and grounded to drain off static charges and stray electrical currents that can discharge in the form of an electric arc. Bonding across flanges is not required as long as the gasket between flanges does not prevent electrical continuity. Static charges and prescribed grounding

procedures are detailed in chapter 1, section F.

(2) Tools and Equipment. Normal repairs and maintenance may be made with standard tools; however, the area must be free of all volatile liquids and vapors. Emergency repairs in areas where volatile liquids and vapors are present should be made in a cautious way to prevent sharp blows that could cause sparks.

(3) Hose. Transfer and cargo hose must be cleaned and inspected after each use and properly stored in racks out of the sun's rays. Hoses are inspected and tested according to chapter 10.

(4) Signs and Markings. Each fuel facility must be inspected according to requirements outlined in chapter 10 for proper permanent signs and markings. All signs must be conspicuously mounted, clearly legible, and adequately indicative of the desired objective. Enough movable or temporary signs are maintained in good condition to serve all possible uses, such as "DANGER," "CLOSED TO TRAFFIC," KEEP FLAMES AWAY," "MEN WORKING," "DO NOT OPEN THIS VALVE UNDER ANY CONDITION," "NO SMOKING," "TURN ON FAN BEFORE ENTERING PIT, PUMP HOUSE," "DANGER NO OPEN FLAME OR IGNITION SOURCE BEYOND THIS POINT" and so forth. Identification banding or coding, according to MIL–STD–161, must be applied, maintained, and inspected according to chapter 10. Bilingual signs will be used when appropriate. Signs must comply with AFOSH Standards and TO 37–1–1 requirements.

(5) Vapor and Explosion-Proof Equipment. All control of electrical equipment in areas where explosive vapors may be present or where volatile fuels are handled must be approved for use in areas having hazardous flammable liquids, as set up by the National Electrical Code and HQ USAF. Each repair project for a fuel facility is inspected to determine if requirements for such equipment have been met.

(6) Housekeeping. Cleanliness, neatness, and order are necessary for safe, efficient operation. It is the duty of each individual to report, or correct if possible, any situation that can create a hazard to personnel or property.

g. Fire Protection. Fire protection facilities are kept in a constant state of readiness according to AFR 92–1.

h. Supervision and Organization. Each active installation will retain the services of an individual qualified to direct the petroleum fuel facilities maintenance program according to the standards established on a fulltime basis. This individual will be employed fulltime as the liquid fuels system maintenance shop supervisor. His or her supervisor will be cognizant of safety precautions and the health of maintenance personnel according to AFOSH Standards 127–38 through 40 and AFM 161–130, volume II. The number of persons assigned to the maintenance crew depends on the size and type of the facilities to be maintained. AFM 26–3 gives guidance on minimum manpower requirements to support maintenance of various type and size petroleum facilities.

i. Preventing Environmental Contamination. Plans for existing fuel facilities include necessary provisions to prevent air, water, and ground contamination. Supervisory personnel are responsible for making sure liquid fuel wastes are not discharged into sewers or streams. Any waste disposal of fuel spills is made according to approved oil and hazardous materials spill contingency plan.

Section B—Quality Surveillance of Liquid Petroleum Products

1–6. Importance of Quality Surveillance. The flow chart in figure 1–2 shows the complex process by which crude oil is converted to finished petroleum products. Each product has characteristics, based on its composition, that make it suitable for its intended use. Any change in composition, therefore, is a serious matter and may result in loss of time, money, and overall efficiency. Although quality control of fuel products begins at the refinery, quality surveillance at base level is a matter of concern to all persons involved in the storage and dispensing of fuel. Improper or inadequate maintenance can contribute to the deterioration and contamination of fuels, thus adversely affecting their usefulness and seriously hindering the mission of an Air Force installation.

1–7. Quality Assurance Representatives' (QARs) Responsibility. QARs determine whether petroleum products purchased by the government are manufactured according to existing specifications. General responsibility for the maintenance of product quality rests on individuals handling or storing Air Force petroleum products and those involved in the maintenance of fuel systems.

1–8. Deteriorating Products. Changes occurring while a product is in storage are marked as the product ages. The changes may be caused by storage conditions. Because these changes are usually not noticed by persons handling the product, their discovery depends on adequate laboratory control programs. The most common forms of deterioration are as follows:

a. Product Weathering. Weathering refers to loss of the more volatile components of some products.

Its effects are most noticeable in motor and aviation gasolines (AVGAS). These products are mixtures of liquid ingredients, some of which evaporate more readily than others. The rate of evaporation increases with rises in temperature and produces gas pressures sufficiently high to rupture an unvented container. For this reason all tanks are vented to atmosphere. Excess vapors escape through the vents, and during weeks or months of storage, a considerable proportion of the more volatile ingredients may be lost. Because the more volatile components of the fuel are required to provide easy starting in engines and a plentiful supply of fuel during warmup periods, if issued in cold weather, the less volatile weathered fuel may give considerable trouble.

b. **Gum Formation.** Gum formation is the most common and troublesome form of deterioration affecting fuels used in internal combustion engines. Gum formation is caused by the presence of unsaturated hydrocarbons in the fuel of the decomposition of fuels by chemical reaction with zinc, copper alloys, or galvanized metals. In the presence of oxygen, these hydrocarbons undergo chemical changes producing first gummy, and eventually resinous materials. The latter are insoluble and slowly settle on the walls and bottoms of containers, from which they are difficult to remove. The gummy substances remain dissolved but are difficult to vaporize.

c. **Effect of Gum Deposits on Fuel Systems.** Gum is sometimes found as deposits in fuel lines; during vaporization of fuel they may clog carburetor jets. In either case they have an adverse effect on the fuel supply. Carried mechanically by the rush of vapors to combustion chamber, they may form sticky deposits on rings and valves, thus decreasing efficiency of operation; resulting in excess carbon deposits. The existence of gum in fuels, in greater than allowable amounts, increases engine maintenance. Although gum or oxidation inhibitors are added to internal combustion engine fuels, these additives are effective for a limited time only and do not offer permanent protection. The use of zinc, galvanized metal, or copper alloys inside storage tanks is prohibited.

d. **Loss of Additives, Tetraethyllead, and Color.** These forms of deterioration are considered together because their causes are not established with certainty, although all have been known to occur during storage. Each may be the delayed result of manufacturers' mis-

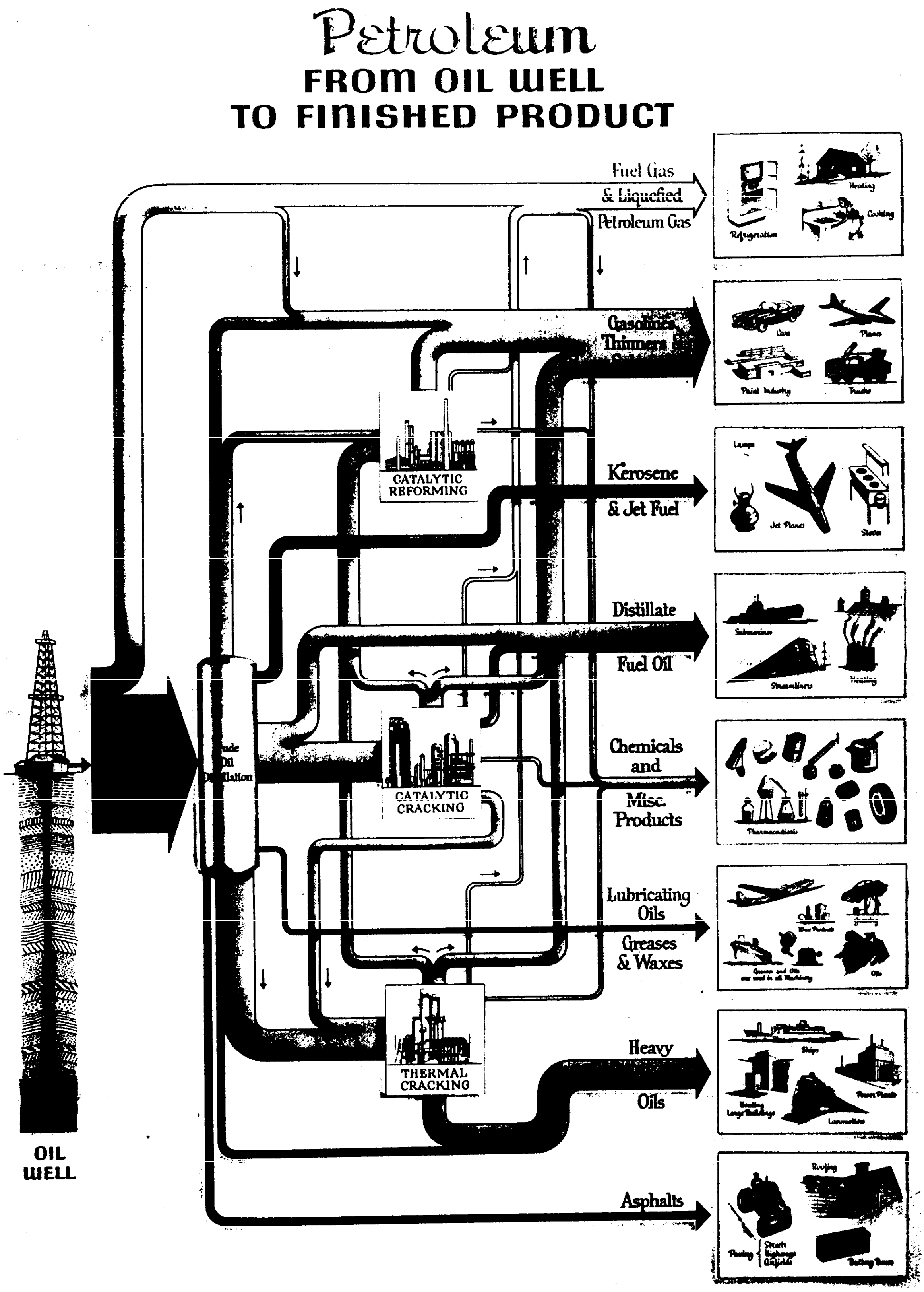


Figure 1-2. Petroleum From Oil Well to Finished Product.

takes, improper handling, or contamination. Loss of oxidation inhibitors decreases the safe storage time of fuel because of possible early formation and rapid development of gum. The loss of tetraethyllead decreases the power-producing characteristic of fuel and indicates very serious deterioration, particularly in aviation fuels. Loss of color, itself, has no importance other than its psychological effect on the consumer, who invariably distrusts such a product.

1-9. Contaminating Products. A contaminated product is one to which has been added some material not usually present (such as dirt, rust, water, or another petroleum product). Such a mixture may permanently change the usual qualities of the product or add new and undesirable characteristics. In either case the contaminated product may be unsuitable for its intended use. Contamination may result from accident, inability or neglect to follow prescribed procedures, gross carelessness, failure to update facilities to current standard criteria, or sabotage. In most instances, contamination can be detected by personnel handling the product. However, any product suspected of being contaminated should be reported to the laboratory, because contamination can sometimes be determined only by laboratory tests. The following are typical contaminating substances:

a. **Dirt:**

(1) Corrective action is taken, if large quantities of sand, clay, or loam are found in petroleum products. It may be the results of carelessness or sabotage; most commonly it is the result of inadequate cleaning and inspection of tanks or containers, the use of open tanks, failure to close small containers, or the use of water to flush pipelines.

(2) In light fuels such as gasoline, in cans or drums, dirt settles in a few hours. The clear fuel may then be drawn off and the bottom (4 to 10 inches) recovered by filtering. An alternative is to pour the fuel into larger containers for further settling. In bulk tanks, the settling may require a minimum of 2 hours. The clear fuel may then be run off to clean storage and the bottom layer passed through fuel filters. Tanks and other containers should be thoroughly cleaned before they are reused. In heavier fuels (such as diesel oils, and jet fuels), settling is much less satisfactory. Filtration is recommended if practicable.

b. **Rust and Mill-Scale:**

(1) Rust is the common name for the product of corrosion formed when unprotected iron or some steel surfaces are subjected to prolonged contact with water or moist air. Rust is brittle and powders quickly. It is insoluble in water and in petroleum products, and may form troublesome suspensions because of turbulent flow in pipelines, the churning action produced while pumping into storage tanks, or the rough handling of small containers. Rust is an occurring source of contamination, particularly in pipelines or containers used without proper cleaning. Active pipelines and large storage facilities do not normally permit its accumulation in appreciable quantity.

(2) Mill-scale is a magnetic product formed on iron and some steel surfaces during the manufacturing process. It is largely responsible for the blue-black appearance of such surfaces. Mill-scale has been observed as a very serious contaminant in bulk products pumped through new pipes during the first few days or weeks of use. The scale is brittle and easy to crack. Corrosion begins at these cracks and proceeds to spread under the scale, causing it to flake off. The scale is then carried along by the product and is broken up still further before it reaches terminal storage. Here it may remain suspended for days. Settling is not, therefore, a satisfactory method elimination. The scale is not removed completely by segregators; so screens are quickly choked. Filtering such stocks is recommended.

c. **Water:**

(1) Batching pigs, not water, will be used to separate and prevent mixing products when two products (such as motor gasoline and aviation gasoline) are pumped through a pipeline one after the other. Using water as a separating medium provides opportunities for contamination of the fuels.

(2) In case of packaged products, water may become a contaminant through the use of open or damaged containers, or through improper storage and handling methods. Water contamination of fuels in drums or cans is avoided by using prescribed methods of inspection, storage, and handling.

(3) The most effective and proper protection for lubricants is to keep them well covered, preferably in an inside storage. If damaged containers permit water to contaminate engine or gear oils, the water may remove some of the essential additive. Even more undesirable is the tendency of water to emulsify in the oil and not settle out, thus decreasing effective lubricating action. Water can be poured off from greases. When this is done, about an inch of surface grease should also be removed. After removal, the surface grease should be disposed of according to the approved oil and hazardous materials spill contingency plan.

d. **Caustic Soda or Alkaline Slimes.** During the manufacturing process of many petroleum products, caustic soda or other alkaline solutions are introduced to the product to remove acids and impurities remaining from the cracking process. The product is then washed with water to remove the caustic soda and alkaline solutions.

(1) These chemicals, if not completely removed by the manufacturer, will be absorbed by any water present in the transfer lines or storage tanks and will form a slime that collects on the interfacial level between the petroleum product and water. Eventually the interfacial level is disturbed, and the slime is released into the fuel and introduced to the remainder of the system as the petroleum product is circulated.

(2) Slime is not stopped by filters or separators but has an affinity for metal, to which it adheres and eventually hardens. Effects of slime are fouling equipment with close mechanical tolerance (pumps, meters, etc.), oxidation and corrosion of some metals (especially aluminum), clogging small drains and orifices, and equipment failure if the slime reaches the end item using the petroleum product.

(3) Control of slime can be made only by eliminating water within the system, and proper tank filling and dis-

pensing procedures that do not disturb water accumulations at the bottoms of storage and operating tanks.

e. **Mixing Products.** Mixing products may cause inadequate evacuation of lines, containers, or storage tanks from the use of unmarked or improperly marked containers and improper handling of manifolds. In such cases, mixing can be decreased by making sure the prescribed petroleum handling procedures are being applied. Products that have been mixed must be laboratory tested to find out the quality of the product. Products that do not meet the specification of their intended use must be downgraded to a specification at which they can be used. Mixing may also result from leaks in tanks or valves aboard tankers. These sources can be minimized by proper inspection and maintenance procedures. Nevertheless, serious contamination of one product by another can and does occur in field operations. Effects of mixing are:

(1) Jet Fuel. The contamination of jet fuel (JP-4) (5 percent or less) by small quantities of AVGAS will affect jet engine performance. Any contamination of jet fuels by hydraulic fluids and specialty products may seriously affect performance and must be avoided.

(2) Aviation Gasoline (AVGAS). AVGASs are carefully blended for antiknock qualities. These qualities can be completely destroyed by slight contamination of other petroleum products, especially jet fuel, diesel fuel, and lubricating oils. The amount of contaminant may be so small that it cannot be detected except by laboratory analysis. Therefore, any contamination of aviation fuel must be avoided. Effects of AVGAS contamination include loss of power, increase in gum content, engine knock, and in some cases, complete engine failure.

(3) Diesel and Lubricating Oils. Diesel and lubricating oils are not affected by slight contamination. However, the lighter, more volatile product will thin these oils and reduce their lubricating qualities and, in some cases, produce a fire or explosion hazard. Contamination of diesel and lubrication oils should be avoided.

(4) Fuel Conversion and Storage Systems. Fuel storage tank lines and servicing equipment should be flushed with the new product and inspected when changing from one fuel to another. Critical inspections are necessary when switching from jet fuel to AVGAS to make sure that all jet fuel is removed. Requirement for tank cleaning is based on actual cleanliness of tank. Jet fuels at times react as a solvent that loosens rust and scale clinging to the walls of storage tanks. Diesel and lubricating oils must be treated the same as jet fuels.

f. **Biological Growth.** Bacteria and fungus living in water pockets at the bottom of fuel tanks use the fuel for their own nutrition and reproduce to form bacterial pellicles and fragments of fungus mycelium. Two major problems caused by fungus mycelium are:

(1) Formation of a fuel-water emulsion that contaminates the fuel.

(2) The entrance of bacteria and fungus particles into the fueling system that causes serious clogging of filters. These two problems can be controlled by eliminating water in storage tanks and maintaining the required level of fuel system icing inhibitor (FSII).

SECTION C—CHARACTERISTICS OF LIQUID PETROLEUM PRODUCTS

1-10. General Information. Although the handling of petroleum products presents many hazards, both bulk and packaged products can be handled safely, if product characteristics are understood and proper precautionary measures are taken. Maintenance personnel should know that the hazard in handling and storing aviation fuels is not only in the fuel itself (which is toxic to the human body whether by skin contact or by ingestion), but also in its vapors. Vapors from all petroleum products constitute fire and explosion hazards and are toxic to the human body. Vapors from petroleum products have caused fires or explosions since they are heavier than air and settle in low places, such as in tanks or pits where they present a serious fire or explosion hazard; they will remain in these low places indefinitely unless removed by ventilation. A detailed discussion of product characteristics is in AFM 161-30, volume II, and DOD MIL-MDBK-201.

1-11. Characteristics of Gasoline Products:

a. **Volatility.** Light products (such as motor and avgas) evaporate under normal atmospheric conditions. Vaporization increases with an increase in temperature or with a decrease in pressure caused by high altitudes or pump suction. Vapor lock in pumps may be caused by the formation of fuel vapor created by suction in the pump or by heat transmitted to the fuel through pipe or container walls. Usually the suction lift of commercial grade gasoline at sea level should not exceed 12 feet, including pipe friction losses. To determine allowable suction lift, make allowances for elevation, heat conditions, length and size of suction line, and number and type of valves and fittings.

b. **Flammability.** Gasoline products vaporize rapidly at ordinary temperatures and even below 0°F. A mixture of vaporized gasoline and oxygen (air) in correct proportion (1 to 7.6 percent gasoline vapor by volume) is combustible when heated to ignition temperature. Under normal atmospheric conditions, mixtures containing more than 7.6 percent gasoline vapor are too rich to burn unless mixed with more air. Combustible mixtures can be ignited by flame, electric sparks, or by contact with any material having a temperature over 540°F. Ignition within a confined space may cause an explosion.

c. **Expansion.** Because gasoline products expand about 0.07 percent for each degree of Fahrenheit temperature increase, the pressure in a closed section of the system, pipeline, or hose increases rapidly when the temperature rises. Unless this condition is relieved, leakage or permanent damage to a valve, meter, or other piece of equipment may result.

d. **Weight.** Gasoline, lighter than water, spreads over the surface of water and will not mix readily with it. Gasoline vapor is heavier than air and settles into pits and low areas, creating mixtures that are fire and explosion hazards and dangerous to breathe.

e. **Chemical Effects.** Care should be used when selecting lubricants for valves, pump shafts, swing joints, or other lubricated points, because must lubricants are soluble in gasoline products. Natural rubber, several synthetic rubbers, sealants, and pipe joint compounds should not be used, because they deteriorate when in contact with gasoline products or their vapors.

f. **Physiological Effects.** Petroleum distillates, after prolonged contact with the skin, produce a defatting and irritant action, causing dermatitis or actual skin burn. If splashed in the eyes, petroleum distillates causes irritation and damage to the eyes.

(1) Inhalation of concentrations of petroleum vapors greater than 500 parts per million (ppm) will produce a stage of excitement eventually leading to unconsciousness if breathing of vapors is continued. Breathing of petroleum vapors in confined spaces may lead to rapid asphyxiation because of oxygen deficiency.

(2) Ingestion of small quantities of petroleum products by means of contaminated food or water, or by accident will have toxic effects. These effects will cause severe discomfort and may be fatal, depending on the quantity consumed.

(3) The aviation gasoline antiknock additive, tetraethyllead or ethyl fluid, is extremely toxic by skin contact or ingestion in the liquid state, or by inhalation in the vapor state or in the form of dust deposits. The degree of exposure to ethyl fluid by means of contact with leaded gasoline is not considered particularly dangerous, exposure to ethyl fluid and its decomposition products that have been separated from the gasoline is extremely dangerous. This condition may be found in storage tank bottom sludge or in places where deposits have resulted from prolonged evaporation of gasoline.

1-12. Characteristics of Jet Fuel. The jet fuel currently adopted for general Air Force use is grade JP-4.

a. **Volatility.** Grade JP-4 is a low vapor-pressure fuel developed by excluding some gasoline fractions in the refining process. It is less susceptible to vapor lock than some earlier jet fuels.

b. **Flammability.** Because of its relatively low vapor-pressure range (Reid vapor pressure of between two and three pounds per square inch (psi)) grade JP-4 requires added precautions in handling. It forms explosive vapors in the space above the liquid in cone roof and below-ground storage tanks in the range of minus 10°F to plus 80°F; these are temperatures usually encountered in storage and handling of fuels. Jet fuel is more subject to buildup of static electric charge than gasoline products.

c. **Expansion.** Jet fuels expand about 0.07 percent for each degree of Fahrenheit temperature increase. In a closed tight pipeline system completely full of fuel with no provision for pressure relief the internal pressure will increase approximately 75 psi for each degree Fahrenheit temperature increase. Therefore, it is abosolutely essential that all closed systems be provided with a pressure relief by-pass system (pressure relief valve and check valve). Relieved fuel must be directed to a vented tank.

d. **Weight.** Grade JP-4 weighs approximately 6.4 pounds per gallon, is similar to gasoline, and requires the same precautions with regard to weight.

e. **Chemical Effects.** Jet fuels can be used with the same materials as aromatic aviation gasoline as long as the concentration of mercaptan-sulfur does not exceed the maximum permissible unit (0.001 percent). Excessive concentration of mercaptan-sulfur increases the corrosive action of the fuel and can cause deterioration of synthetic rubber packng, gaskets, and hoses.

f. **Physiological Effects.** Jet fuels do not contain tetraethyllead. However, they contain more toxic aromatics than AVGAS. They should, therefore, be handled with the same health precautions that apply to leaded gasolines.

1-13. Characteristics of Fuel Oils:

a. **Volatility.** Fuel oil is stable at normal temperatures, and its evaporation at these temperatures is relatively unimportant. Be sure to protect tanks and piping in cold climates, because fuel oil thickens at low temperatures. Supply heat to heavier grades of fuels by using steam coils or other approved methods.

b. **Flammability.** Fuel oil in the form of a vapor or gas is combustible when mixed with the proper amount of oxygen (air) and heated to its ignition temperature. Although fuel oil does not vaporize as easily as gasoline, dangers caused by accumulation of vapors in low areas or confined spaces are serious.

c. **Expansion.** Observe the same precautions for relieving gasoline expansion pressure of fuel oils as for relieving gasoline expansion pressures.

d. **Weight.** Fuel oil vapors are heavier than air and settle into pits and low areas, creating mixtures that may be fire and explosion hazards. Fuel oil is lighter than water and spreads over the surface of water.

e. **Chemical Effects.** Although fuel oil does not attack lubricants, rubber, and pump seals as rapidly as gasoline, use materials able to resist this action on all parts of the system in contact with fuel oil.

1-14. Characteristics of Lubricating Oils. The primary purpose of any lubricant is to reduce friction by eliminating metal-to-metal contact. Lubricating oil provides a film that permits surfaces to glide over each other with less friction. The four important functions of lubricants are lubrication, cooling, cleaning, and sealing.

a. **Lubrication.** To lubricate properly, an oil must be of low viscosity to flow readily between closely fitted, rapidly moving parts, but of sufficient viscosity to prevent metal-to-metal contact between these parts.

b. **Cooling.** A lubricant must cool parts by carrying off waste heat.

c. **Cleaning.** Another major function of a lubricating oil is cleaning or carrying off dirt, carbon deposits, gum varnish, and the like from moving parts and mechanisms. This characteristic is enhanced by the addition of detergents to the lubricating oil.

d. **Sealing.** Another function of lubricating oil is to seal spaces between piston rings and cylinder walls to prevent gas blow-by.

NOTE: At ordinary operating temperatures and pressures, lubricating oils have a sufficiently low volatility and flammability point and therefore do not present hazards involving fire, explosion, and toxic effects on the human body.

Section D—Safety Precautions and Hazards of Liquid Petroleum Products

1-15. General Information. Petroleum products are hazardous because they are toxic, explosive, and flammable. Adequate safety precautions are required and must be strictly followed for the safety of personnel and government property.

1-16. Toxic Liquids, Vapors, and Dusts:

a. Liquids. Most petroleum products are toxic because of their aromatic content or additives (especially tetraethyllead). Avoid getting jet fuel and gasoline on the skin and clothing. Jet fuel and gasoline remove protective oils from the skin, but cause drying, chapping and cracking that lead to infection, and possible blood poisoning. Severe chemical burns may result if jet fuel and gasoline remain in contact with the skin. Shower and remove contaminated clothing at once and avoid any source of ignition. Remove jet fuel and gasoline from the skin by washing with soap and water as soon as possible after contact. Remove any fuel that comes in contact with the eye immediately by means of the eye bath or by any other available means of flushing the eye with water and then secure medical attention as soon as possible. Petroleum products accidentally swallowed may cause central nervous system depression and pneumonia. Do not induce vomiting, and do not allow the victim to smoke! Victims should be taken to the medical facility at once. Be sure to inform medical authorities on the type of fuel and approximate amount ingested. Our body's natural way to get rid of the volatile petroleum liquid is by slowly venting off the absorbed liquid in vapor form through the lungs. In this case, even though the patient's life is not in immediate danger, he or she may be admitted to the hospital for observation. Other effects from liquid contact may be to liver, kidneys, or bone marrow, from additives or contaminants such as benzene.

b. Vapors. Vapors accumulate inside enclosed areas (such as tanks and pump houses) and settle in low areas (such as pits and valleys). Effects of vapors are detailed in paragraph 1-11f. Although with rest and fresh air there may be recovery from these effects within a few hours, all physical reaction resulting from jet fuel or gasoline vapor inhalation must be reported promptly to a physician (base surgeon). To eliminate personnel hazards of vapor concentrations, the following precautions must be observed:

(1) Any area known to contain or suspected of containing concentrations of jet fuel or gasoline vapors must be checked with a vapor meter (see paragraph 11-10 for details of entrance into hazardous areas).

(2) After an area has been cleared, constant surveillance is necessary to make sure vapor concentration does not rise above the safe limit while work is in progress. Sludge, ground leaks, and saturated items can continue to give off vapor, thus contaminating an area after it has been cleared.

(3) Petroleum products that are not considered toxic should not give reason to relax safety precautions. Regardless of their toxicity, petroleum vapors will displace oxygen in an area because of their heavier weight, and may cause asphyxiation.

(4) Vapor concentrations within the combustible or explosive range, whether confined or free, are easily ignited. The precautions outlined in paragraph 1-21 must be strictly followed.

c. Dusts. Dusts are formed by additives in the petroleum product remaining after the volatile liquids have evaporated, solid particles of sludge being dispersed into the air as the sludge dries, and scale and rust particles being removed from tank walls and strainers during the cleaning operation. Proper disposal of sludge and cleaning waste, as directed by the BCE will eliminate the major cause of toxic dusts.

1-17. Hazards of Tetraethyllead and Jet Fuel. Tetraethyllead (TEL) in the forms of liquid, vapor, and dust is extremely toxic to personnel and must be avoided. TEL can enter the body by being absorbed through the skin, breathing vapors and dust particles, and handling contaminated materials that permit TEL particles to be transferred by the hands to the mouth and other parts of the body. Areas, especially tanks that have contained tetraethyllead, present a special problem (see paragraph 11-13c). Both jet fuels and avgas have moderate skin irritant properties that can result after more than momentary contact in scaling, in skin breaks and blistering. Accidental swallowing is considered hazardous; if aspiration into the lungs occurs, pulmonary edema may result. If the substances enter the eyes, rinse out immediately with an eye bath and seek medical attention.

1-18. Hazards of Fire and Explosion. Fire hazards are present wherever petroleum products are stored, transferred, or dispensed. Such hazards arise through leakage or spillage of petroleum products; accumulation of vapor in enclosed or low areas; improper grounding and bonding of components; ignition from external source; and relaxed discipline in regard to fire regulations. Inspection of all static grounding devices must be made according to chapter 10. Leakage and spillage must be kept to a minimum by promptly reporting all leaks and deficiencies to the proper authority, and by observing proper dispensing procedures. Rules, regulations, and safety notices must be observed and strictly enforced at all times. Chapter 1, section E, outlines source of fires and methods of prevention, and prescribes fire fighting procedures.

1-19. Required Safety Features. Alteration or modification of petroleum facilities must conform strictly to such Air Force standards as AFM 88-15 (chapter 2); and AFOSH Standard 127-38 through 40. Alterations may be affected when existing facilities are uneconomical to maintain and operate. Attention should be given to the special facility features below:

a. Pit Access. Where necessary, pit covers should be altered or replaced to provide free and unobstructed access. A survey should be made to determine pits essential to the operation and control of the system. Existing pits not essential, or that can be nonessential, should be filed with sand to eliminate vapor hazard unless flanged connections are in the pit. Pits containing items of equipment requiring protection such as valves, pumps, electrical motors, controls, etc., will be kept clean, dry and vapor-free.

b. Ventilation. Adequate ventilation must be provided for below grade pumphouses and deep pits to prevent accumulation of explosive vapors. Opening of pit covers normally provides sufficient ventilation for shallow pits and manholes (generally used for maintenance purposes only).

(1) Use the two-person policy when it is necessary to enter a fuel pit that is not equipped with an operative positive mechanical ventilation system.

(2) Below grade pits with installed pumps or pits more than 6 feet in depth, where entrance of personnel is required, will be provided with positive mechanical means for removal of hazardous vapors. Use louvers at roof, ceiling, and floor levels to ventilate an aboveground installation, other than an operating pumphouse and control room that requires positive-pressure mechanical ventilation.

c. Drainage. Where water from seepage, flooding, or other causes is encountered in large pits, drainage by gravity or sump pumps should be provided. Hand pumps should be used to remove water from small pits. Drains from pits or pumphouse floor will not be connected to sanitary or storm sewer systems. Sump pumps will not be required in lateral control pits of hydrant fueling system type II unless justified by local conditions.

d. Personal Clothing Requirements. Studies have proven that all cotton clothing and cotton polyester blend clothing (50 percent polyester and 50 percent cotton blend) give about the same degree of risk in generating static electricity—both types of clothing will generate sufficient static charges to ignite fuel-air mixtures.

(1) The 50-50 blend produces less charging than the 100 percent cotton; therefore, it is the preferred clothing. Considering this, all personnel involved in servicing operations or repair must exercise care in frequently grounding themselves during operations to remove static charges.

(2) The studies have further identified that the greatest static charges recreated during the replacement or removal of outer garments such as field jackets, parkas, etc., are caused by the electrostatic interaction of the fabric fibers.

(3) To eliminate this hazard potential, personnel must not put on or remove such garments while engaged in fuels handling or servicing operations.

(4) Civilian or military clothing of all wool, silk, or nylon materials, or blends of silk or nylon, generates far greater electrostatic charges and constitutes an unacceptable hazard potential; therefore, clothing made of these materials must not be worn as outer garments during fuels servicing or handling operations. The wearing of wool stockings, wool glove inserts, woolen navy stocking caps (where authorized) and underwear of nylon, silk, or polyester poses no significant hazard and are acceptable.

(5) Additional guidance concerning wearing of clothes and outer garments is as follows:

(a) The Air Force nylon and polyvinyl raincoat is not authorized for wear during fueling operations. Foul weather gear is allowed in TA 016 for LFM personnel who are subject to outside work during inclement weather.

(b) Personnel assigned duties in tank inspection or cleaning operations will wear coveralls fabricated from 50 percent polyester and 50 percent cotton, that are authorized in TA 016.

(c) Specifications for conductive footwear are being updated and, when available, will be the preferred item in fuel handling areas.

1-20. First Aid:

a. Inhaling Vapors. The concentration of gasoline, jet fuel, or fuel oil vapors that can be inhaled safely is far below that required to reproduce combustible or explosive mixtures with air. Even one-tenth of the concentration needed for combustion or explosion is harmful if inhaled for too long a time. Remove persons showing signs of dizziness, nausea, or headache from the hazardous area. Recovery from early symptoms is usually prompt after removal to fresh air. If a person is overcome, administer first aid at once and obtain prompt medical attention. If breathing has stopped, apply cardiopulmonary resuscitation.

b. Swallowing. Petroleum products are exceedingly irritating when swallowed. If swallowed, do not induce vomiting except by direction of a physician, as uncontrolled vomiting may cause more petroleum products to go down the windpipe and produce severe and rapidly progressing pneumonia. If choking or vomiting occurs, the subject should be placed on his or her stomach with head turned to side and airway cleared to ensure drainage by gravity and to decrease the chance of aspiration. If subject is unconscious and not breathing, administer cardiopulmonary resuscitation.

★**c. Skin Irritation.** Avoid getting gasoline on the skin. Petroleum fuels remove protective oils from the skin, but cause drying, chapping, cracking, and infection. Severe burns result if gasoline remains in contact with the skin. Remove by washing with soap and water as soon as possible after contact. If a person becomes drenched, shower and remove soaked clothing, shoes, or gloves, at once and avoid exposure to any source of ignition.

Section E—Fire Prevention

1–21. Preventing Petroleum Fires.

a. General Information. Three simultaneous conditions (as shown in (figure 1–3) are necessary to create petroleum fires:

(1) Petroleum must be in the form of vapor.

(2) Air-vapor mixture must be present in correct proportion to support combustion or explosion.

(3) The combustible mixture of air and petroleum vapor must be raised to its ignition temperature or subjected to a source of ignition. The absence of any one of these conditions, as represented by the missing leg of the fire triangle in figure 1–3 prevents a fire. It is not practical to eliminate air completely or to control air-vapor proportions where gasoline is handled and dispensed. Temperatures cannot be controlled to the point where vapors are not possible. Therefore, to eliminate all sources of ignition is essential to prevent fires.

NOTE: Liquid oxygen coming in contact with fuel reacts violently to produce spontaneous combustion. It is mandatory that these materials be kept isolated from each other.

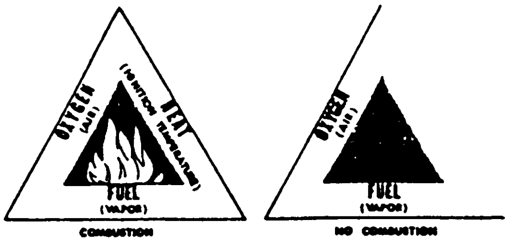


Figure 1-3. Principles of Ignition.

b. **Sources of Fire and Explosion:**

(1) Vapors above the explosive limit are not combustible, providing the tank is not opened. However, after the tank has been opened, vapors escaping to the atmosphere are quickly diluted within the explosive limit, and, if ignited will cause fire at manholes and other outlets of the tank. Eventually the vapor concentration in the tank is diluted creating a fire and explosion within the tank.

(2) Extra precautions must be taken when venting a tank to be sure all sources of ignition are eliminated. Petroleum vapors are heavier than air and will travel several hundred feet before they dissipate into the atmosphere. Any source of ignition may ignite such vapors and cause a flashback, resulting in fatalities of personnel caught in the flashback and loss of the property issuing such vapors.

(3) Sludge and other saturated material (sediment, hollow roof supports, sidewall scale, oil-soaked wooden structures, etc.) continuously release petroleum vapors. These vapors can accumulate to above the explosive limit in an enclosed area. A tank should not be declared safe until all such materials have been removed.

(4) Primary sources of ignition are negligence, relaxed disciplinary action to violators of safety regulations, and static or stray electrical currents.

c. **Preventive Measures.** Preventing petroleum fires can best be done by reducing or controlling the open presence of petroleum products and vapors, and by eliminating sources of ignition as follows:

(1) Provide proper ventilation for pumphouses, pits, and other enclosed spaces where petroleum vapors may accumulate.

(2) Take all precautions to prevent leakage or spillage of petroleum products.

(3) When spillage may be expected from pipes, hose connections, or opened equipment, ventilate the area and eliminate all sources of ignition. Direct spillage to an enclosed or covered container and return to storage when practicable.

(4) If a small amount of liquid petroleum spills on the ground, cover it immediately with dry sand or earth. If a small amount spills on concrete or asphalt surfaces, cover it with dry sand or earth, or flush it off with water to a safe location. When petroleum products or vapors collect in catch basins, or discharge into streams or drainage systems, they remain hazardous.

(a) Extreme precautions must be taken to prevent any petroleum product from entering the sanitary or storm sewer system. Call the responsible individual designated in the Base Oil and Hazardous Substance Pollution Contingency Plan for specific instructions on handling fuel spills.

(b) Do not move a vehicle from an area where petroleum products have been spilled until all flammable liquid is removed and the area is freed of hazardous vapors (unless vehicle is rolled or towed away without starting the motor or using other sources of ignition).

(5) Prohibit open flames within 50 feet of hazardous installed facilities (50 feet distance limitation for LPG containers) or vehicles transporting flammable liquids or performing fuel servicing operations. Post safety signs conspicuously in remote areas and locations unfamiliar to operating personnel.

(6) Be sure all static grounding and electrical work is done according to chapter 1, section F.

(7) Do not weld, cut, rivet, or perform mechanical or other hot work on storage tanks, floating roof pontoons, pipe columns, pipework, or other equipment that has contained flammable substances until the equipment is properly ventilated and vapor free. Drain, purge, and ventilate tanks or other equipment brought to shops for repair. Keep them outside the building, well away from open flames and other sources of ignition.

(8) Allow only experienced personnel to perform welding, riveting, or other hot work on tanks or liquids or vapors. All hot work will be done by certified personnel under the direct supervision of a person designated by the MAJCOM liquid fuels engineer.

(9) Immediately dispose of gasoline-soaked or oil-soaked rags or waste, or place them in approved closed noncombustible containers until they can be disposed of permanently. Where major repair operations raise a possibility of sizeable spills, call fire department authorities for standby.

(10) Any person saturated with fuel will require a water shower deluge in the immediate area before removing any clothing.

1-22. Fire Fighting Precautions:

a. Provide approved "Class B" fire extinguishers at all locations where flammables are unloaded, pumped, stored, or dispensed. Appropriate types and quantities of extinguishers are determined by local fire department authorities.

b. If fire blankets are provided, keep them in conspicuous and easily accessible locations. Blankets are effective mainly for prompt extinguishment of burning clothing on personnel and should be reserved for this use.

c. Post conspicuous signs or placards showing the nearest location of fire-reporting stations or telephones in remote areas and locations unfamiliar to operating personnel. See that all personnel are familiar with their location.

d. Instruct all inspecting, operating, maintenance, and repair personnel to call the fire department immediately in case of fire or explosion.

e. Training sessions for maintenance and operation personnel will be conducted by the base fire chief on request and should include operation of firefighting equipment. Sessions should include the actual extinguishing of fires to familiarize personnel with the various types of fire fighting equipment, and simulated fires to train operators in the proper procedure of stopping the fuel flow to the fire area.

f. Inspection, maintenance, and repair of automatic fire extinguisher systems when installed in bulk storage areas are the responsibility of the base civil engineer shop or fire protection personnel.

1-23. Extinguishing Fires. Make sure that personnel responsible for inspection, maintenance, and operation of liquid fuel systems know how to operate all types of fire extinguishers and are trained to extinguish fires. During each operation involving fuel transfer, adequate extinguishers of a type suitable for use on fuel spill fires should be readily available. Call the fire department immediately when any type of major spill, leakage, or fire occurs (see AFR 92-1).

a. **Brush or Grass Fires.** Extinguish brush or grass fires with water.

b. **Fire at Dome of Tank Car or Tank Truck.** In case of fire in the dome of a tank car or tank truck:

(1) Close opening with dome cover.

(2) Apply Halon 1211 or other suitable extinguishing agents.

c. **Ground Fire or Burning Pool at Fueling Area.** To extinguish fires or burning pools at a fueling area:

(1) Apply aqueous film forming foam (AFFF) separately or in combination with Halon 1211 or other suitable extinguishing agent.

(2) Extinguish with a very fine water spray or fog; then cover with AFFF or otherwise dispose of residual fuel.

d. **Tank Vent or Manhole Fire.** If fire starts at a tank vent or manhole, apply Halon 1211 or other suitable extinguishing agent.

e. **Fire at Break or Leak in Pipelines.** In case of fire at a break or leak in a pipeline:

(1) Shut off flow of liquid and apply AFFF, Halon 1211, or other suitable extinguishing agent.

(2) Apply water spray or fog. Water fog may not extinguish the fire but is most useful in confining a flowing gasoline fire to a limited area.

f. **Fire in Open Tank or Pool of Liquid.** Extinguish fires in open tanks or open pools of fuel as follows:

(1) Apply AFFF on surface of liquid.

(2) Apply Halon 1211 or other suitable extinguishing agent.

(3) Apply water spray or fog.

g. **Pit Fires.** To extinguish a pit fire, extinguish fire with a water-spray nozzle on an applicator or long extension pipe, with AFFF, Halon 1211, or other suitable extinguishing agent. When a pit fire is extinguished, cool the pit and surrounding area to prevent reignition.

h. **Electrical Fires.** In case of an electrical fire, cut off source of power supply to apparatus involved. Extinguish fire with Halon 1211 or other suitable extinguishing agent that is a nonconductor of electricity. Do not use water or AFFF extinguishers on electrical fires, because they conduct electricity and may expose operators to electric shock.

Section F—Static-Electrical Grounding and Bonding

1-24. General Information. This section provides general information related to the two hazardous conditions that must be considered in handling and dispensing petroleum products. These major hazards are stray electrical current, and static electricity. See TO 00-25-172 for additional guidance on static electricity hazards.

1-25. Static Charge Generation in Refueling Systems. When low conductivity liquids, such as jet fuel, flow through POL Systems, they become electrostatically charged. These charges can produce enough electrical energy that will result in an ignition and fire or explosion of the fuel-air mixtures above the liquid fuel surface.

a. The mechanism of electrostatic charge generation is very complex with many variables that can increase or decrease the amount of electrical energy in fuel itself.

★b. Certain types of equipment and conditions are known producers of high static charges, and POL systems are designed to retard these hazards. However, the filter separator portion of these systems is a known prolific static generator, because of its filter media. Because of the large amount of static electricity generated by these filter elements, precautionary measures have been designed into each system to prevent hazards of fire protection.

★c. POL systems are grounded to earth potential, and each piece of equipment is electrically interconnected by bonding through mechanical connections; if no continuity exists, jumper wires are installed across insulated sections. Where flange sections are broken, bonding is attained by installing jumper wires. The static electricity generated in the system is given the opportunity to equalize its charge to ground potential, whether negatively or positively charged. However, some static electricity that has been entrapped in the fuel (due to low conductivity) will flow into the vessel being filled and will tend to breakout at the top of the liquid. Relaxation of static electricity is also the reason for providing grounding or bonding of aircraft.

d. Many other factors contribute to electrostatic charge generation in aircraft fuels, more detailed information may be found in technical libraries and TO 00-25-172.

(1) Aircraft refuelers and commercial transports during filling operations have developed measured electrostatic charges exceeding 50,000 volts (50 K volts). One reason for these high voltage build-ups is due to the insulating effect of the rubber tires from ground potential, if the vehicle is not properly grounded and bonded to the servicing system.

(2) The overhead method of filling refuelers and transport trucks is being replaced with "bottom loading" methods. The former overhead method allowed fuel to "free fall" creating a large static charge inside the vehicle's tank in an atmosphere conductive for an explosion. The bottom loading procedure is a much safer method of filling large volume tanks in fuel service, since there is no free fall of liquid to create static electricity.

(3) Flow of fuel through equipment and transfer pipes will generate sufficient static electricity to create a potential hazard. Tests have shown that a normal flow of fuel through a filter separator will produce sufficient static electricity to create a spark.

(4) The movement of contaminants (rust, mill-scale, water, air, etc.) during quiescent settling in storage tanks ionizes the contaminants to produce a static charge. These charges build up around triggering points (gaging and sampling devices, floats, and swing pipes) and, if not discharged through the fuel to the wall of the tank (that is, grounded), sparks can occur in the vapor space above the fuel. Petroleum products are poor conductors of electricity and do not bleed off static charges too rapidly; therefore, contaminants ionized during the transfer of fuel to the tank accelerate the build-up of static charges within the tank and increase the possibility of electrical sparks.

(5) Particles suspended in air of vapor can become ionized and create a difference of potential with the liquid fuel. The normal relative humidity of the atmosphere (moisture in air) provides a path to dissipate the static charge safely. However, in dry areas particularly at low temperatures the rate of discharge is slow and a dangerous accumulation of static electricity can build up.

(6) Personnel and clothing (wool, rayon, and synthetic materials) accumulate static electricity from normal body movement. These charges can be discharged through clothing, skin, or tools and equipment as they come in contact with components of the fuel system.

(7) Aircraft or service equipment may become electrostatically charged due to atmospheric inductive coupling. In this case, the base weather service notifies the maintenance officer of the impending hazardous condition such as lightning storms, and subsequently most fuel handling operations must be temporarily discontinued.

(8) Static charges accumulated on a person may be discharged by touching the cold bare metal of the grounded equipment to be serviced with a warm metal object such as a coin before making any fuel connections. This method places the human body at the same electrical potential as the equipment and reduces the changes of discharges (or sparking).

1-26. Preventing Static Electricity. Completely eliminating static electricity is impossible. However, the following precautions will reduce the quantity of charge and therefore the possibility of sparks.

a. Static bonding wire should be connected between two components before making or breaking a connection and before working on flanged connections insulated from one another by nonmetallic insulating materials. Grounding wires must be attached to the vehicle or aircraft before bonding to the grounding rod. This is especially important for operations involving the transfer of fuels (fueling, defueling, loading, and unloading operations).

b. Surface agitation should be avoided. The initial flow rate into a tank should not exceed 3 feet per second until the roof of a floating roof tank is afloat, or until the fill pipe in a nonfloating roof tank is completely submerged in the fuel. Fuel discharge in a tank should be horizontal rather than straight downward.

c. Contaminants (air, water, and solid particles) should be removed from fuel before it enters the tank. Filter separators and air eliminators must be grounded to drain off a static charge generated in the fuel while passing through this equipment.

d. No one will be allowed on an aboveground fuel tank until at least 30 minutes has elapsed after completing the loading or unloading operation.

e. Personnel working on or around tanks will wear only cotton or 50 percent cotton and polyester, cotton type work clothing or an approved antistatic type (see paragraph 1-19d).

f. Personnel will ground themselves to the tank by making firm contact between the tank and back of the bare hand or be holding a coin in the bare hand before opening any access covers or inspection holes. In addition, the sampling device should always be grounded to the tank before the sampling well is opened.

1-27. The Relaxation (Release) of Electrostatic Energy. If the fuel in Air Force systems were a perfect insulator, the electrostatic charges within the fuel would remain entrapped indefinitely.

a. The chemicals, hydrocarbons, etc., of which fuels are composed, do permit a flow of electrons. In the case of electrostatically charged fuel in a tank or pipe, the mutual repulsion of like charges in the fuel and their attraction to an opposite charge on the tank or pipe causes a current flow. This is the reason for grounding and bonding the POL system.

b. After a period of time, the electrostatic charge relaxes to a lower voltage level. The charges will never relax to zero or neutral, but will be reduced to a value considered safe in the presence of a volatile fuel-air mixture.

c. The time to relax fuels to a safe level, because of the varying conditions, ranges from a few minutes to many hours. Any visual or audible sounds such as fuel glowing or crackling in a fuel tank should be considered a *warning* to shut down the fueling operation.

d. Corrective measures should be taken to prevent immediate ignition or explosion. Preventive measures either in basic system design, method of use or other source of elimination of the potential hazard must then be taken.

1-28. Grounding or Bonding Procedures. Although generation of static electricity and stray currents can be reduced, they cannot be completely eliminated. To further reduce the hazard of a possible spark discharge, the static charges can be greatly reduced as they are generated by proper grounding or bonding techniques. The fol-

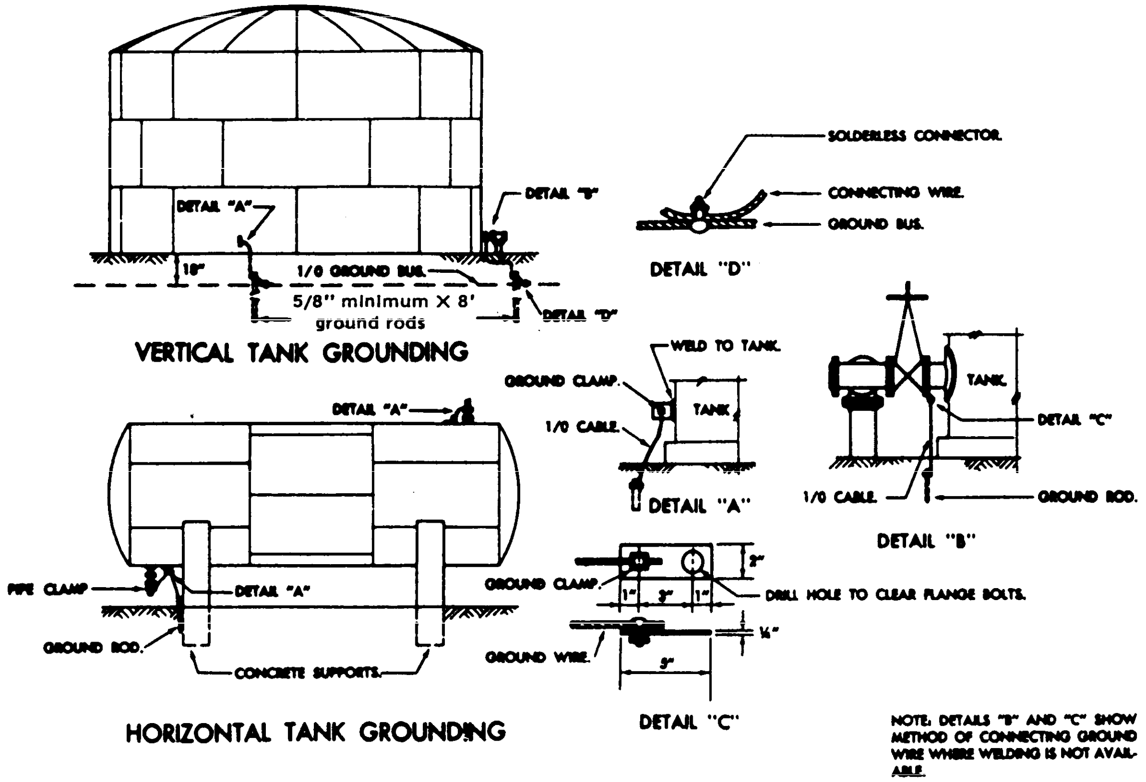


Figure 1-4. Typical Method of Grounding Above-Ground Storage Tanks.

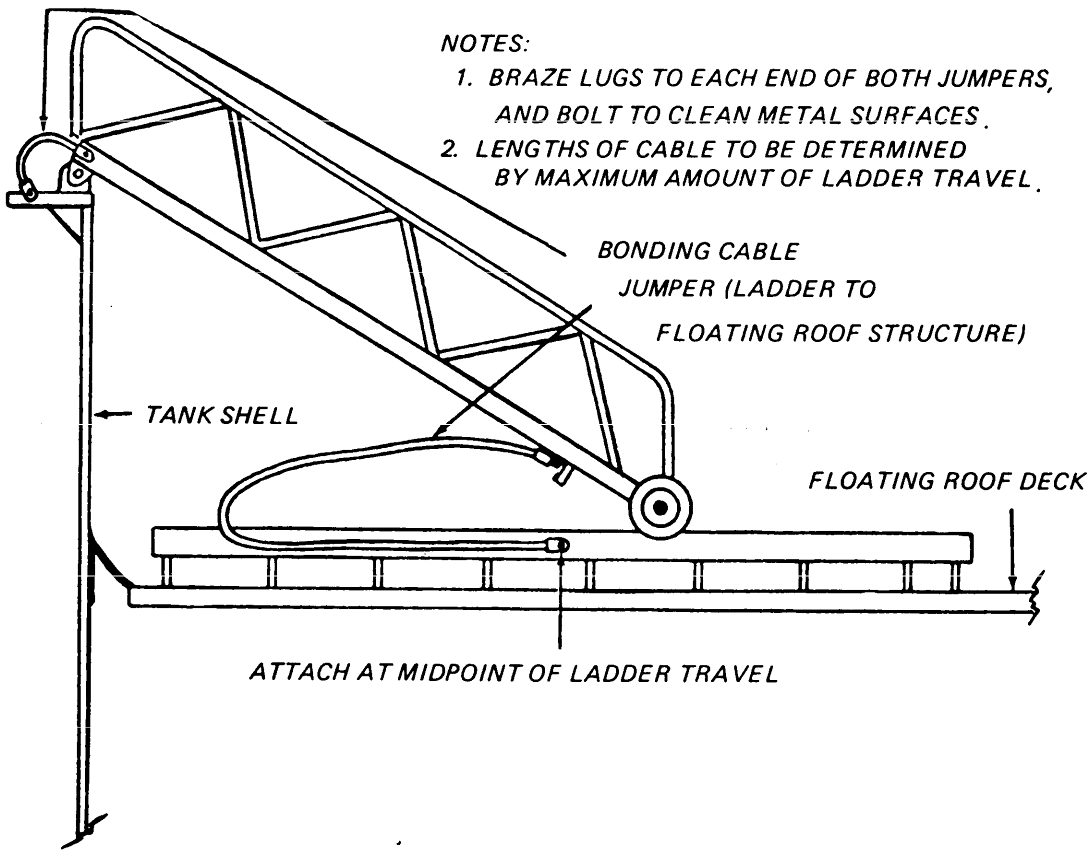


Figure 1-5. Ladder Bonding—Floating Roof Tanks.

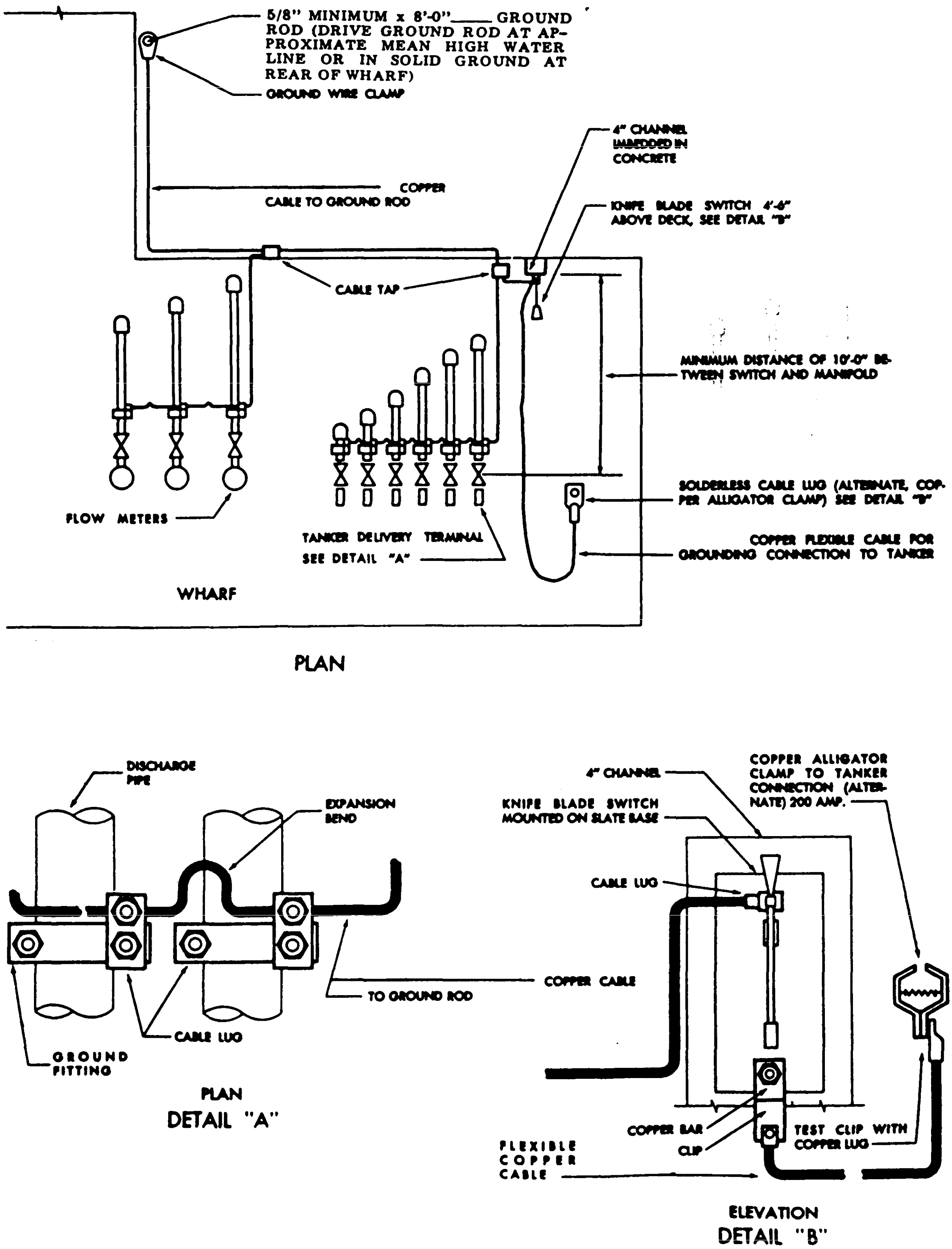


Figure 1-6. Typical Method of Grounding Pier, Floating, and Barge Facilities.

lowing grounding procedures must be followed with still greater care during the storage and handling of jet fuel because of the increased possibility of ignition by static charge. (Standard grounding criteria are in AFM 88-12, chapter 2.)

★**a. Storage Tanks.** Figure 1-4 shows a typical grounding method installed on existing aboveground tanks. The current design criteria on new aboveground tanks that rest on the earth (primarily vertical tanks which include those that rest on oil treated sand) do not require the use of ground rods unless a plastic liner is placed between the oil sand and the native soil. If necessary, a grounding system will be installed using galvanized steel ground rods and 1/4 to 3/8-inch galvanized guy wires as the grounding conductor. No copper is used in the grounding system. The purpose of this requirement is to eliminate corrosion caused by steel reacting with copper. On existing aboveground tanks in contact with the earth (including oil treated sand) where grounding is provided, using copper ground rods or copper grounding conductors, the grounding system should be removed and treated in the same way as prescribed for new installations. Also original design criteria calls for various methods of bonding floating roofs to tanks walls in floating roof tanks. A typical grounding method for existing aboveground tanks is shown in figure 1-4. This includes bonding of ladders on floating roof tanks as shown in figure 1-5. When these bonding cables require replacement use 3/32-inch stainless steel wire rope, nylon covered (NSN 4010-00-575-6234).

b. Pier Facilities. Before the start of unloading operations from a barge or tanker, and before hose connections are made, the ground wire on the dock must be securely bolted to a clean, paint-free surface of the discharge line of the ship.

(1) After this ground has been established, the switch on the dock should be closed, completing the circuit. The circuit must be maintained until discharging has been made and hoses have been disconnected. The typical procedure for grounding and bonding is shown in Figure 1-6. When replacement of the existing number 4 AWG copper (stranded cable) or copper alligator clamps becomes necessary, replace with 3/32-inch corrosion resistant plastic covered steel cables (NSN 4010-00-286-2681 and MS 27610 Clip, Electrical Ground, NSN 5999-00-134-5844, respectively).

(2) All ground-connection cables, switches, and bonding jumpers should be checked periodically for condition and tightness of contacts. These components will be inspected as specified in chapter 10.

★**c. Tank Car Loading and Unloading Facilities.** When a tank car is being loaded, the grounding cable must be securely attached to a clean connection on the car before any valve or dome covers are opened or fuel hose connection is made. There is no requirement to connect a grounding cable between the tank car and stand or fuel line header during unloading operations because adequate grounding is provided to the rails without the use of the grounding cable.

d. Truck Fillstand and Unloading Facilities. Under some atmospheric conditions a truck in motion builds up a considerable charge of static electricity. The cable must be attached before the fill hatch or outlet valve is opened or fuel hose connection is made. Figure 1-8 shows a typical bonding cable system and all grounding details. Ground rod B (figure 1-8) is located near the base of the fillstand. As soon as loading or unloading operations are completed and the fuel hose detached from the vehicle, the ground conductor must be disconnected. Periodic inspections should be made to ensure tight bonding and good ground conditions at all times. Grounding components will be maintained and tested as outlined under chapter 10, section G, and TO 00-25-172. When replacement of the existing number 4 AWG Copper (stranded cable) becomes necessary, replace with 3/32-inch stainless steel wire rope, nylon cover (NSN 4010-00-286-2681). The fillstand grounding assembly as shown in figures 1-9 and 1-10 should be installed as soon as possible. It is installed as follows:

(1) The grounding assembly will be affixed to the fillstand, readily accessible to the refueler operator and electrically interconnected to an existing approved static ground. The standard grounding hardware installed on the refueler is used for grounding.

(2) The assembly will be attached to any surface with standard cadmium-plated nuts and bolts. A number 10 or larger solid copper wire should interconnect with the lug and approved static ground. Galvanic corrosion between the different metals should be minimal.

(3) Trucks are grounded by the insertion of a standard plug into an aircraft receptacle on the assembly. After the operation is completed, the plug is pulled out before the trucks depart.

e. Hydrant Fueling Systems:

(1) Static grounding for all hydrant systems is done by installing a galvanized steel combination or stainless steel ground rod tie-down anchor (5/8-inch minimum by 8 feet minimum size) that is usually centered between the hydrant outlet box and the electrical junction box for System II (see figure 1-11) and at any other location convenient to the aircraft for all other systems. The top of this rod should be driven to a depth of 2 inches below the surface of the apron paving. The surface of the paving should then be cupped out to provide accessibility.

(2) A standard electrical ground clip should be provided on one end of the grounding cable. This connecting fitting should be designed to provide positive gripping by

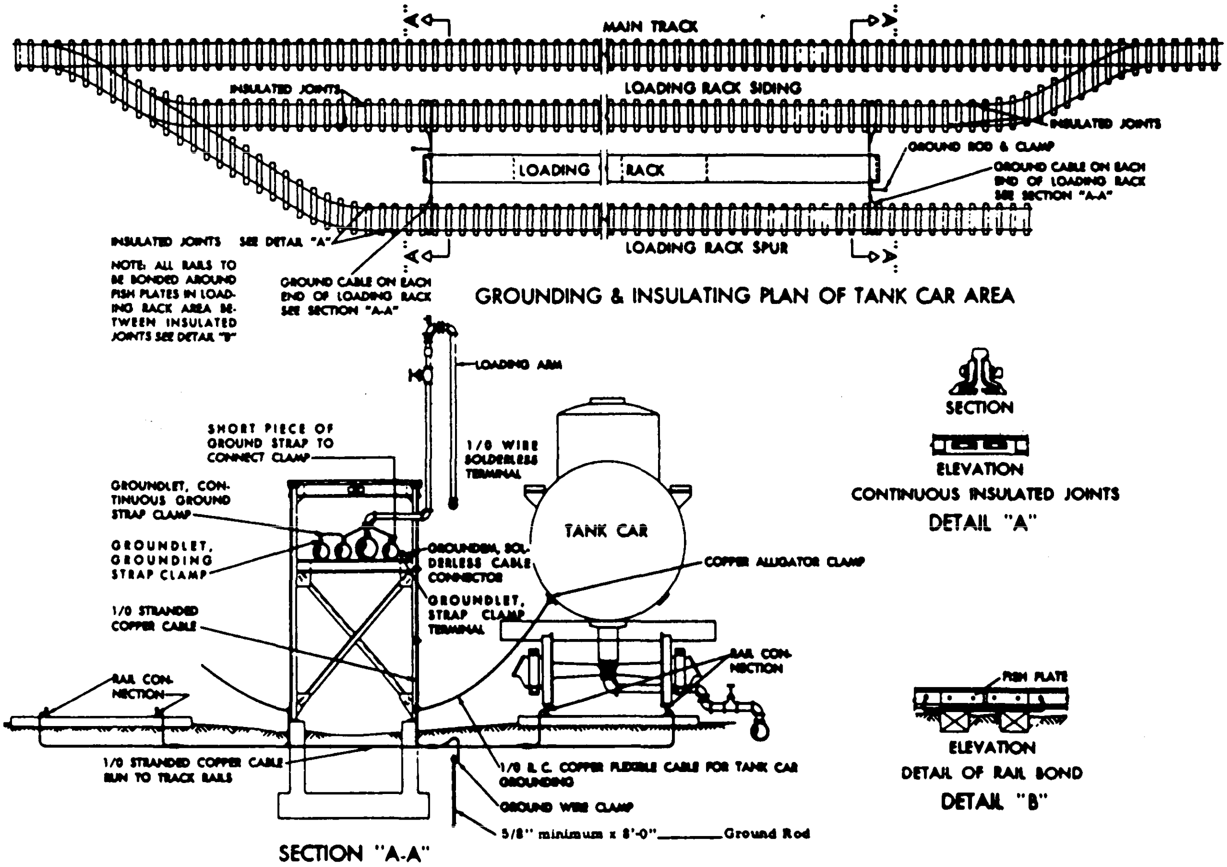


Figure 1–7. Typical Method of Grounding Tank Car Loading and Unloading Facilities.

the clips' teeth only, so the clip must be opened to be removed. For System II bond: the piping at the hydrant outlet to the driven ground rod, thence to the electric conduit at the electrical junction-receptacle box with 1/0 copper bonding cable and approved grounding clamps. Where cathodic protection is applied to retard corrosion on a hydrant fueling system the hydrant outlet will be bonded to the ground rod; however, the outlet must be electrically isolated from the piping system at the first pair of flanges below the outlet. This is required to effect satisfactory protection to the underground piping of the hydrant system.

(3) For nonmetal pipe, such as fiberglass reinforced plastic pipe, the grounding cable will be connected from ground rod to hydrant outlet (metal).

(4) Only ⅝-inch minimum diameter and 8 foot long (minimum length and diameter) galvanized steel or electrically conductive stainless steel rods (type 300 series), with tie down ring (or Shephard's hook), will be used for static grounds. The stainless steel rod is preferred. For bare base and remote locations, ground rod NSN 5975-00-240-3859 is to be used. Changing soil conditions may cause resistance to increase to over 10,000 ohms.

★(5) Resistance of an approved static ground may be as high as 10,000 ohms maximum. However, the lowest possible resistance obtainable is preferred to obtain maximum electrostatic charge "bleed-off" in minimal time.

1–29. Electrical Currents. Electrical currents originate in generators, transmission systems, wiring, and electrical appliances. Electrical currents are more dangerous than static charges because of the possibility of a continuous electrical spark as opposed to the brief spark released by a static charge. The following precautions must be observed to eliminate the hazard of electrical currents.

a. Be sure all electrical work in connection with petroleum storage and dispensing systems complies with requirements of the National Electric Code for hazardous locations. Do not permit inferior or temporary wiring. (Submit unsatisfactory or hazard report when these conditions exist.)

b. Electric motors must be inspected before they are installed to be sure they are explosion proof and designed for use in hazardous areas. This inspection is extremely important for motors and wiring used in equipment not primarily designed for use in hazardous areas (such as ventilating fans, water coolers, power tools, and electrical switches).

1–30. Stray Currents:

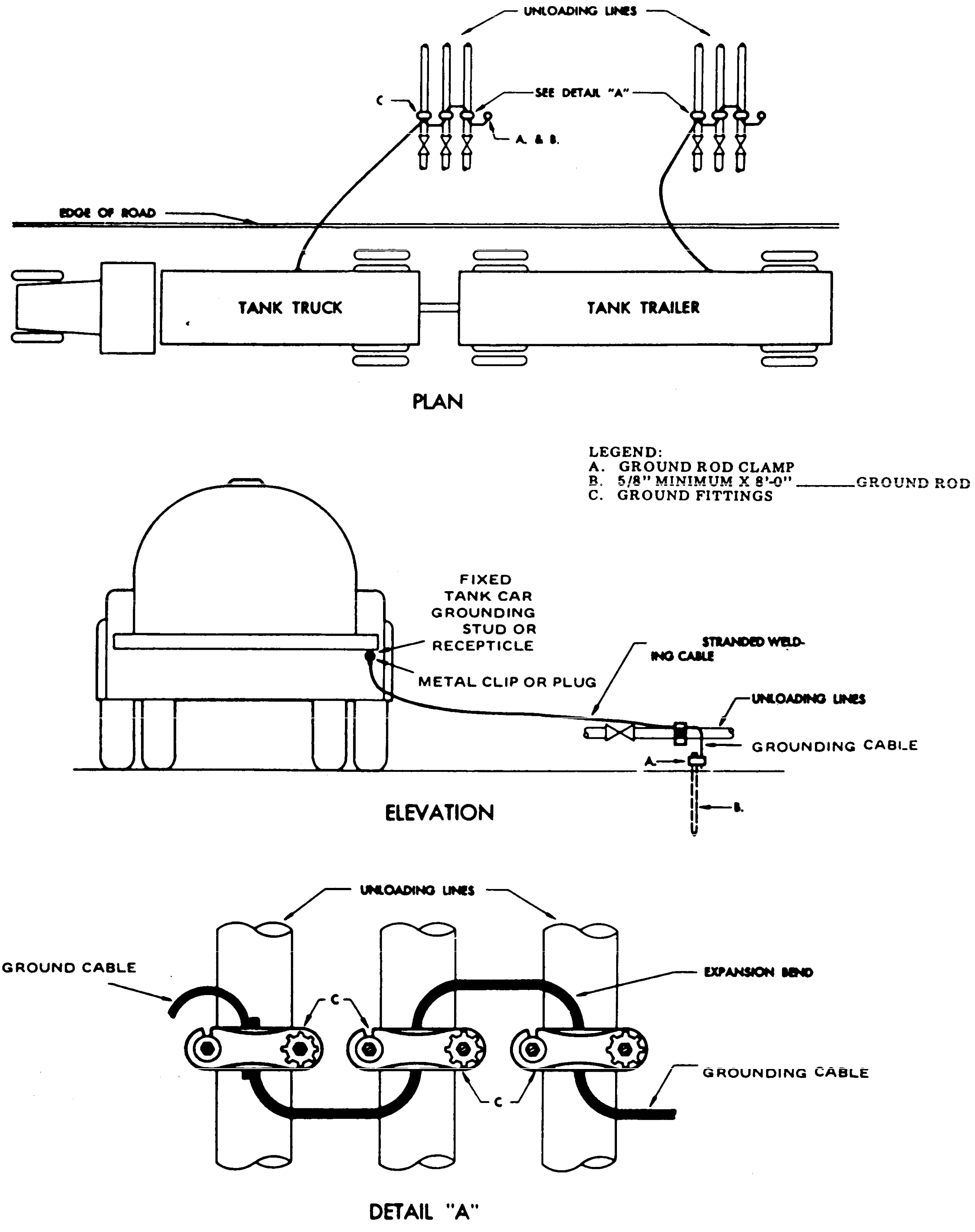


Figure 1–8. Typical Method of Grounding Tank Truck Unloading Facilities.

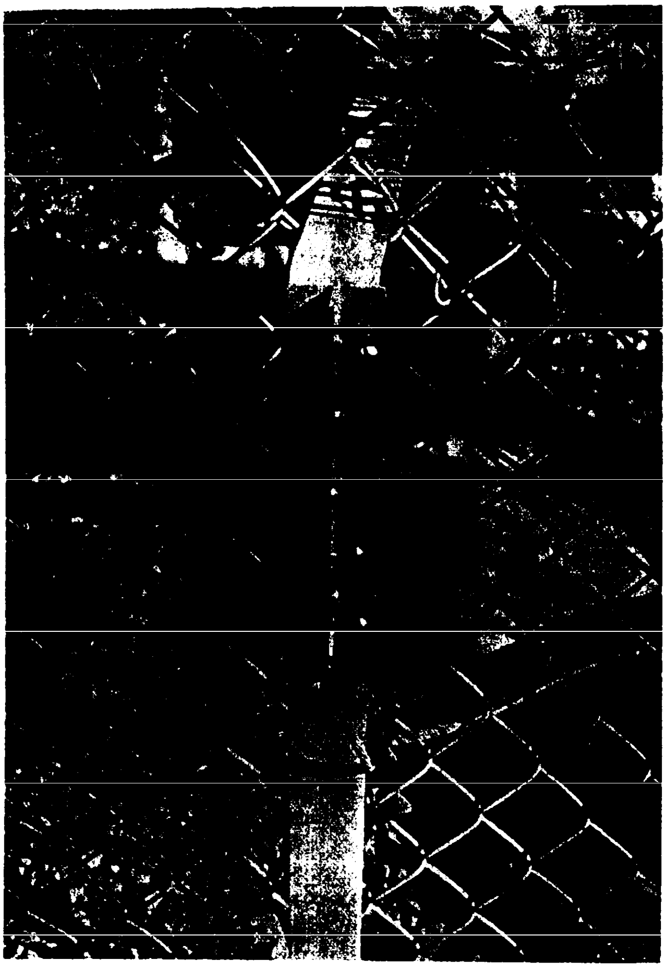


Figure 1-9. Typical Truck Filling and Unloading Stand Grounding Cable Plug (MS 3493/Receptacle (MS 90298) Installation.

a. **General Information.** Stray currents are those currents that flow through paths other than their intended circuits, or any extraneous current in the earth. Sources of stray currents include electric railways, electric power systems, electric welders, cathodic protection systems, and aircraft aeronautics electrical equipment malfunctions. Since Air Force fixed refueling systems are in intimate contact with the earth, stray currents sometimes take paths through the conducting parts of the system.

b. **Hazards Due to Stray Currents.** The principal stray current hazard is from arcs that will ignite combustible fuel-air mixtures.

c. **Eliminating Hazards Due to Stray Currents.** The grounding and bonding method used for reducing static hazards is of value in eliminating stray current hazards. This method does not eliminate stray currents, but does ensure that a continuous path is provided to conduct any such currents into the earth without arcing.

d. **Tank Car Loading and Unloading Facilities.** Railroad spurs, used for loading and unloading tank cars, should be insulated from the main line rails. The spur rails are thus isolated from stray currents that may flow in the main line rails.

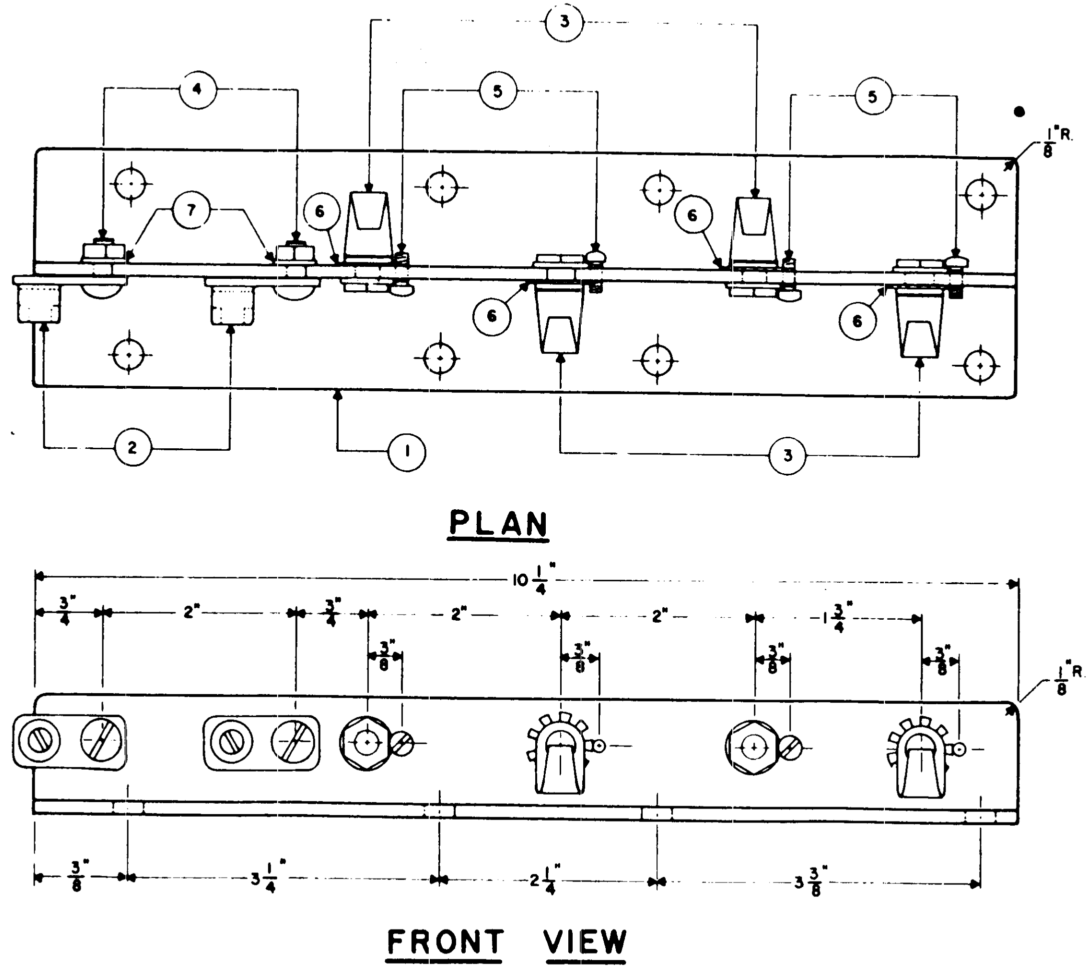
e. **Marine Terminals.** Stray currents from cathodic protection systems at marine terminals require special attention. These systems, used for protecting piping and steel piers, cause currents to flow in the water. The steel hull of the vessel acts as a conductor of these currents. The ship-to-shore fuel handling hose constitutes a conductor, since it contains reinforcing wire, and will complete a low-resistance circuit from the vessel to the shoreside piping. Arcs may then occur between the vessel and the hose, when the hose is connected, disconnected, or brought in contact with the vessel's deck. To prevent this arcing, a grounding cable is connected between the shoreside piping and the vessel before operations begin. A switch in series with the cable is closed after the cable connection is made, and before the fuel handling hose is taken aboard the vessel. Any stray current is conducted from vessel to shore by means of the cable, and arcing is avoided at the fuel handling hose and its connections (see figure 1-12).

f. **Piping.** Stray current may flow through piping systems due to their low resistance in comparison with the surrounding earth's resistance. When removing any section of piping, valve, meter, or other component that will interrupt the continuity of the system, a bonding jumper must be installed. This jumper, installed around the component to be removed, will prevent an arc when the component is removed.

Section G—Static-Electrical Inspection, Testing, and Identification Procedures

★ **1-31. Approved Static Grounds.** Approved static grounds are provided for the purpose of conducting electrostatic charges and stray electrical currents to earth or ground potential. These electrostatic voltages may be as high as 50,000 volts with low currents and consequently, the static ground resistance may be as high as 10,000 ohms; lower resistance is preferred. The purpose of an approved static ground interconnected with aircraft and support equipment is to place all components of the system to equal electrical potential to prevent arcing (or sparking).

★ **1-32. Identifying and Marking Static Grounds.** Testing Static Grounds. All static grounds referenced in this manual will have resistances of less than 10,000 ohms. All existing static grounds will have a one time test with resistance values permanently recorded. Any static ground with a resistance greater than 10,000 ohms will be removed or replaced. Any static ground mechanically damaged will be repaired and retested. Static grounds do not need to be tested periodically after the initial test.



BILL OF MATERIALS			
PART NO.	QUANITITY	FEDERAL STOCK NO.	DESCRIPTION
1	1	9540-806-0793	Aluminum T-Bar, 10 1/4 x 2 1/2 x 1 1/4 x 1/8
2	2	—	Ground wire terminal, H.B. Sherman Mfg. Co., Battle Creek, Mich (or Equal).
3	4	5935-432-9340	Receptacle, MS 90298
4	2	—	Terminal Mounting Bolts, 1/4 x 24 x 1/2
5	4	—	Set Screw, Self-Tapping, #8 x 32 x 1/2
6	4	—	Lock Washer, Star, 3/8"
7	2	—	Lock Washer, Spring, 1/4"
8	4	—	Assembly Mounting Bolts, 1/4 x 24 x 1

HOLE DATA	
PART	DIAMETER
1	5/16"
3	3/8"
4	5/16"
5	7/64"

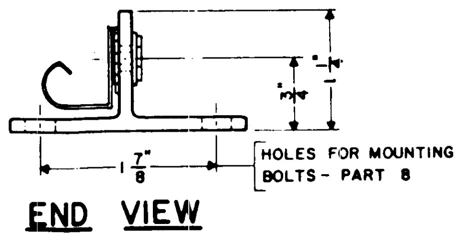


Figure 1-10. Fillstand Grounding Assembly.

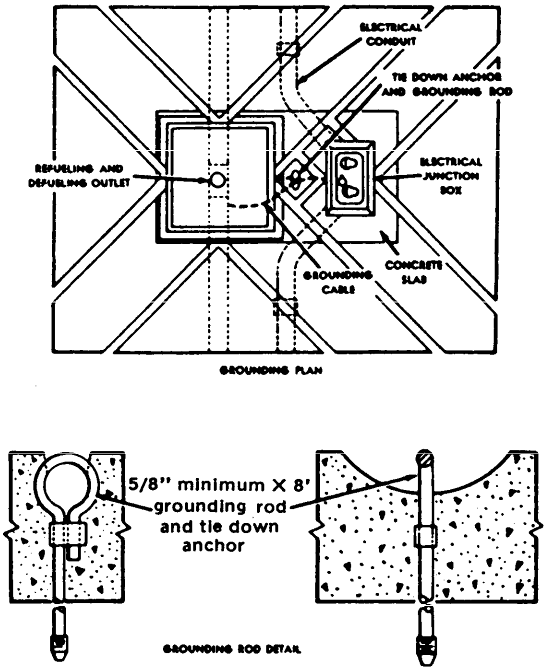


Figure 1-11. Grounding Details for Hydrant Fueling System II (Pritchard).

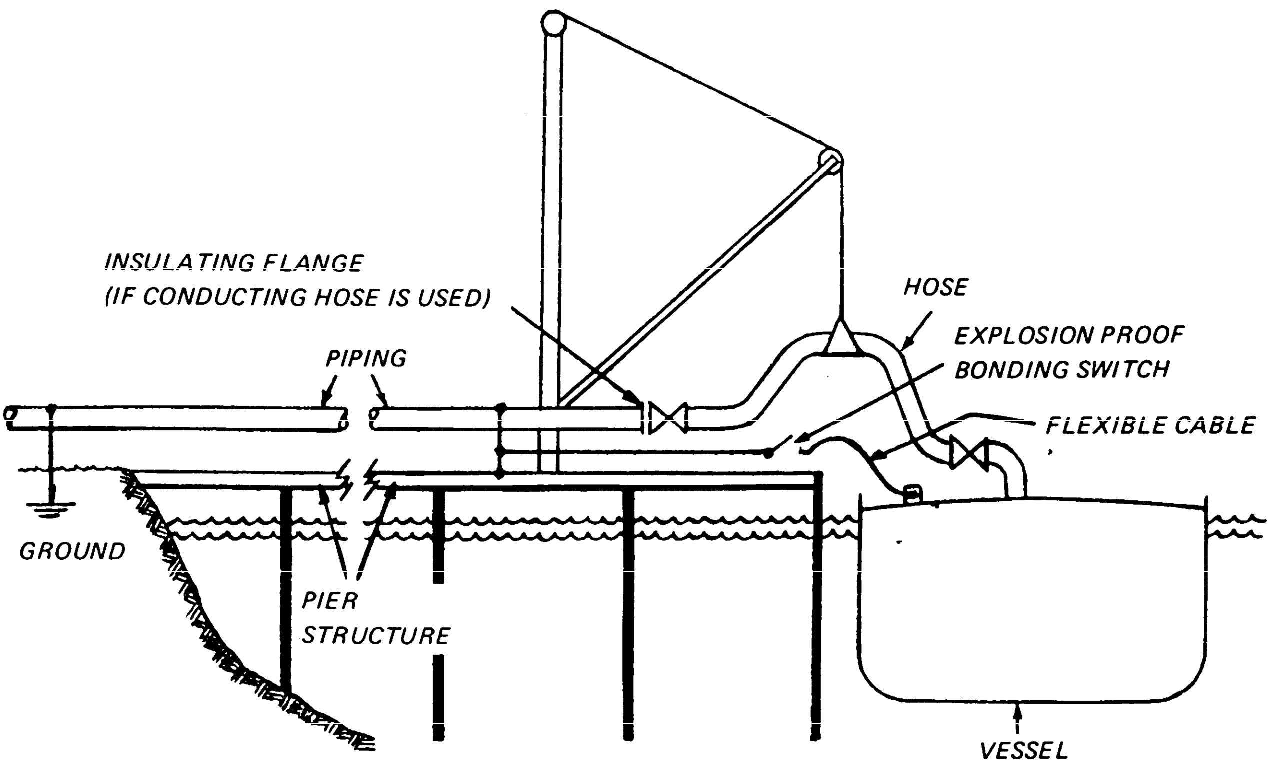


Figure 1-12. Bonding Connections for Marine Facilities.

★ **1-33. Truck Fillstand Grounding Assembly** (See figure 1-9 and 1-10):

a. The assembly modification to the truck fillstand is done by the base civil engineer from local resources along with the base fuels management officer (BFMO).

b. The grounding assembly is installed according to paragraph 1-28d and must be attached to a permanent structure of the fillstand, readily available for the refueler operator, and must be electrically interconnected to an existing approved static ground. The fixture uses the standard grounding hardware already installed on the refueler's reel cables. The design provides extra features that make the receptacles available from either direction of entry, and automatically disconnects if the vehicle is accidentally driven off; it also includes additional receptacles in case of a jack failure.

c. The aluminum T-bar may be attached to any type of surface (painted or bare metal) with standard cadmium plated nuts and bolts. A number 10 or larger solid copper wire should interconnect with the assembly lug and approved static ground. Galvanic corrosion between two different types of metals will be minimal and will have little effect on the assembly.

Chapter 2

DESCRIPTION AND MAINTENANCE OF COMMON COMPONENTS

SECTION A—RECEIVING AND OUTLOADING FACILITIES

2-1. General Information. Routine maintenance of petroleum systems is necessary for efficient functioning and reduction of major repairs, as well as to avoid contamination of products and minimize hazards. Operation of systems is discussed in this chapter and following chapters only as it pertains directly to the avoidance of hazards or practices that may increase maintenance. Items or components described in this chapter are common to most installed fuel systems. They will be covered in detail in this chapter and only mentioned or referenced in the remaining chapters.

2-2. Tanker or Barge-Unloading and Loading. Facilities used to receive and discharge fuel from marine vessels at air bases and tank farms located near navigable waters include tankers and barges at fuel piers, wharves, and offshore moorings, with submerged pipeline to shore (see figure 2-1).

a. **Fuel Piers and Wharves:**

(1) Where liquid fuels are received by tankers or barges, a separate unloading pier or wharf is provided for loading and unloading liquid fuels. The wharf is provided with mooring facilities, hose connections, derricks, attaching hose, hose storage racks, pipelines, and fire protection equipment. A separate pipeline is usually provided for each product to be unloaded. Tankers are provided with pumps to discharge their cargo. When necessary, booster or transfer pumps are installed in the pipelines on shore to transfer fuel from the tanker to the tank farm. Ordinarily, tankers will discharge from 4,000 to 20,000 barrels per hour at 90 to 125 pounds per square inch (psi).

b. **Submerged Sea Unloading Lines** (see figure 2-1):

(1) Where shore conditions are such that construction of an unloading dock would not be economical, or waters are too shallow, submerged sea unloading lines are installed. The lines, installed on the bottom on the sea, may be 6-inch or larger standard steel pipe. Sea hose, 6 to 12 inches in diameter, attached to a flange at the end of the submerged pipeline, provides a flexible ship connection. Sufficient hose should be provided to make up a length equal to 2½ times the depth of high water at the ship moorings.

(2) Mooring anchors are installed for ships, with buoys to mark the anchors for berthing the tanker. The submerged hose has a spool piece and a chain at the ship end. The chain is connected to a marker buoy and is used to lift the submerged hose from the bottom of the ship connection for unloading the tanker.

(3) Corrosion of submerged lines is a serious problem, especially in tropical waters, and may warrant the use of cathodic protection in addition to protective coating. Frequent inspection of the submerged pipeline and hose connection at the sea end of pipeline is necessary according to requirements of paragraph 10-13d. Special engineering evaluations may permit the use of fiberglass reinforced plastic pipe.

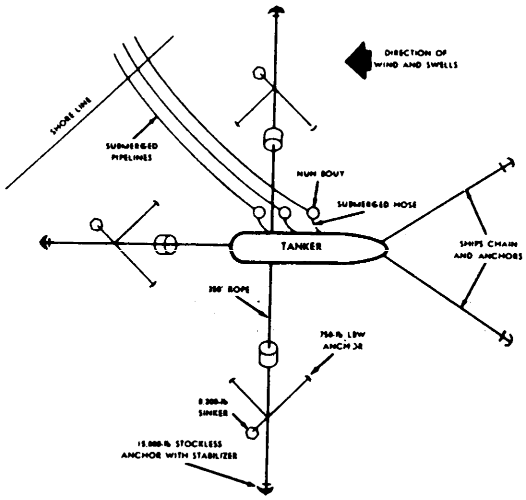


Figure 2-1. Tanker Mooring.

SECTION B—PUMPS

2-3. General Information. Pumps are used for unloading bulk fuel from carriers, transferring fuel to bulk storage and from bulk storage to operating storage, and finally, for dispensing and defueling operations. This section covers operation and maintenance of the various types of pumps used in hydrant fueling systems.

2-4. Types of Pumps:

a. **Types in use.** Horizontal centrifugal or turbine pumps are used as transfer pumps when they can be installed in a position that creates positive or flooded suction pressure in the pumps. When suction lifts are high, rotary positive displacement pumps are recommended. Figures 2-2 through 2-5 illustrate various types of pumps used as transfer pumps.

b. **Operating Pumps.** In operating pumps include:

(1) Satisfactory prime.

(2) Right direction of rotation.

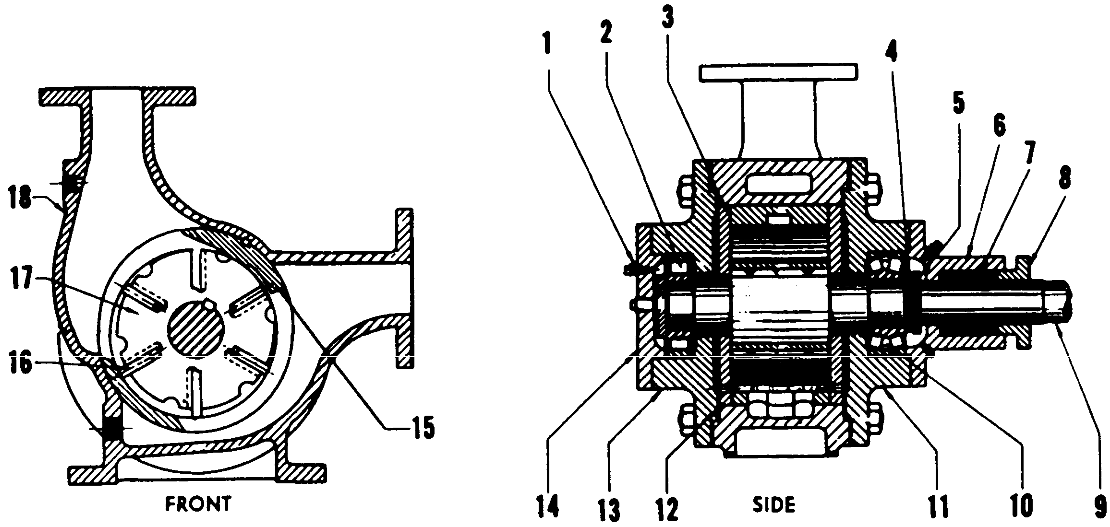
(3) Corrected adjustment of mechanical seal or packing.

(4) Adequate supply of recommended lubricant.

(5) Adjustment of sealing and cooling liquid flow to lantern rings.

(6) Proper and timely opening of valves in suction and discharge lines.

c. **Pump Maintenance.** Operator inspections must be made during operation according to information outlined in TO 37-1-1, to check for overheating of pump or motor, excessive noise or vibration, and performance. When necessary for inspection and replacement of work interior parts, pumps must be disassembled according to manufacturer's instructions. The specific procedure given must be followed carefully in each state of replacing and assembling parts. Pumps that have been properly selected and installed will give years of trouble-free operation with relatively little maintenance. General instructions are below:



1. Grease fitting
2. Outer Bearing
3. End plate
4. Bearing retainer
5. Bearing locknut
6. Bearing cover
7. Stuffing box packing
8. Gland
9. Pump shaft
10. Inner bearing
11. Inner head
12. Head gasket
13. Outer head
14. Outer bearing cover
15. Liner
16. Rotor vane (sliding)
17. Rotor
18. Pump body

Figure 2-2. Rotary Positive Displacement Pump.

(1) Lubricate a pump according to the manufacturer's recommendations. Lack of lubrication may cause bearings to seize and seals to wear out. Lubrication of lower bearings on vertical submerged turbine-type pump is provided by the fuel being pumped. Never run a turbine-type pump unless the first stage is submerged in fuel.

(2) Check the tightness of seals, packing glands, etc., with pumps operating. Never tighten packing glands unless a pump is operating.

(3) Examine pump packings for leakage and undue wear. If a tight seal cannot be made without overtightening the gland, replaces packing. Use packing designed for use with the fuel being pumped, as recommended by the manufacturer.

(4) Do not operate pumps by holding the relay or starting switch. Shut the pump off when it is not pumping.

(5) Keep pump motors clean. (Motor lubrication and maintenance is done by an electrician only.)

(6) Do not over-lubricate pump motors. Over-lubrication causes excess oil to run into wiring, resulting in insulation failure and accumulation of dust and dirt. Lubricate motors according to manufacturer's recommendations. Consult appropriate manuals for maintenance and repair of motors.

d. **Seals and Packing:**

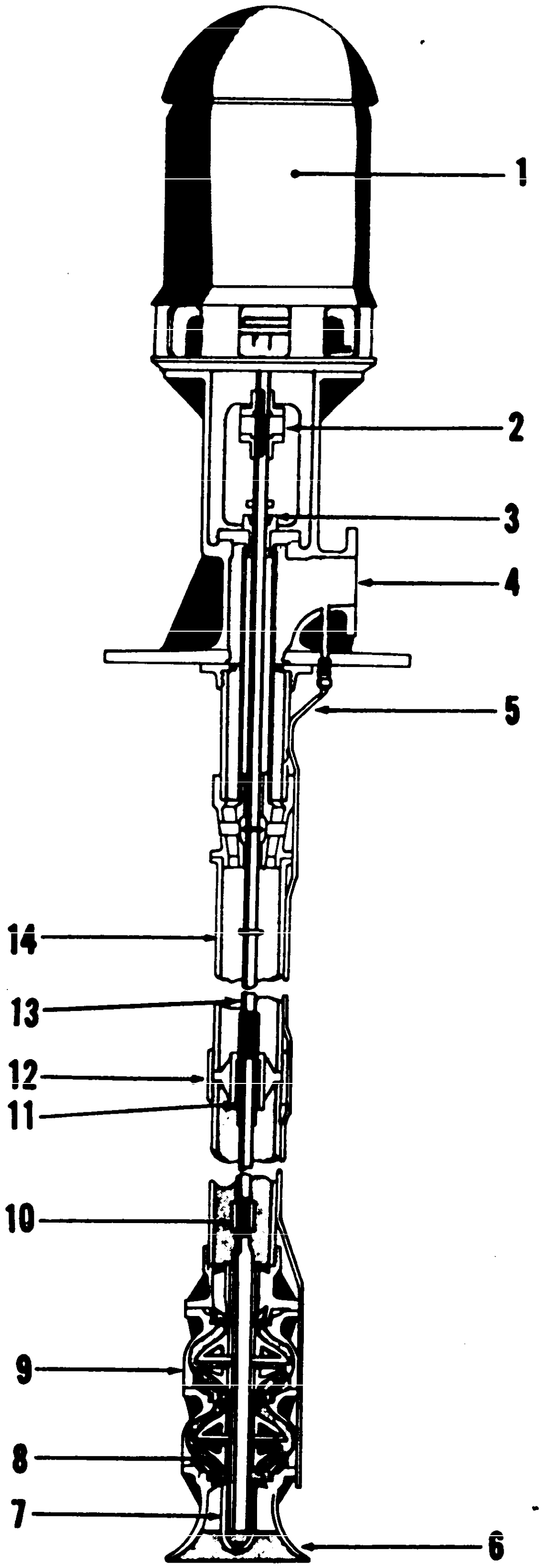
(1) Stuffing box seals:

(a) When repacking seals use the softest packing recommended by the manufacturer for the products handled. The following summary gives correct selection:

Product	*Packing*
Benzene	Micarta or High lead bronze
Fuel oil	Micarta or High lead bronze
Jet fuel	Micarta or High lead bronze
Gasoline	Micarta or High lead bronze
Lubricating oil	Micarta or High lead bronze
Naphtha	Micarta or High lead bronze
Kerosene	Micarta or High lead bronze
Carbon tetrachloride	Plastic
Water	Asbestos

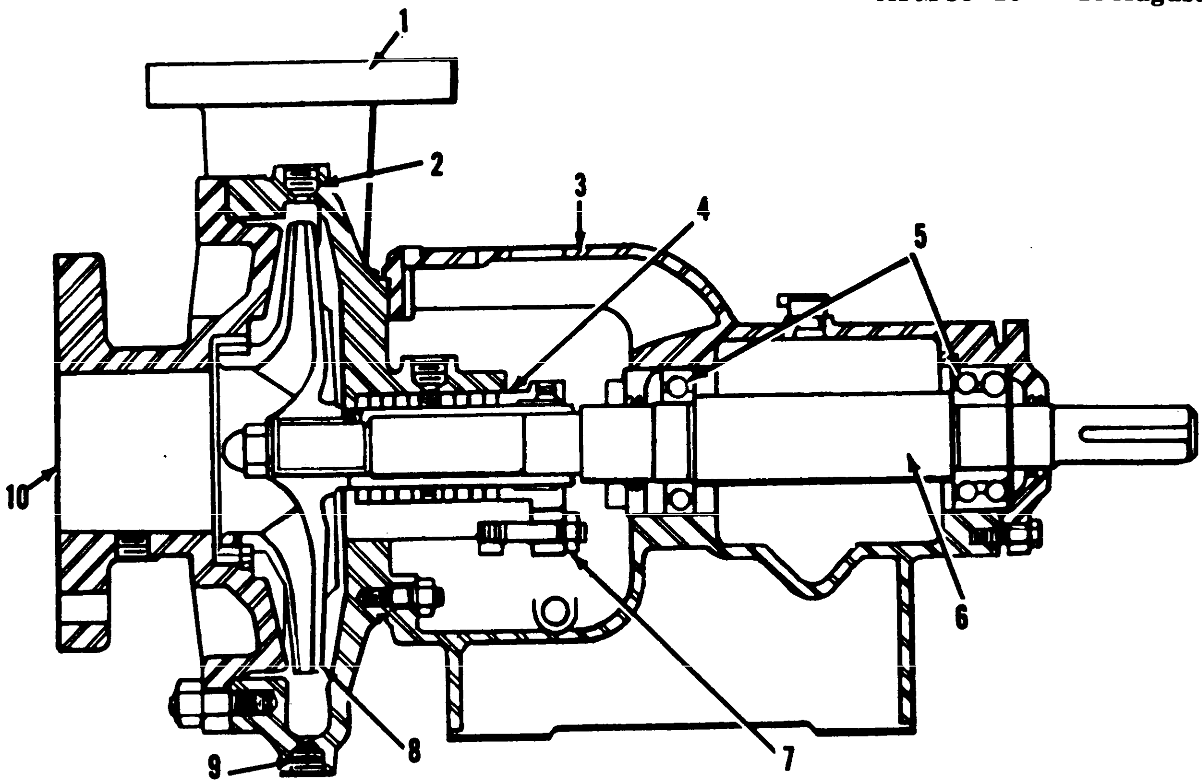
NOTE: Benzene, carbon tetrachloride, and asebestos are considered highly toxic. Use of these materials is to be eliminated if possible. The base bioenvironmental engineer must be informed of any operation or process involving these materials.

(b) Metallic packing must be used only with hardened shaft sleeves. Attention must be given to lubricating metallic packing to prevent excessive wear between packing and shaft sleeve. Metallic packing must be the correct size for a good fit between both the stuffing box and the shaft sleeve. When adjusting the stuffing box gland, pull up the nuts evenly while the pump is running. A gland pulled up too tightly causes excessive wear. Packing in the stuffing box on standard pumps is divided into two parts by a seal cage or liquid seal (as shown in figure 2-6). The seal cage provides a space to introduce grease or li-



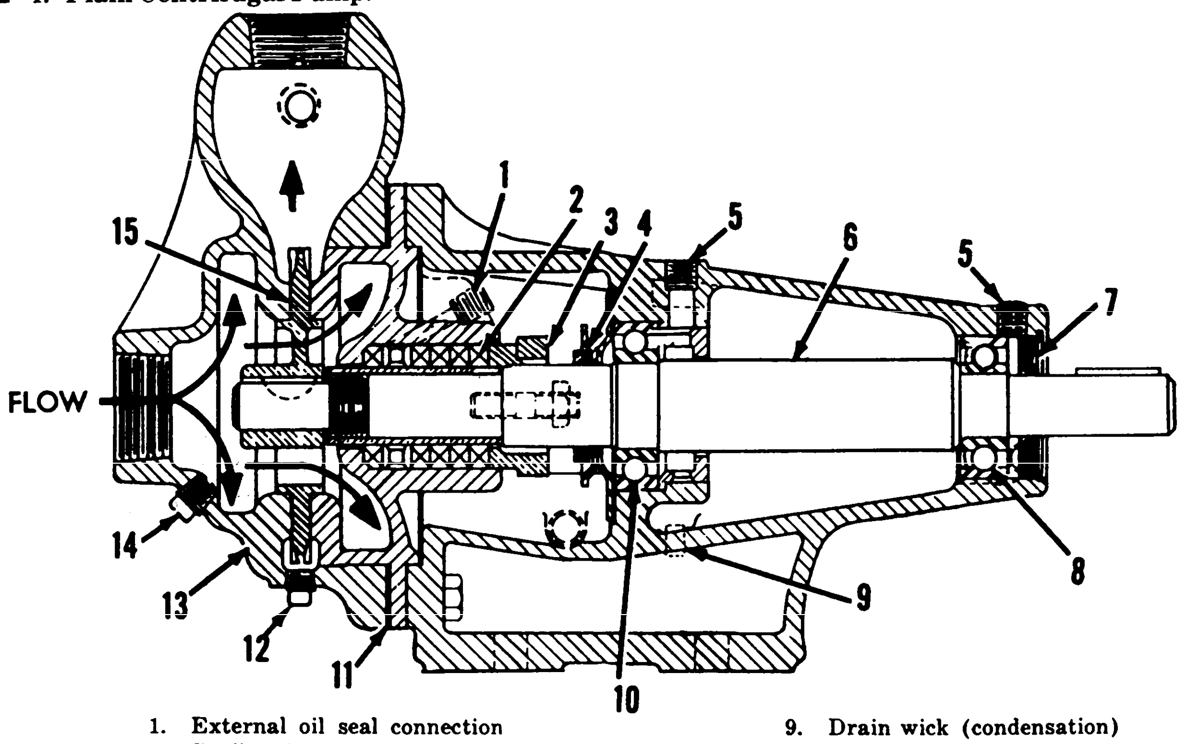
1. Electric motor	8. Impeller
2. Coupling	9. Bowl assembly
3. Mechanical seal	10. Shaft coupling
4. Discharge housing	11. Intermediate bearing
5. Bypass line	12. Column coupling
6. Strainer assembly	13. Column shaft
7. Lower bearing assembly	14. Column

Figure 2-3. Deep Well (Vertical) Turbine Pump.



1. Discharge outlet
2. Filler (priming) plug
3. Lantern
4. Packing rings
5. Bearings
6. Shaft
7. Packing adjustment
8. Impeller
9. Drain plug
10. Suction entrance

Figure 2-4. Plain Centrifugal Pump.

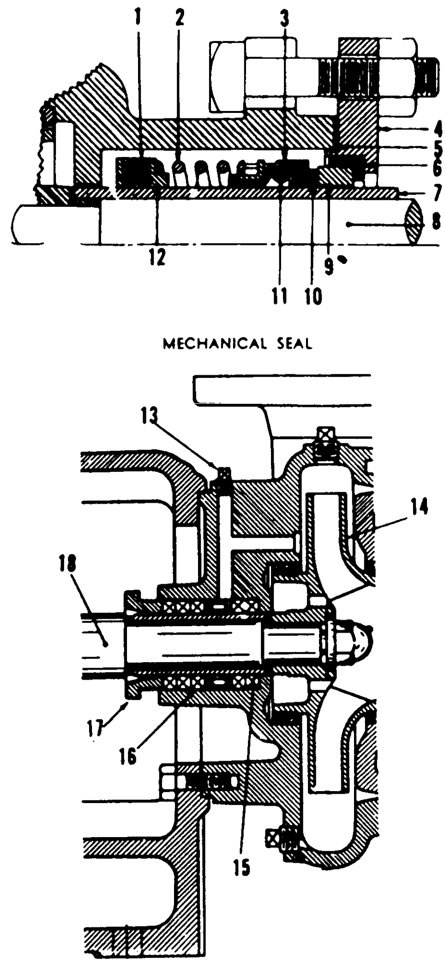


1. External oil seal connection
2. Stuffing box packing
3. Gland
4. Bearing retainer
5. Lubrication plug
6. Pump shaft
7. Seal and bearing retainer
8. Bearing
9. Drain wick (condensation)
10. Inner bearing
11. Head gasket
12. Impeller drain plug
13. Head
14. Valve drain plug
15. Turbine impeller

Figure 2-5. Turbine Centrifugal Pump.

quid to seal, lubricate, cool, or reduce pressure on the stuffing box. On many fuel pumps, a line from the discharge and suction is piped through a value back to the stufffing box and acts as a seal when there is a suction lift.

(2) Mechanical seals have a suitable stationary face mounted in the gland, against which a corresponding rotary face operates. Flexible members effect static seals between the shaft sleeve and the backs of rotary and stationary faces. If a mechanical seal leaks, it is removed, cleaned and repaired, or replaced.



1.	Setscrew	10.	Rotating seal face
2.	Spring	11.	Bellows
3.	Retainer	12.	Seal retaining ring
4.	Gland	13.	Oil seal plug
5.	Gasket	14.	Impeller
6.	Packing ring	15.	Pump shaft sleeve
7.	Pump shaft sleeve	16.	Stuffing box packing
8.	Pump shaft	17.	Packing gland
9.	Stationary seal face	18.	Pump shaft

Figure 2-6. Pump Shaft Seals.

e. **Trouble shooting**. General problems encountered during pumping operations are listed in table 2-1 along with the probable cause of the trouble. Problems that arise with specific pumps are:

(1) Overheated Shaft Housing. This condition is common to rotary pumps and centrifugal pumps. Possible causes and corrective action are given below:

(a) Misalignment of Pumping Assembly. This is usually caused by poor connections. During installation, use of leverage to spring the pipe into alignment with pump port may throw the pump out of alignment at the base, or may spring the base. To check for this condition, disconnect piping from pump and see whether pipe is aligned with pump ports. Improper handling may also shift pump out of alignment. If reduction gear unit is open, run a 1½ by 10-inch piece of wrapping paper through mesh between pinion and pump drive gear. Uneven impressions indicate that the pump is not aligned.

(b) Improperly Lubricated Pump Bearings. Lubricate according to the manufacturer's recommendation.

(c) Packing Too Tight. Loosen packing gland nut and let pump run a few minutes until product being handled leaks out through the packing. Tighten nut firmly and then back it off about three-quarters of a turn.

(2) Defective Oil Seal. Oil seals are used on centrifugal pumps between the pump housing and motor. The symptoms of defective oil seal are given below.

NOTE: Always maintain proper oil level in seal chamber.

(a) If a pump is supplied with fuel from above-ground storage and fuel is found in the oil, this indicates the seal is leaking and must be replaced. Replace diluted oil with new oil to prevent injury to seal bearings.

(b) If a pump is supplied from underground storage and oil is ejected from the chamber when the pump is running, this indicates the seal is leaking and must be repaired or replaced. Repair and replace seals according to the manufacturer's handbook of instructions.

(3) Vapor Lock. Wherever a centrifugal pump is used in transfer services, it is probable that some difficulty will be encountered from vapor lock caused by loss of prime. Vapor lock may be caused by vaporization of fuel from the heat of the sun, by reducing the pressure at the point of suction, by trapped suction piping, or by air drawn into the system through a leak in the suction piping. Vapor or air accumulates in the top of the pump scroll until the pump loses prime and stops delivering fuel. The accumulated vapor can be vented manually by stopping the pump and opening the petcock on top of the pump casing, or by use of auxiliary priming method.

(4) Deep Well (Vertical) Turbine Pump. Deep well turbine pumps are usually installed in underground tank or in a line within a well or vertical section of large pipe, with pump motor and dis-

charge outlet mounted directly above the tanks or well. Bearings in this type of pump are lubricated by pumping the liquid. Do not operate a pump unless there is enough liquid in the tank or lines to fill the pump bowl, shaft column, and head assemblies. A common source of trouble experienced with deep well turbine pumps is vibration. Vibration can be caused by a bent pump shaft or shaft column, improper vertical setting of the pump shaft, pump not hanging freely in a vertical position, and strain transmitted to the pump through discharge piping. To remove a pump for overhaul or repair, do the following.

(a) Place catch basins to receive fuel that spills when flanged fittings are unbolted. Have a cover plate ready to place over the tank opening when the unit is removed.

(b) Provide adequate ventilation if the pump is located in a pit or building.

(c) Unbolt pipe and tank flanges on the pump.

(d) Lift the pump out of tank with a crane or hoist located directly over the pump well. Be careful not to damage the motor, pump shaft column, or pump bowls.

(e) Cover opening with a heavy cover or blind flange to prevent entry of foreign matter into tanks and reduce escape of vapors.

(f) Consult the manufacturer's manual when disassembling the pump.

(g) Make sure flanges are clean and gaskets are new when replacing the pump in the tank or well.

2-5. Hydraulic Gradient. Hydraulic gradient is usually used in design of a pumping and piping system to help in proper sizing of lines and selecting pumps to deliver a given amount of fuel by a certain time. An example of a hydraulic gradient for a given system is shown in figure 2-7. In this sample, fuel is pumped from an aboveground storage tank to two truck fillstands simultaneously, at the rate of 250 gallons per minute (gpm) to each. The centerline of the tank outlet is 3 feet above the eye of the pump. Minimum desirable elevation of the liquid is taken as the line friction loss of 13.84 feet to the elevation of the pump or 7 feet. The pump raises the head to 60 feet. The drop in the 4-inch line to the connection to the two fillstands drops the elevation to 46.98 feet. The drop at 250 gpm in each piping system to the truck fillstands drops the elevation to 39.90 feet. The elevation of the truck fillstand is 23 feet. The difference in head (39.90-23=16.90) is the head available for delivering fuel.

Table 2-1. Trouble Shooting (Pumps).

Trouble	Probable Causes
No fuel delivered	Pump not primed. Speed too low; check motor voltage. Air leak on suction. Discharge head too high. Impeller plugged.
Not enough fuel delivered	Air leaks in suction or stuffing box. Speed too low. Suction lift too high. Impeller partially plugged. Total head too high. Pump defects: excessive ring clearances, damaged impeller. Suction not submerged enough.
Not enough pressure	Speed too low. Air leaks on suction. Pump defects: excessive ring clearances, impeller diameter too small.
Pump works for awhile then loses suction	Leaky suction line. Seal plugged. Suction lift too high. Air in liquid. Air leaks in suction or at stuffing box.
Motor runs hot	Pump taking too much power. Speed too high. Head lower than rating, allowing pump to handle too much fuel. Liquid heavier and more viscous than rating. Pump defects: excessive ring clearance; stuffing boxes too tight; rotor binding. Electrical defects: voltage and frequency lower than rating, defects in motor.
Excessive noise, hammering and vibration	Inadequate lubrication. Cavitation (starvation). Undue pipe tension or poorly supported pipes. Worn or bent shaft and bearings (motors and pumps) Relief or bypass valve chattering.

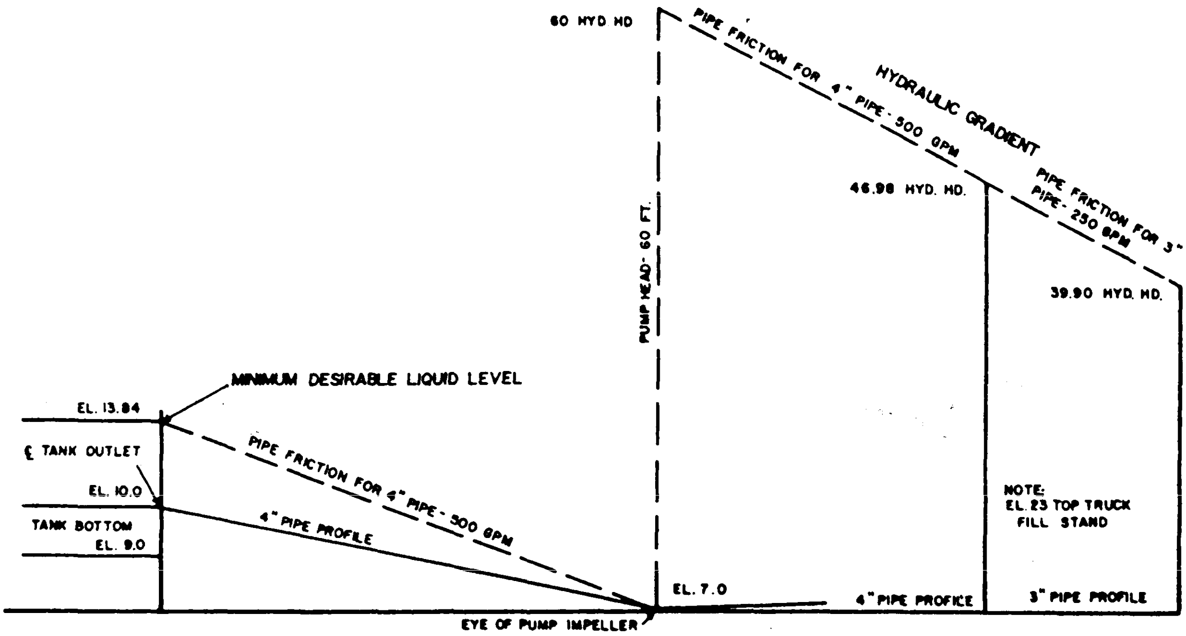


Figure 2-7. Example of Hydraulic Gradient.

Section C—Bulk Storage and Operating Storage

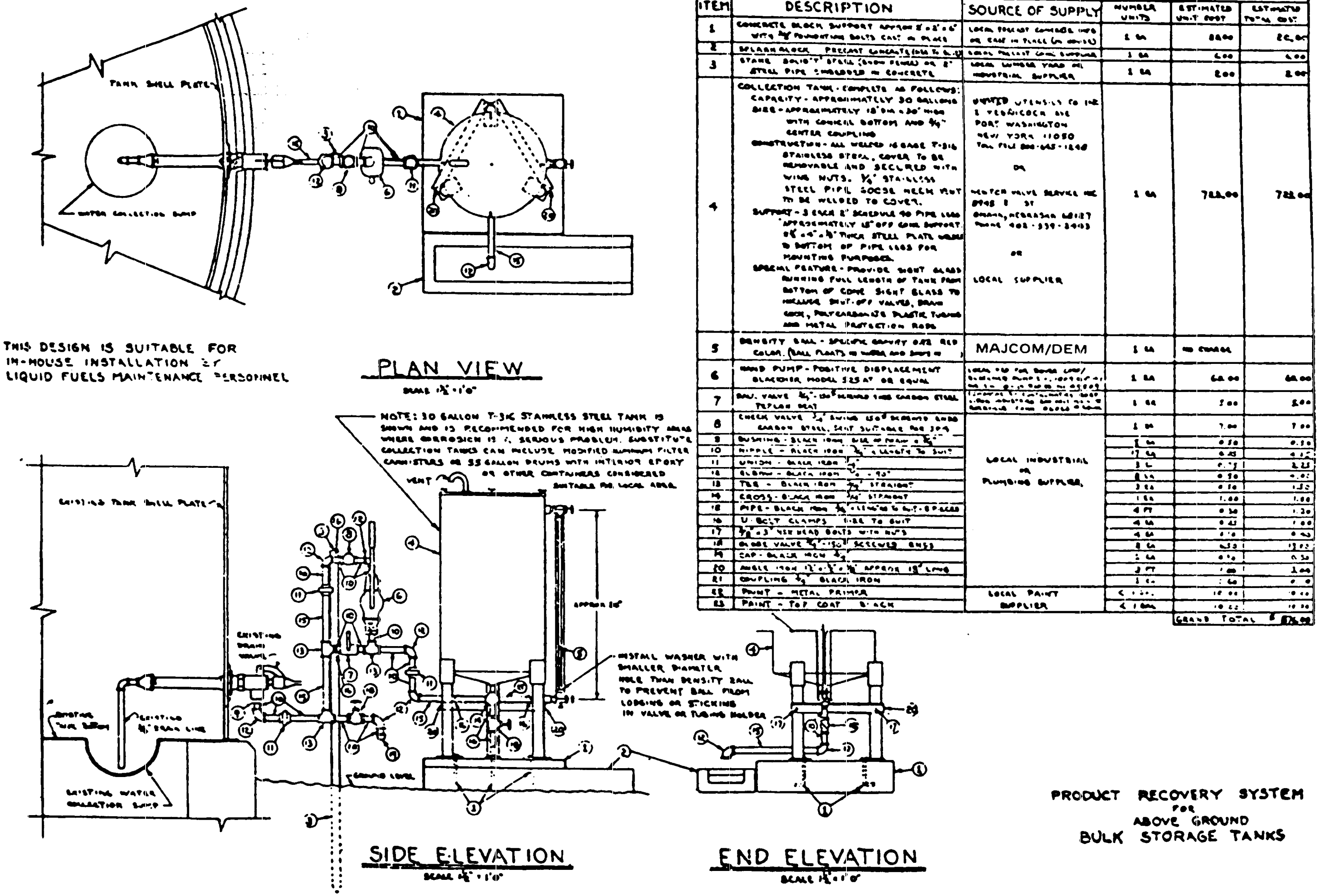
★2-6. **General Information.** The majority of the above-ground storage tanks for Air Force petroleum products are built according to American Petroleum Institute (API) Specifications and Air Force Standard Design. Belowground horizontal cylindrical storage tanks up to 30,000 gallons are usually built according to National Bureau of Fire Underwriters (NBFU) specifications. Belowground horizontal cylindrical operating storage tanks over 30,000 gallons capacity are built according to Air Force Standard design. Under proper conditions, such tanks are also satisfactory for bulk storage. Aboveground steel tanks are of cylindrical design (vertical or horizontal) and of all-welded construction. Belowground vertical cylindrical tanks are built according to Air Force standard design. Water bottoms are not permitted in petroleum storage tanks. Existing jet fuel tanks without provisions for daily water removal are modified to provide a low point or sump (several sumps around outer portion of bottom for large diameter vertical tanks) to accumulate water settling out of the fuel. A drain valve for aboveground tanks and portable pumps for belowground tanks will be provided for daily water removal. Drain valves will be provided with a lock and will be kept closed except when water is being drained. Current criteria for above- and belowground bulk storage tanks storing aviation fuels require installed a product recovery system at the water draw-off value of the tank. See AFM 88-15. They should also be programmed for installation on existing facilities. See figures 2-8 and 2-9. Motorized models should only be used when an electrical power source is readily available and the additional cost can be justified. The hand-operated model must be used on all other installations. Product recovery systems are not required on ground product bulk storage tanks (diesel, heating fuels, etc.); however, it may be desirable to have such a system installed on bulk motor gasoline (MOGAS) storage tanks. This system should only be installed on aboveground bulk MOGAS storage tanks with a capacity of 2,000 barrels or larger. Approval must be obtained from the MAJCOM liquid fuels engineer before installing this system. If local environmental pollution laws require a product recovery system to be installed on ground product bulk tanks, other than the MOGAS tanks, installation approval must be granted to HQ AFESC/DEMM through the proper MAJCOM channels. Operating instructions are contained in TO 37-1-1.

NOTE: Hydraulic displacement aqua systems are not used for the storage and dispensing of jet fuels.

2-7. **Types of Tanks.** Tanks used for petroleum products are:

a. Aboveground:

(1) Floating Roof. Figure 2-10 is a cutaway view of an open-top, pontoon-type, floating roof tank. Figures 2-11 and 2-12 show the current standard design cone roof with internal floating pan tank. These types of tanks are in general use for storage of light-weight volatile liquids and jet fuels. The tank is designed to decrease vapor space over the stored liquid. The problem of rainfall or melting snow accumulating on the top roof deck of the open-top floating roof tank is solved by sloping the roof to a center sump. The sump is connected to a hose or multijointed pipe extending through the fuel to an outside water drawoff valve. The installation of aluminum fixed roofs over open top type floating roof tanks is recommended where excessive water contamination of fuel is a serious problem in areas of high rain and snowfall. For maintenance require-



LIST OF MATERIALS
(FOR ONE PRODUCT RECOVERY SYSTEM)

ITEM	DESCRIPTION	SOURCE OF SUPPLY	NUMBER UNITS	ESTIMATED UNIT COST	ESTIMATED TOTAL COST
1	CONCRETE BLOCK SUPPORT APPROX 2' x 2' x 6' WITH 3/8" FOUNDATION BOLTS CAST IN PLACE	LOCAL PRECAST CONCRETE INFO OR CAST IN PLACE (IN HOUSE)	1 EA	22.00	22.00
2	SPLASH BLOCK PRECAST CONCRETE [illegible]	LOCAL PRECAST CONC SUPPLIER	1 EA	4.00	4.00
3	STAKE SOLID "T" STEEL (SNOW FENCE) OR 2" STEEL PIPE EMBEDDED IN CONCRETE	LOCAL LUMBER YARD OR INDUSTRIAL SUPPLIER	1 EA	2.00	2.00
4	COLLECTION TANK - COMPLETE AS FOLLOWS: CAPACITY - APPROXIMATELY 30 GALLONS. SIZE - APPROXIMATELY 18" DIA x 30" HIGH WITH CONICAL BOTTOM AND 3/4" CENTER COUPLING. CONSTRUCTION - ALL WELDED 16 GAGE T-316 STAINLESS STEEL, COVER TO BE REMOVABLE AND SECURED WITH WING NUTS. 3/4" STAINLESS STEEL PIPE GOOSE NECK VENT TO BE WELDED TO COVER. SUPPORT - 3 EACH 2" SCHEDULE 40 PIPE LEGS APPROXIMATELY 18" OFF CONC SUPPORT. [illegible] THICK STEEL PLATE WELDED TO BOTTOM OF PIPE LEGS FOR MOUNTING PURPOSES. SPECIAL FEATURE - PROVIDE SIGHT GLASS RUNNING FULL LENGTH OF TANK FROM BOTTOM OF CONE. SIGHT GLASS TO INCLUDE SHUT-OFF VALVES, DRAIN COCK, POLYCARBONATE PLASTIC TUBING AND METAL PROTECTION RODS	UNITED UTENSILS CO INC, 1 [illegible] AVE, PORT WASHINGTON, NEW YORK 11050, TOLL FREE [illegible] OR [illegible] VALVE SERVICE INC, [illegible] ST, OMAHA, NEBRASKA [illegible], PHONE 402-339-[illegible] OR LOCAL SUPPLIER	1 EA	722.00	722.00
5	DENSITY BALL - SPECIFIC GRAVITY [illegible] RED COLOR. (BALL FLOATS IN WATER AND SINKS IN [illegible])	MAJCOM/DEM	1 EA	NO CHARGE	
6	HAND PUMP - POSITIVE DISPLACEMENT BLACKMER MODEL 525 AT OR EQUAL	[illegible]	1 EA	68.00	68.00
7	BALL VALVE 3/4" - 150# SCREWED [illegible] CARBON STEEL TEFLON SEAT	[illegible]	1 EA	5.00	5.00
8	CHECK VALVE 3/4" SWING 150# SCREWED ENDS CARBON STEEL, SEAT SUITABLE FOR JP4	LOCAL INDUSTRIAL OR PLUMBING SUPPLIER	1 EA	7.00	7.00
9	BUSHING - BLACK IRON SIZE [illegible] x 3/4"		1 EA	0.50	0.50
10	NIPPLE - BLACK IRON 3/4" x LENGTH TO SUIT		17 EA	0.25	[illegible]
11	UNION - BLACK IRON 3/4"		3 EA	[illegible]	2.25
12	ELBOW - BLACK IRON 3/4" - 90°		8 EA	0.50	[illegible]
13	TEE - BLACK IRON 3/4" STRAIGHT		3 EA	0.50	1.50
14	CROSS - BLACK IRON 3/4" STRAIGHT		1 EA	1.00	1.00
15	PIPE - BLACK IRON 3/4" x LENGTH TO SUIT - 8 PIECES		4 FT	0.30	1.20
16	U-BOLT CLAMPS SIZE TO SUIT		4 EA	0.25	1.00
17	3/8" x 3" HEX HEAD BOLTS WITH NUTS		4 EA	[illegible]	[illegible]
18	GLOBE VALVE 3/4" - 150# SCREWED ENDS		2 EA	[illegible]	[illegible]
19	CAP - BLACK IRON 3/4"		1 EA	[illegible]	0.30
20	ANGLE IRON 1 1/2" x 1 1/2" x 1/8" APPROX 18" LONG		2 FT	[illegible]	2.00
21	COUPLING 3/4" BLACK IRON		1 EA	[illegible]	[illegible]
22	PAINT - METAL PRIMER	LOCAL PAINT SUPPLIER	1 GAL	10.00	10.00
23	PAINT - TOP COAT BLACK		1 GAL	10.00	10.00
				GRAND TOTAL	$ [illegible]

Figure 2–8. Product Recovery System (Hand-Pump Model).

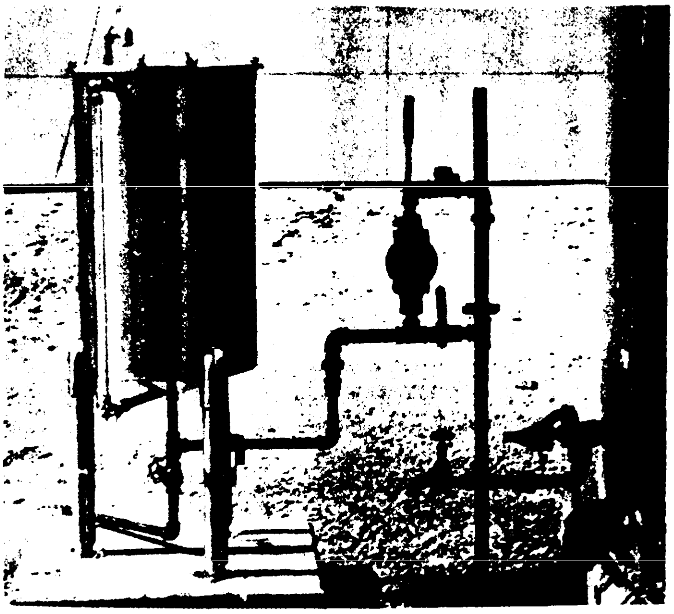


Figure 2-9. Product Recovery System.

ments and responsibilities see paragraph 10-9b(4)(c). For all new construction, the cone roof tank with internal floating pan (see figures 2-11 and 2-12), or cone roof modified with an aluminum floating roof or pan, are the only approved tanks for storage of JP-4 jet fuel, because the hazardous vapor space present in cone roof tanks is eliminated. Also the floating roof or pan provides a ready path for eliminating a static charge. Until the floating roof or pan lifts clear of its legs, the same operational precautions for JP-4 jet fuel storage must be followed.

(a) Effective Seal. The efficiency of an open top floating roof, in preventing evaporation losses and entrance of precipitation and in reducing the possibility of rim fires, depends largely on the effectiveness of the seal closing the space between the rim of the roof and the tank shell. If the seal does not prevent the escape of vapor within the rim, space evaporation will occur. The sealing ring must fit the tank shell snugly. The type of seal in general use with the open top floating roof tank has a continuous, steel ring with vertical flexures about 22 inches apart (see figure 2-13c). A continuous, gastight, weatherproof, synthetic-rubber-coated fabric closes the space between the sealing rim and the rim of the roof. The sealing rim is supported and held firmly but gently against the tank shell by pantograph hangers. Because these hangers apply a uniform, outward radial pressure at each flexure in the sealing ring, they tend to keep the roof property centered in the tank. The sealing ring and fabric seal should be inspected as outlined in chapter 10 for evidence of warping or tank circumference due to settling of the tank or other conditions likely to cause the seal to leak. (In freezing weather, the seal must be kept free of ice. The moderate use of calcium chloride crystals is permitted at the discretion of the base civil engineer). The sealing ring must be free of the tank shell during filling as well as during removal of fuel from the tank. Open top floating roof seals are also of the type shown in figure 2-13A. Seals for the cone roof tanks that have been converted with the floating plan "floater" usually have the type of rim seal shown in figure 2-13B.

(b) Automatic Float Gage. Figure 2-14 illustrates the type of gage used on an open top floating roof tank. The gage is actuated by a float in a well in the deck. The float is connected to the gage tape by a $1/16$-inch stainless steel cable. By connecting the float to the cable with a turnbuckle, it will be possible to make quick adjustments for overreading or underreading. (Lengthen the cable for underreading, shorten the cable for overreading.) The tape is counterweighted, and both tape and counterweight are enclosed in a weatherproof housing. The tape is read through a window. The newer type gage head (figure 2-15) incorporates a spring-actuated storage sheave to take up the tape instead of counterweights; the tape is passed over a sprocket sheave, that registers the liquid level in the tank on counterwheels for a more accurate reading.

(2) Cone Roof. The cone roof tank is designed for aboveground storage but is not as satisfactory as other types for storage of petroleum products because of high evaporation losses due to the transfer of heat from the sun's rays to the stored fuel. The cone roof tank is not recommended for storage of jet fuel and will only be used for such storage when floating roof type tanks are not available. (If these tanks are used for storage of JP-4 or AVGAS, they must have a floating pan installed or programmed. Also check local EPA requirements.) The vapor space in the tank would probably be in the explosive range at normal temperatures. Static charge tends to collect on free liquid surfaces such as those found in the cone roof tank. If the static charge builds up to a sparking potential under these circumstances, an exposion can occur.

(3) Horizontal Cylindrical. In figure 2-16 horizontal cylindrical tanks without pressure are sued for aboveground bulk as well as belowground operating storage. These tanks are of 25,000 and 50,000 gallons capacity. However, new design criteria limits the operation storage tank size to 40,000 gallon maximum. They are equipped with direct-reading gages and have provision for stick gaging to determine fuel level in the tank. Figure 2-16 illustrates a horizontal cylindrical tank.

b. **Belowground:**

(1) Horizontal Cylindrical. As noted in paragraph 2-7a the horizontal cylindrical tank is also used for belowground storage.

(2) Concrete. Concrete storage tanks are some-

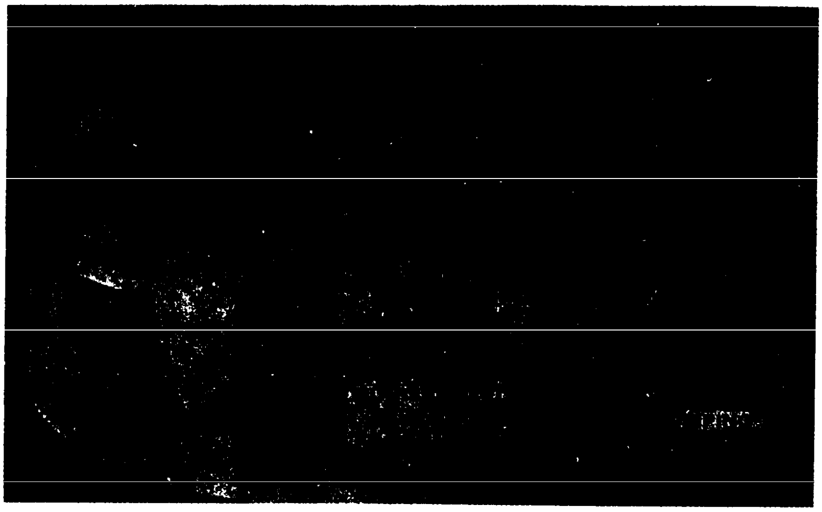


Figure 2-10. Uncovered Floating Roof Storage Tank (Pontoon type).

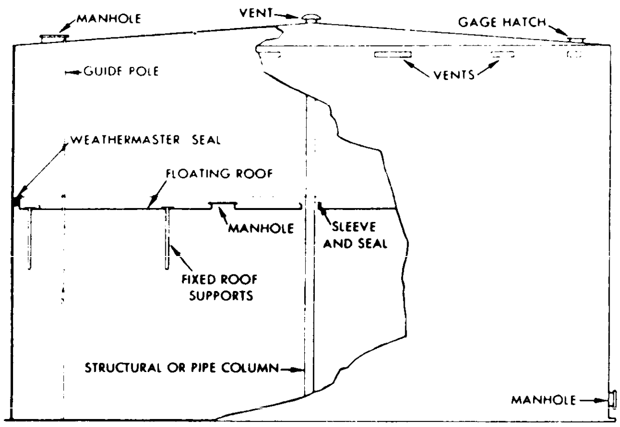


Figure 2-11. Cone Roof With Internal Floating Pan Storage Tank (Steel or Aluminum Pan) (Interior View).

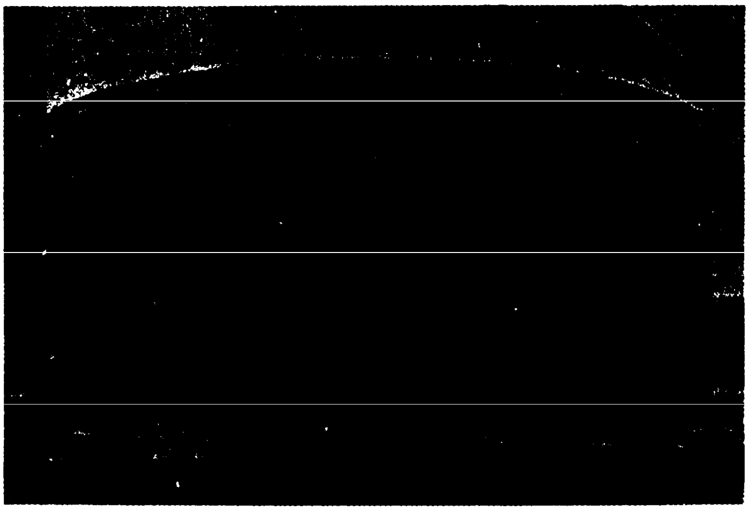
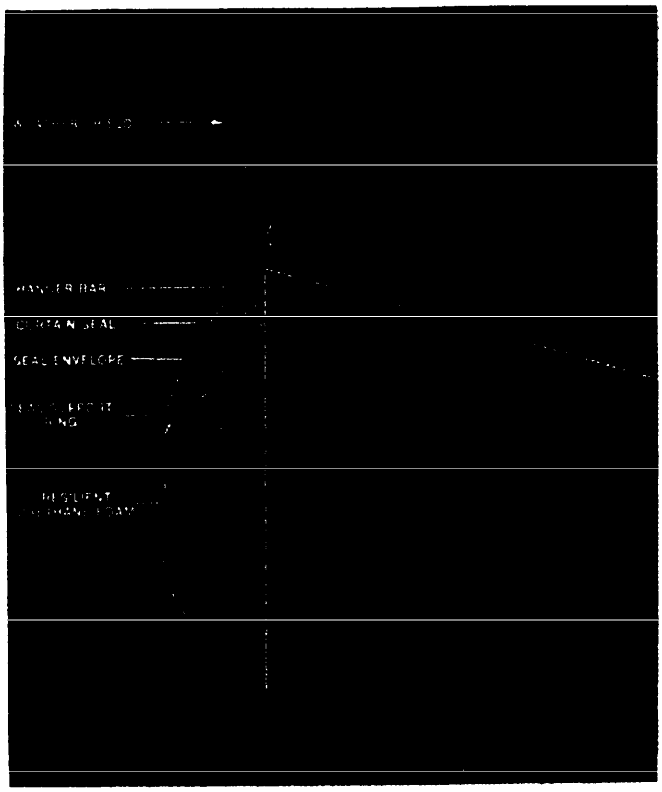
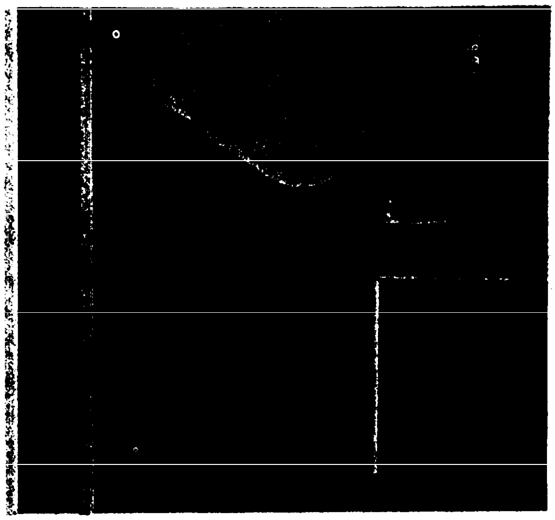


Figure 2-12. Cone Roof With Internal Floating Pan Storage Tank (Exterior View).





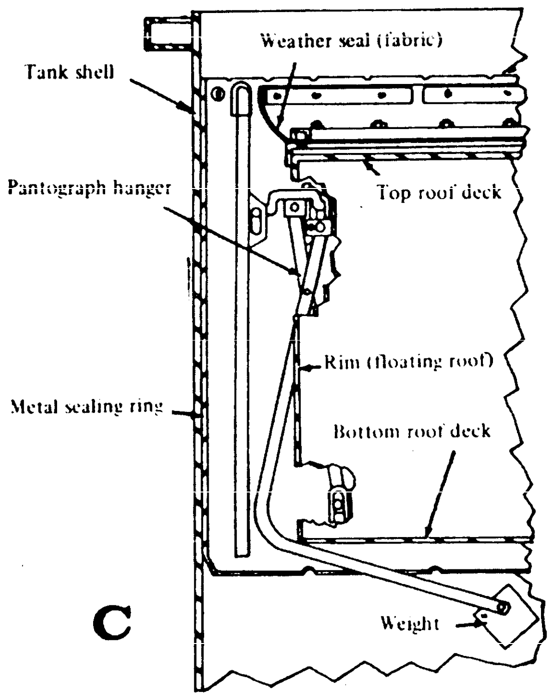


Figure 2-13. Typical Seals Used With Floating Roof Storage Tanks.

times used for belowground storage of petroleum products. Concrete storage tanks required by the Air Force will either be steel lined, and therefore, used and maintained the same as any steel tank or lined with an organic protective coating system approved by HQ AFESC/DEMM.

2-8. Maintenance of Storage Tanks:

a. **Aboveground.** All aboveground storage tanks are carefully selected and maintained to prevent losses because of evaporation of the product. Evaporation seriously affects the quality of the product.

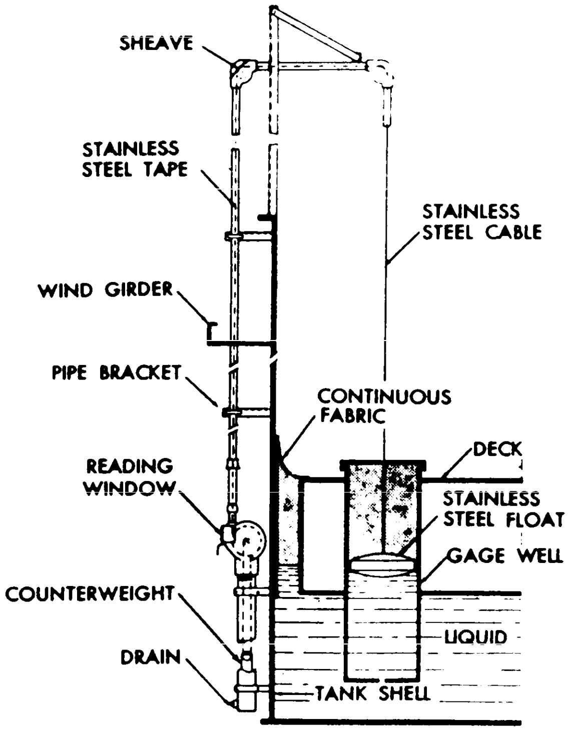
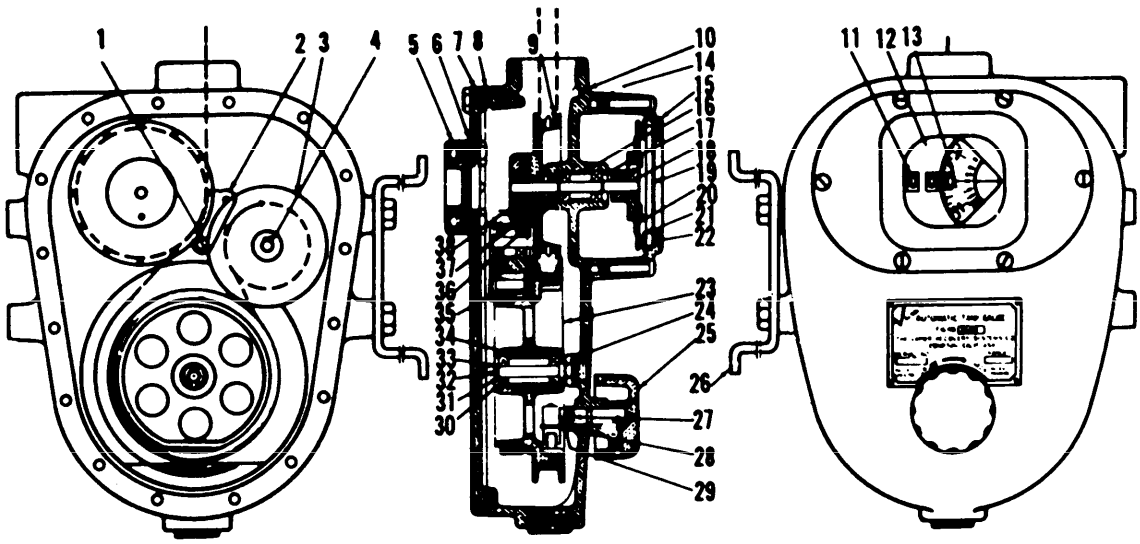


Figure 2-14. Automatic Float Gage.

When evaporation takes place, the lighter components with higher vapor pressure excape more readily. It is these fractions that provide easy staring and antiknock properties so essential in modern fuel. When they are lost, a product of inferior quality remains. General maintenance of aboveground storage tanks can be roughly divided as follows:

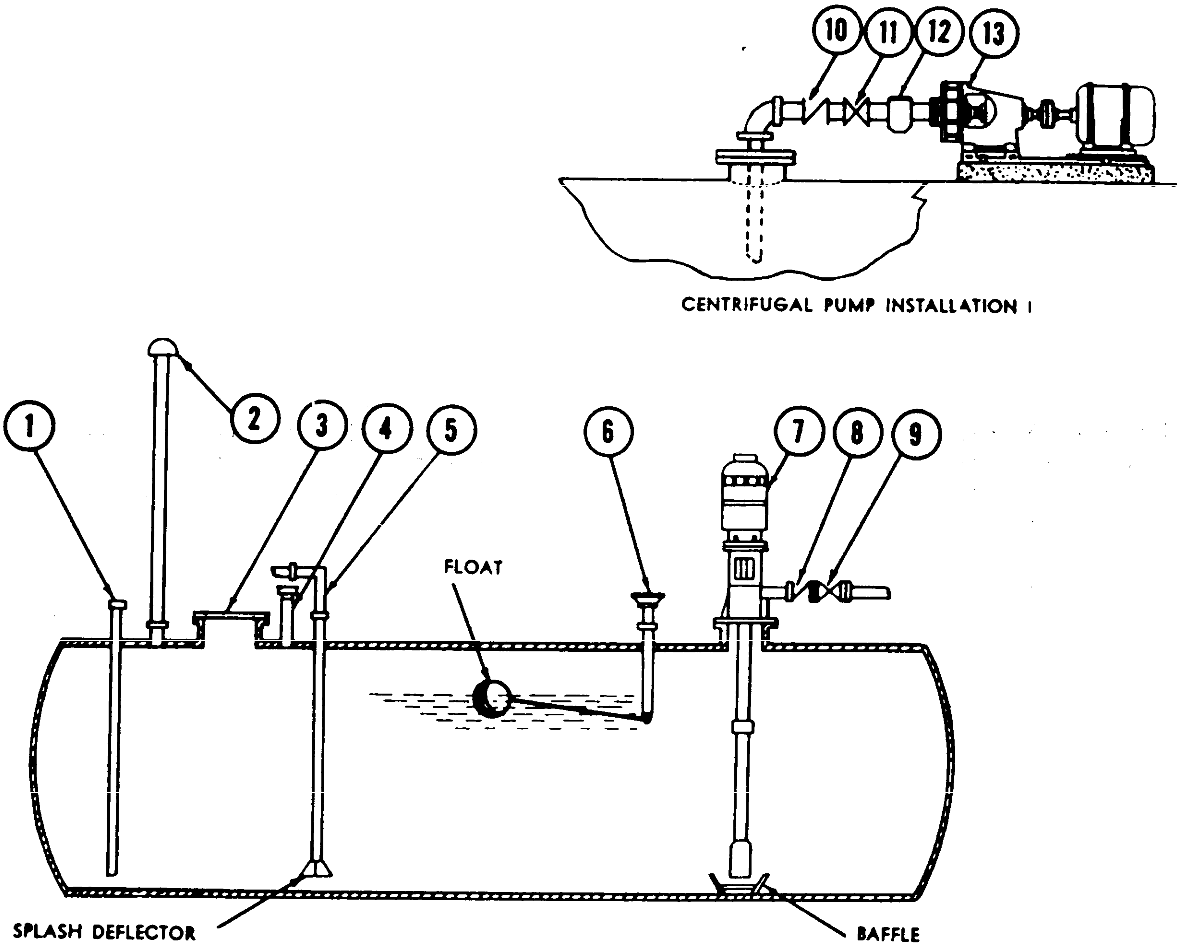
(1) Maintenance of exterior surfaces of tank components, piping and equipment, including periodic inspection for corrosion and repainting as required. Only touch-up painting is done by liquid fuels maintenance personnel; overall painting is usually done under contract (see chapter 9, section D).

(a) One repainting contract for an aboveground, flat bottom tank, the exterior shell (started 5 feet above the tank bottom) and all stairways, ladders, platforms and appurtenances, must be painted after proper surface preparation according to AFM 85-3, with a primer coat, plus one coat (using contrasting colors), and a final overcoat colored white. The lower 5 feet of the exterior shell (including all stairways, ladders, platforms, and



1. Machine screw
2. Guide, tape
3. Motor storage sheave
4. Shaft, motor storage sheave
5. Cap
6. Gasket, cap
7. Back cover
8. Gasket, back cover
9. Sprocket sheave assembly
10. Case
11. Counter assembly
12. Mask
13. Pinion
14. Gasket, counter cover
15. Cover, counter
16. Spacer, counter drive shaft
17. Ball bearing
18. Shaft, counter drive
19. Glass, counter
20. Dial plate assembly
21. Clip, glass mounting
22. Gasket, glass
23. Sheave, tape storage
24. Support, drive shaft
25. Knob, tape tester
26. Bracket, mounting
27. Spring, gage check
28. Gage check subassembly
29. Pin, stop
30. Ring, locking
31. Washer
32. Shaft, tape storage sheave
33. Ring, locking
34. Spacer, tape storage sheave
35. Spring motor assembly
36. Spacer, seal
37. Seal
38. Pin

Figure 2-15. Automatic Float Gage Head.



1. Cleanout connection
2. Tank vent
3. Manhole
4. Gage hatch
5. Fill line
6. Liquid level gage
7. Deep well pump
8. Check valve
9. Plug valve
10. Check valve
11. Plug valve
12. Line strainer
13. Centrifugal pump

Figure 2-16. **Horizontal Cylindrical Storage Tank (No Pressure).**

appurtenances) must be coated after proper surface preparation according to AFM 85-3 with a primer coat, plus one coat (using contrasting colors), and a final overcoat colored black.

NOTES: 1. The coating materials must be suitable for the exterior protection of fuel tanks, and the overall color system must conform to MIL-STD-140. "Tank Roof and Shell Paint."

2. The 5-foot splatter area at the bottom of the tank is generally painted black to reduce the cleaning required to keep a good appearance. This is not mandatory; if desired, the entire tank may be white.

(b) Repainting of aboveground horizontal tanks, component piping for all tanks, and those portions of related mechanical equipment usually painted (except plug valves, but including all steel supports and anchors) must be primed, overcoated, and the final overcoat be colored white, as specified for the upper part of aboveground flat bottom tanks.

(c) In areas where wet surfaces are prevalent nonslip coatings or tape if suitable, and more economical are applied on roof area walkways, ladder rungs, etc. See AFM 85-3 for applicable nonslip coatings.

(2) Interior surface maintenance, including inspection for sludge deposits and corrosion, are on a scheduled recurrent basis according to requirements of paragraph 10-9, with cleaning and repair as required.

(a) Cleaning of interior surfaces will follow the procedure given in chapter IV, section A of this manual and chapter 12, if cleaned by contract. For inhouse type cleaning, the procedure given in chapter 11 applies.

(b) Carefully inspect the underside of the tank roof for corrosion and signs of weakening due to the action of oxygen in vapor.

(3) Maintenance of tank venting equipment and safety devices:

(a) All vents, gaging devices, and other fittings must be inspected at regular intervals to make sure that they are vapor tight and in good operating condition. (See paragraphs 10-10 and 10-11).

(b) Grounding cables, clamps, connections, and grounding rods are installed on many existing aboveground tanks (see figure 1-4). Current design criteria for aboveground tanks that rest on the earth do not require grounding by the ground rod method. Therefore, there is no requirement to remove these ground rods from existing tanks, and further maintenance on them is not required unless tank-to-earth ohmic resistance measurements indicate an inadequate ground exists.

(4) The seals on aboveground open top floating roof tanks are subject to deterioration by atmospheric conditions; the following maintenance services are recommended and are performed at intervals as outline in chapter 10:

(a) Brush the fabric clamps and bolts with a nonferrous wire brush to remove rust and scale.

(b) Replace deteriorated or defective bolts; tighten loose bolts and clamps.

(c) Thoroughly clean fabric surfaces with cleansing solvent.

(d) Apply one or more coats of neoprene maintenance coating to fabric, clamps, and bolts.

(e) Neoprene coating should meet specification MIL-C-21067.

b. **Belowground.** Maintenance of belowground storage tanks can be roughly divided as follows:

(1) Maintenance of outside surfaces of tanks and vapor lines. Inspection is limited to those portions of tank and lines that are exposed inside manhole vaults and pits. Inspect these exposed surfaces periodically for corrosion and chip, and repaint if necessary.

(2) Interior surface maintenance (including inspection for sludge deposits and corrosion) must be on a scheduled recurring basis according to requirements of paragraph 10-9c, with cleaning and repair as needed. In cleaning interior surfaces, follow the procedure given in chapter 11 of this manual for in-house work, and chapter 12 for contract work.

(3) Operating storage tanks with buried access manholes must be modified to extend manholes to 8 inches above grade. Extensions will be 36 inches in diameter and include ladder rungs as required.

(4) For quality control reasons, the requirement for the slotted pipe gage hatch in operating storage tanks has been deleted from the standard design criteria for new tankage. The portion of the gage hatch inside the tank, whether slotted pipe or not, is removed at the tank shell.

2-9. Vacuum and Pressure Vents:

a. **Description and Use.** Combination vacuum and pressure breather vents (figure 2-17) are provided on some existing belowground storage tanks containing aviation fuel, and on all expansion roof tanks, regardless of the type of fuel contained. New design criteria require this type vent on all tanks (except open top floating roof or floating pan tanks) having a capacity of 2,000 gallons or more used for storing products that have a flash point below 100°F (see AFM 85-15). Vents are designed to

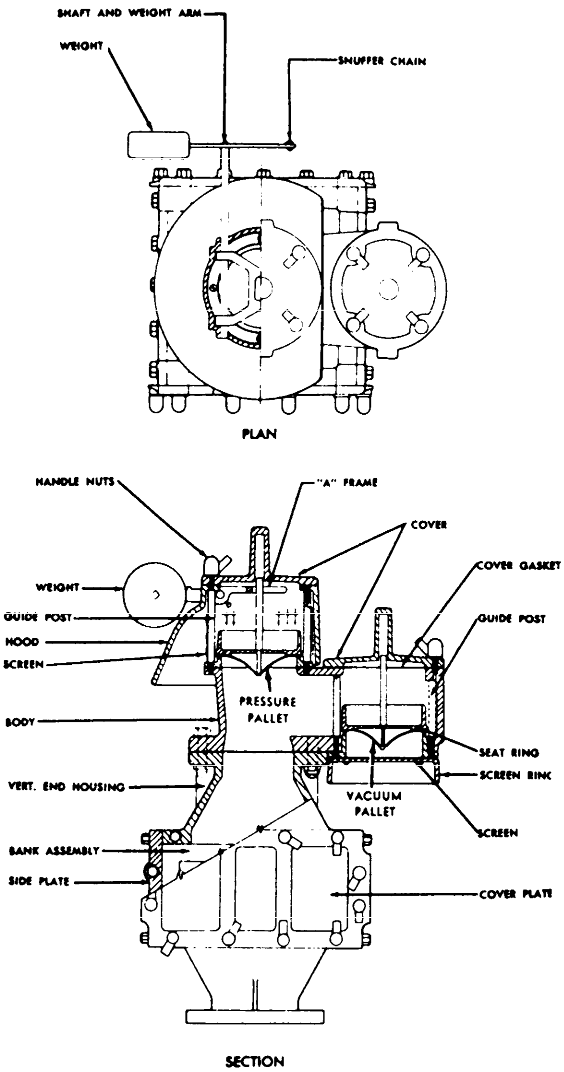


Figure 2-17. Components of Vacuum and Pressure Vents.

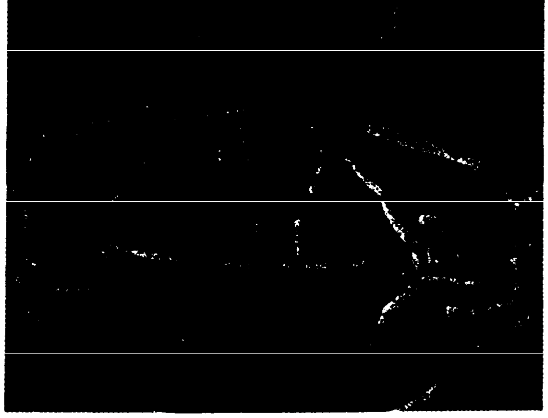


Figure 2-18. Below-Ground Tank Vent.

maintain working pressure in the tank within the safety limits of pressure and vacuum, and prevent normal breathing and consequent loss of fuel by evaporation. When vacuum and pressure vents are used, flame arresters are not permitted. Where installed in conjunction with vacuum and pressure vents, flame arresters should be removed except at United States Air Force European bases where it is a North Atlantic Treaty Organization (NATO) and host nation mandatory requirement that flame arresters be used in vent lines. These flame arresters must be of the "nonfreeze" type. Figure 2-18 illustrates a simple belowground tank vent.

b. **Maintenance.** Vacuum and pressure vents must be kept in perfect working order to prevent sticking and subjecting the tank to collapsing or bursting pressures.

(1) In freezing weather, operations personnel are required by TO 37-1-1 to check tank vacuum and pressure vents for freedom of movement of intake and outlet poppet valves.

(2) Vacuum and pressure vent pallets should be maintained at intervals as prescribed in chapter 10.

(a) Clean seating surfaces of pallets and valve seats carefully with a suitable cleaning solvent.

(b) Inspect seating surfaces for damage or undue wear.

(c) When replacing pallets, make sure they move freely in their guides and that seating surfaces contact evenly and tightly.

(d) Inspect and clean protective screen at pressure and vacuum ports. Remove bird- and wasp nests.

(3) On valves with metal-to-metal seating, it may be necessary at long intervals (because of corrosion) to regrind the seating surfaces of pallets and valve seats to maintain tightness. This operation is done by grinding each pallet onto its respective valve seat, using extra fine grinding compound and a light, even, oscillating motion.

(4) On valves with nonmetallic pallet seat inserts, it may be necessary at long intervals to replace nonmetallic inserts. Carefully clean insert groove. Install new insert in groove, making sure it fits evenly and smoothly into groove.

(5) If seating surface of a valve seat becomes damaged, it may be reground, using a true flat metal plate the same diameter as the pallet. Fine grinding compound should be used between plate and seat with a light, even, oscillating motion.

2-10. Diking:

★**a. General Information.** Each aboveground petroleum tank having a capacity of 661 gallons or more is surrounded by a dike or containment structure to provide a reservoir adequate to hold 100 percent of tank capacity. On earthen dikes, a 12-inch freeboard is also installed. Several small tanks (less than 2,500 barrels (bbls) each) may be enclosed in one dike up to a total combined capacity of 10,000 barrels. The dike capacity for more than one tank inside the same diked area equals the volume of the largest tank plus 10 percent of the total capacity of the other tanks. Whenever existing earthen dikes are replaced with concrete walls or covered with reinforced concrete paving according to criteria specified in AFM 88-15, the enclosed diked areas only require a capacity equal to the entire volume of the enclosed tank or tanks. The drainage ditch in the dike interior is graded to carry drainage to the area of the drain. A swing line or open drain will be used according to geographical requirements. A swing line that may be raised or lowered in the interior of the diked area will be used in cold weather areas. An open drain will be used where freezing conditions do not present a problem. An open drain uses a lock type gate valve on the exterior of the dike. This valve must be in the closed position and locked and opened only as required. The valve is staffed during drainage operation to prevent possible discharge of fuel pollutants into sanitary systems or bodies of water. The drainpipe must be large enough to drain rainfall within the tank enclosure and not less than 6 inches in size to prevent normal stoppage. Provision is made for drawing water from diked areas to prevent fuel products from entering natural water courses, storm drains or sanitary sewers (see AFM 88-15, paragraph 14-16k). Water should never be allowed to stand in the dike area or in the drainpipe from the dike enclosure. Figure 2-19 illustrates one type of tank enclosure and dike (reference Air Force standard criteria for construction features).

★**b. Asphalt Covering.** Earth dikes and basins around fuel storage tanks require continuous maintenance to prevent impounding of rain water control erosion, and eliminate vegetation. To decrease maintenance on these areas, it is recommended that a nonselective soil sterilant conforming to ecology regulations be applied to the top and inside surfaces of the dike to prevent vegetation from growing; all treated surfaces should be covered with crushed rock or pit run gravel to a minimum thickness of 3 inches. The dikes should be sprayed sufficiently with SC-250 asphalt to bind the stones in place. Grading within the basin must be designed to concentrate all surface water into the drain outlet. Concrete splash blocks will be provided at water drawoffs and roof drain outlets to prevent erosion. Earth dikes are inspected according to requirements outlined in chapter 10.

Section D—Filter Separators

2-11. General Information. A filter separator is designed to remove undissolved (free) water and solids from petroleum products. Very fine water particles pass through the coalesce filter elements and grow in size (coalesce) into larger droplets that collect on a second stage teflon screen or treated paper elements and fall to the bottom of the filter separator vessel. The solids in the fuel are trapped in the elements and build-up a differential pressure across the filter separator. Water accumulated in the bottom of the filter separator is either removed manually or automatically. Filter separators are equipped with a differential pressure gage to determine when elements are required to be changed, and a sampling port is located in the outlet pipe to assure fuel quality. Element change criteria are outlined in chapter 10.

2-12. Initial Filing of Aviation Turbine Fuel Filter Separators:

a. Internal flash fires have occurred within filter separators. In some cases, there were no audible sounds or immediate indications that an incident had occurred. These incidents are mainly due to electrostatic ignition of the volatile fuel and air mixture during the initial filling operation.

b. In some instances a leaking filter separator fuel valve allows fuel to siphon through the automatic air eliminator permitting air to enter and replace the fuel. When the filter separator is placed on line pressure, an electrostatic ignition of the volatile fuel and air mixture is possible. These electrostatic ignitions can char or damage elements so they do not function properly. The elements must be replaced. Sometimes, the result is structural damage or ruptured head gaskets.

c. When major maintenance or an element change is performed on a filter separator, air is trapped inside the housing. As fuel fills the housing, the fuel and air vapor mixture passes through the explosive range. The pressure and turbulence created as fuel enters the housing and the filter elements create prolific electrostatic generation. An electrostatic arc can develop; and if the fuel and air mixture is in the explosive range, ignition may occur if proper filling procedures are not followed. The procedures for initial filling after elements have been changed are given in paragraph 2-14.

WARNING

An ignition inside a filter separator is possible regardless of the type of aviation turbine fuel handled (JP–4, JP–5, JP–8, etc.) or if the fuel has been treated with a conductivity additive such as ASA–3.

2–13. Horizontal Filter Separators:

a. The horizontal filter separator has a steel tank (vessel) mounted on steel supports. One end of the tank is adapted with a cartridge manifold housing and filter

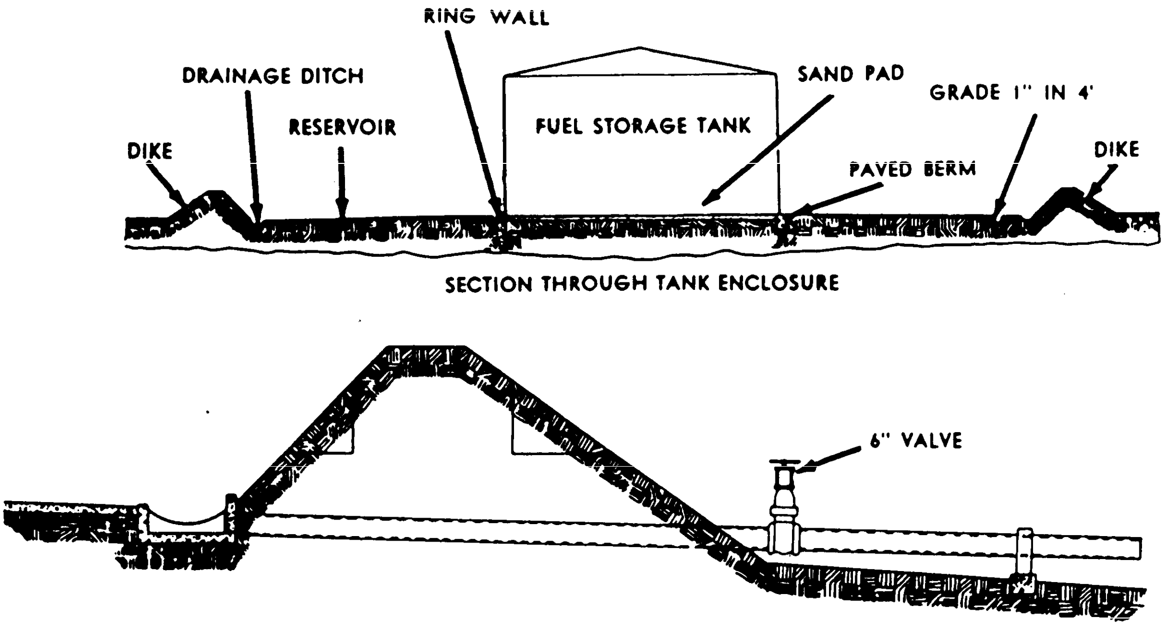


Figure 2-19. Dike for Above-Ground Storage.

separator cartridges, through which the incoming fuel passes, thence through a second stage filter (teflon coated) screen to the discharge end of the tank. A sump is located on the bottom of the discharge end of the tank for accumulation of the water separated from the fuel by the filter separator cartridges.

(1) A float assembly (figure 2-20) is installed in the sump and linked directly to a flange-mounted pilot valve installed on the sump. The float is designed to float on water and sink in aviation fuel; therefore, it rises and falls with the water level. The movement of the float actuates the pilot valve to open and close the water drain valve and the fuel discharge valve. Operation is fully automatic; it gives complete control of water removal and fuel discharge. When the float is down, the water drain valve is closed and the fuel discharge valve is open, permitting fuel to pass. When the float is in the center position, both valves are open. When the float is in the up position, the water drain valve is still open, but the fuel discharge valve is closed, stopping the fuel flow. The control is unaffected by the maximum separator working pressure. Porting arrangement permits control of water drain valve and a fuel discharge valve in the following sequence:

Float Position	Water Drain Valve	Fuel Discharge Valve
Down	Closed	Open
In Center	Open	Open
Up	Open	Closed

When an abnormal amount of water enters the filter separator and fills the sump, the float rises to the predetermined fullup position. This positions the pilot valve to direct pressure on the top of the fuel discharge valve, causing the diaphragm to close the valve and preventing fuel from being discharged until water level in sump has been lowered; thus, water cannot be discharged with the fuel.

When removal or repair is required on the flange float control valve, refer to manufacturer's literature.

(2) The bottom of the sump is equipped with a vortex breaker (figure 2-21 and 2-22), to eliminate any whirlpool effect that would draw fuel into the water being discharged.

(3) A 1-inch valve is installed on the bottom of the sump for manually draining water and sediment from the bottom of the sump. Manual drain lines will be open to atmosphere and sufficient space will be allowed for taking samples. The use of plugs or caps on water drain valve lines is prohibited. Figures 2-20 and 2-21 illustrate the basic components of a horizontal filter separator.

(4) A diaphragm-operated valve is installed in the discharge piping on the outlet end of the filter separator. Originally, a fuel discharge control valve was installed. However, the early model discharge valves did not incorporate a rate of flow controller. These models must be modified so the flow rate through the filter separator does not exceed the rated capacity. Then, water particles are forced through the coalescing media and therefore will not have sufficient time to settle from the fuel. This is particularly noticeable in fuels of higher specific gravities (jet fuels).

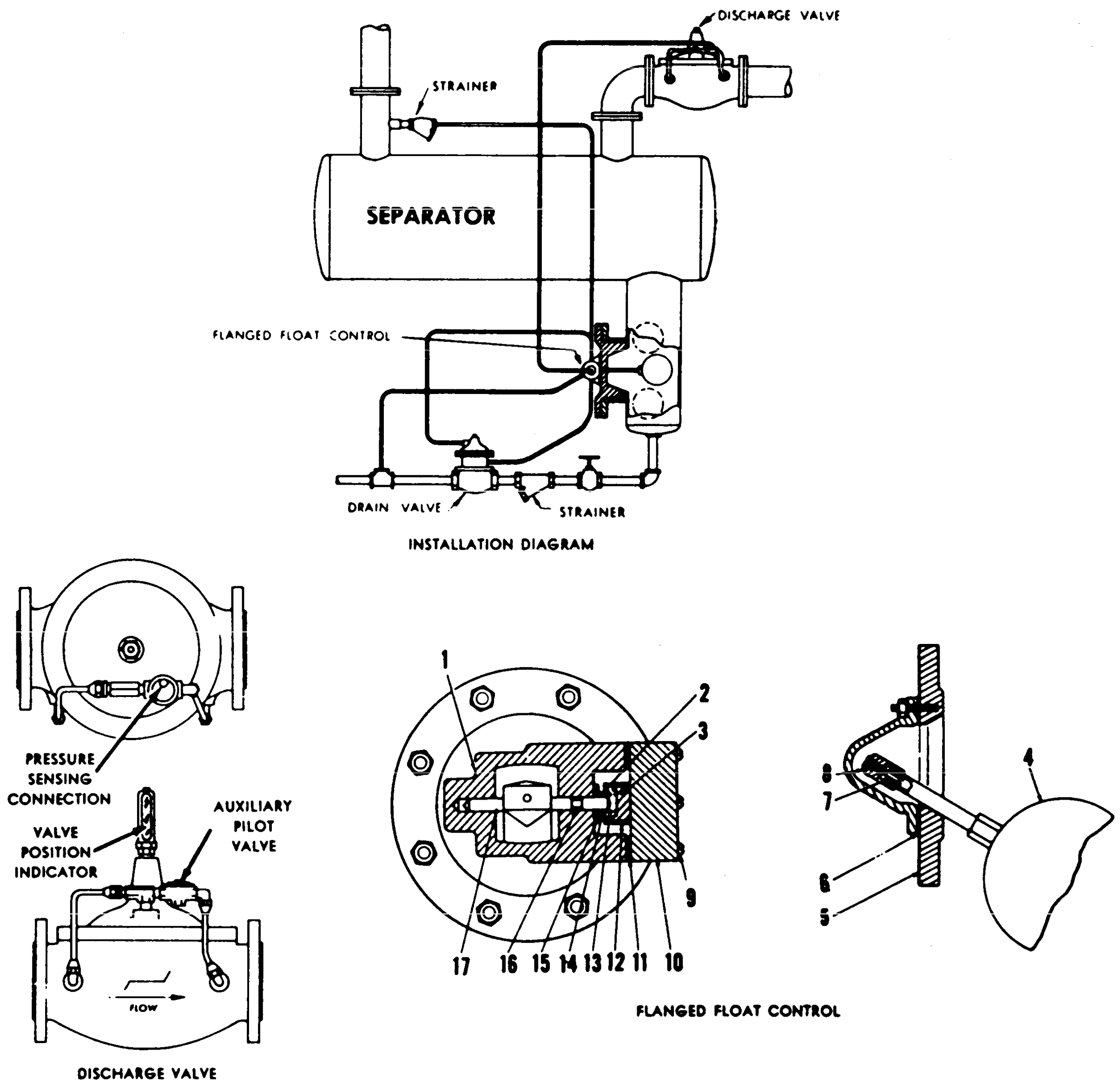
(a) General Information. The combination rate of flow controller and automatic fuel shutoff valve (figure 2-22) (commonly referred to by LFM personnel as a fuel discharge valve) acts as an emergency shutoff valve when water in the sump of the filter separator rises above a predetermined level, and as a rate of flow control to prevent flow rate through the filter separator from exceeding rated capacity.

(b) Rate of Flow Controller. The fuel discharge valve originally installed did not incorporate a rate of flow controller, but it can easily be modified by the addition of an orifice plate and differential pressure control similar to the excess flow control shutoff valve prescribed in paragraph 4-7c. Consult the manufacturer for components and instructions that apply. Figure 2-22 illustrates a discharge valve modified to incorporate a rate of flow controller.

(5) A diaphragm operated valve is installed in the water drain line from the sump (figure 2-23). As the water level raises the float to the horizontal position, the pilot valve positions to direct pressure to the lower side of the diaphragm, forcing it to open and allowing water to drain from the sump through the water drain line. The water drain valve remains fully open as long as the water level holds the float above the horizontal position. As water drains from the sump and lowers the float below the horizontal position, the pilot valve changes position to close the water drain valve automatically as the float bottoms.

★(a) If the water drain valve (figure 2-23) should fail to operate after cartridge replacement or during the other maintenance tests, proceed as follows: (See figure 2-21).

1. Remove, check and clean Y-strainer (2).



1. Housing
2. Driver
3. Disk
4. Float assembly
5. Flange
6. Gasket
7. Lock pin
8. Float arm
9. Machine screw
10. Distributor
11. Gasket
12. Skirt
13. Spring
14. Thrust washer
15. Spacer washer
16. "O"-ring
17. Stem

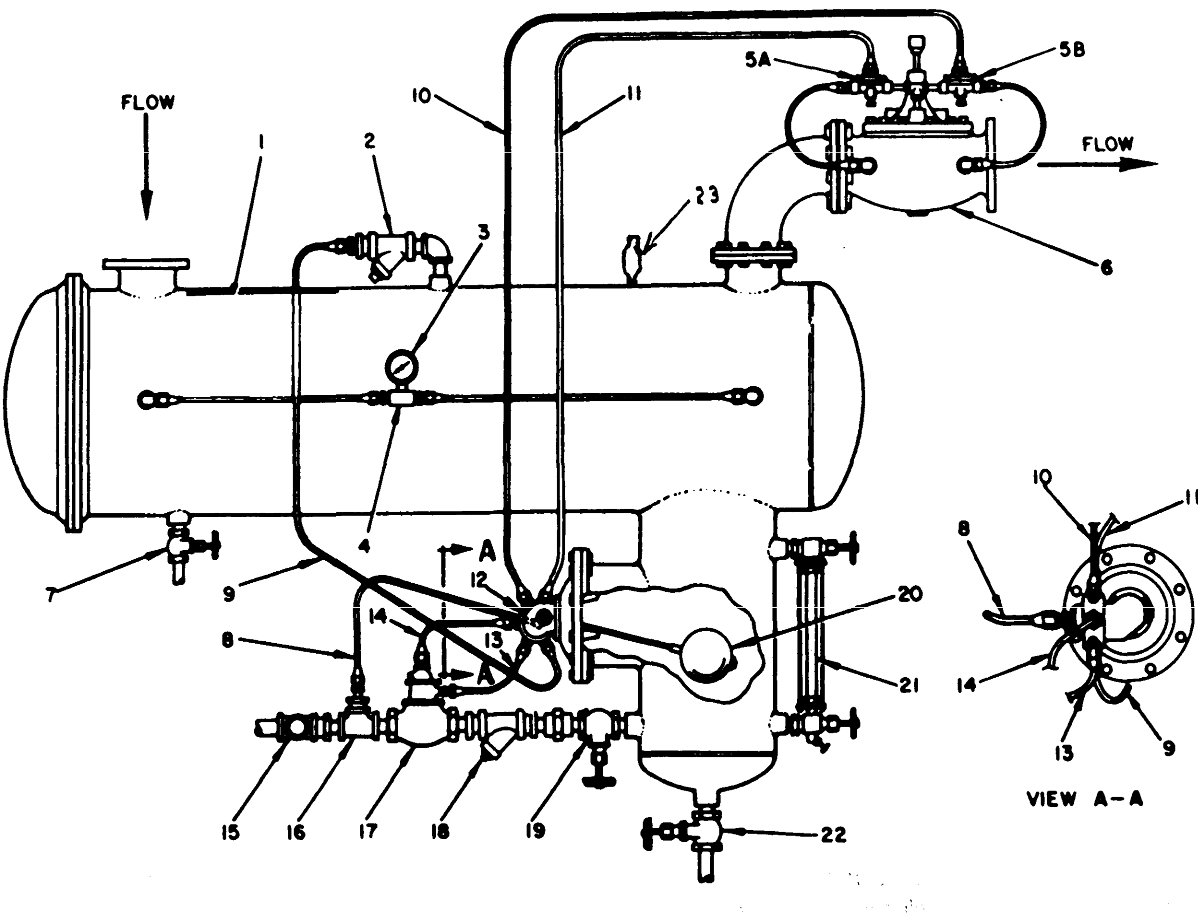
Figure 2-20. Flanged Float Control Valve for Filter Separator.

★2. Disconnect pilot supply tubing (8) at pilot valve and check to see that liquid flows freely from tubing. If a full stream fails to flow, remove tubing and clean out obstructions. If fuel flows freely from supply tubing, disconnect control tubing (11) from water drain valve (15); check to see if fuel flows freely. If fuel does not flow, remove obstruction from tubing. If, after tubing is removed from the pilot valve (10), fuel does not flow from the connection at the pilot valve, it indicates that trouble is in float operated pilot valve, which should be removed and checked.

(6) In certain installations where filter separators are exposed to freezing temperatures, the separators are equipped with sump heater assemblies to prevent ice formation in the sump and water drain valves. These heaters are not required in separators handling military jet fuel, because the fuel contains an anti-icing inhibitor (FSII). This equipment has an insulated heating coil (around the sump, water discharge line, and valves) that is controlled by a thermal switch mounted in the sump. It is important that the heater be maintained in good working condition, since failure would cause ice to form and would render the filter separator discharge and water drain valve inoperative. The sump should be checked and drained free of accumulated water daily by operator personnel according to guidance in TO 42B-1-1.

NOTE: If density sensitive balls are installed, the sump is drained according to guidance in TO 42B-1-1.

2-14. Testing Procedures. Water test, cartridge re-



1. Filter Separater Vessel
2. One inch Y-pattern strainer with 100 mesh screen
3. Pressure gage (Differential)
4. Selector valve
5. High level control auxiliary
6. No. 1 high level discharge control valve
7. Debris blowdown valve
8. Pilot valve drain tubing
9. Pilot valve supply tubing
10. High level discharge control valve tubing
11. High level discharge control valve tubing
12. Pilot valve assembly
13. Power control water drain valve control tubing
14. Power control water drain valve control tubing
15. Sight gage
16. Tee
17. Power-control water drain valve
18. Two-inch, Y-pattern strainer with 20 mesh screen
19. One-inch gate valve
20. Float
21. Liquid level gage
22. One-inch gate valve
23. Pressure Relief-Air Eliminater Valve

★Figure 2-21. Horizontal Filter Separator, Major Components.

placement, and initial gravity bottom filling procedures for the horizontal type filter separator are as follows:

a. Close the inlet and outlet manual valves, open the drain valve on sump, and drain off all water, if any. Next, drain the remaining fuel back to tank or into a clean container for return to tank. (Provision should be made to drain fuel back to operating tanks to prevent fuel spillage in pumphouse building.)

b. After the vessel is thoroughly drained remove head flange bolts and open vessel.

c. For original KMU-416/F modification kit (figure 2-24) use the following method:

(1) Starting with the bottom cartridge, loosen the ½-inch nut on the adapter mounting rod (12, figure 2-24). The fuel trapped in the manifold can be slowly drained by loosening the bottom element (cartridge).

(2) After the fuel has been drained from the manifold, the 15 elements can be removed on the outlet side of the manifold.

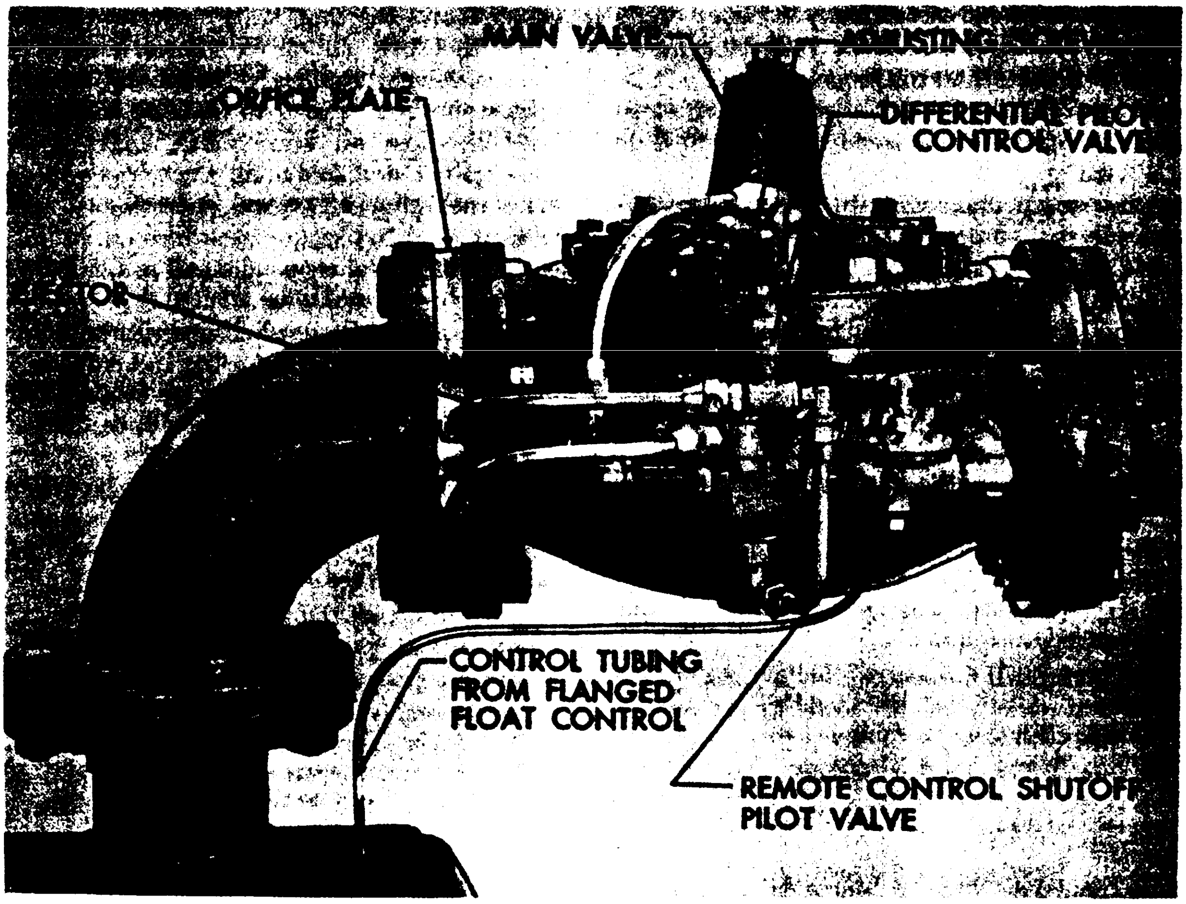


Figure 2-22. Discharge Valve Modified for Combination Rate of Flow Controller and Automatic Fuel Shutoff Valve.

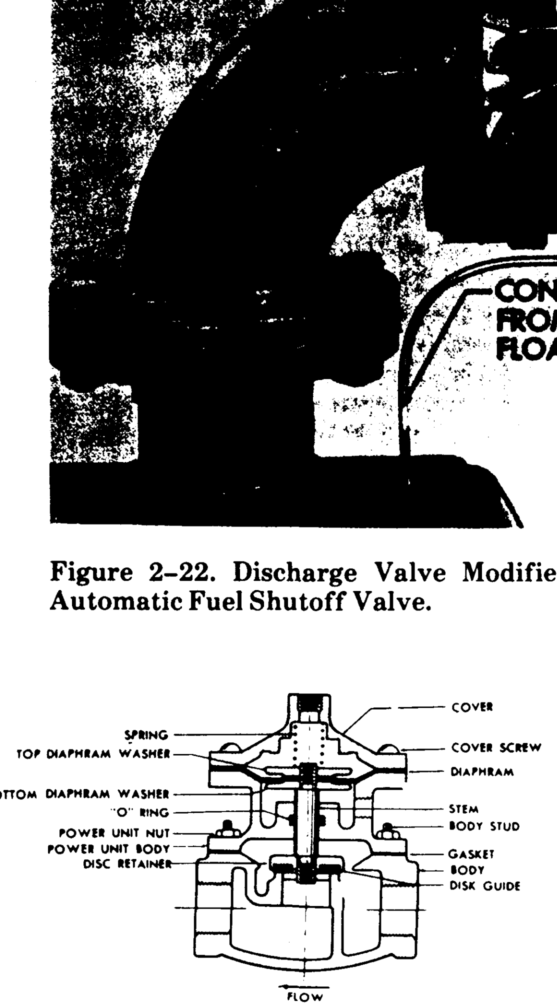


Figure 2-23. Power Control Water Drain Valve.

(3) To remove the cartridge holddown plate (17, figure 2-24), a screw driver may be used for leverage to pry the seals outward from the elements. The "O" ring seals on the element mounts can be more easily removed by a slight twisting motion as opposed to direct pull.

(4) Loosen and remove the coupling (19, figure 2-24) from the inlet pipe, sliding the sealing gasket down on the manifold pipe section.

(5) Remove the manifold (9, figure 2-24). This requires two persons sliding the manifold forward using the protruding element holddown rods (5, figure 2-24) as handles to assist in removing the manifold. Dispose of unuseable cartridges (filter elements) by burying or burning in an approved location. Do not allow fuel soaked cartridge to remain in the area, or to be disposed of in any manner that can create a safety or fire hazard. (Use care when handling used cartridges because of their toxicity and flammability.) Then follow steps f through v.

d. For modified KMU-416/F (300 gpm) kits (P/N 09038-9) with nine additional elements on backside of the manifold, (figure 2-24) follow steps c(1) through c(5) above, except only remove the bottom front six elements instead of all 15 elements mentioned in step c(2) above. Then remove the manifold from the vessel. This will balance the manifold (nine elements on both sides) so it can be removed easily.

e. For KMU-417/F (600 gpm) kits (figure 2-24) follow steps c(4) and c(5) above and leave all the elements in place when removing the manifold. This is necessary for balance and easy removal of the manifold.

f. Inspect the inside of the vessel. If accumulation of contaminants are present, clean inside of the vessel thoroughly.

g. The separator element of second stage screen, as it is sometimes called, (6, figure 2-24) must be removed and cleaned.

NOTE: It will be necessary for one person to get inside the filter separator vessel for removal or installation of the separator second stage. If adequate time has not been allowed for ventilation, an air blower should be provided to ensure protection of personnel. Manufacturer's recommended procedures should be used for removal or installation of the separator second stage.

h. Cleaning procedures for the teflon screen separator second stage are the same as mentioned in paragraph 2-23.

i. Close the sump manual drain valve (22, figure 2-21) and fill the sump with water to check the operation of the automatic valves.

j. Follow the manufacturer's instructions for assembling and installing new cartridges (filter elements). Also, follow the manufacturer's instructions for reinstalling complete kit into the separator vessel.

k Clean and inspect the head (dome) assembly and gasket. If gasket is compressed or broken, a new gasket must be installed. Position cover and tightening cover bolts and nuts.

l. Modification of Horizontal Filter Separators (HFS). To reduce the chances of an ignition, all 300 or 600 gpm aviation turbine fuel filter separators in fixed fuel facilities will be modified as follows:

NOTE: Filter separator modification kit is not required on types III or IV systems.

(1) Two or more HFS colocated. Modify the existing bottom drain underneath each installed HFS according to figure 2-25. All HFS shall be equipped with ¾-inch ball valves (preferred) and quick disconnect hose fittings. This will provide for initial gravity filling through the bottom connection and allow the liquid levels in the two vessels to equalize.

(2) Isolated HFS. When a single HFS is located where it cannot be gravity filled from another HFS, modify the HFS vessel with a bottom drain valve and a quick hose connect fitting (fiture 2-25). Install a mating quick disconnect fitting onto an over-the-wing nozzle so a refueling unit can be used to fill the HFS vessel.

(3) Unique Installations. If installation of ¾-inch piping to the discharge side of a pump is required, the valve and hose arrangement of figure 2-25 would be used. Evaluation will be done by the Base Civil Engineer in cooperation with the command civil engineer prior to any modifications after consulting the base fuels management officer.

m. Initial Filling Procedures for HFS:

(1) Colocate HFS. The following steps will be followed:

(a) Connect ¾-inch service station hose between the empty and full separators. All main inlet and outlet line valves shall be closed to isolate the HFS from the fuel system.

(b) Open manual air release valves on top of both HFS during the initial filling operation for gravity flow.

(c) Open separator drain valves and hose valves to allow fuel to gravity feed from the full to empty separator. Wait 10 minutes for separators to equalize and the new HFS elements to absorb fuel.

(d) Close all drain, hose, and manual air release valves. Refill the supplying separator. Repeat steps 1, 2, and 3 to equalize the liquid levels.

(e) Close all drain, hose, and manual air release valves and again fill the supplying separator. With the supplying vessel operating at regular line pressure and bypassing back into operating storage, open all drain valves to one-half of their travel.

(f) Open receiving HFS (new elements) manual air release valve to one-half opening and allow vessel to bottom fill.

(g) Close immediately when liquid starts to come out of the manual air release. Wipe off any fuel from HFS housing.

(h) The new element vessel is now full. All valves on both vessels should be secured in closed position and the hose assembly removed from each separator.

(i) Set the main refueling and defueling manifold valves to permit fuel to circulate through both separators. An inline monitor sample will be taken in accordance with TO 42B-1-1 for HFS vessel.

(2) Isolated HFS. The following will be followed:

(a) Connect the modified over-the-wing nozzle to bottom of the HFS. A full refueling unit will gravity feed in the flow mode to fill the HFS vessel.

(b) Shut off the valve after liquid flows out of the air vent valve.

(c) The closed system can be shut down and the nozzle assembly replaced with a standard nozzle. The HFS vessel can then be pressurized.

NOTE: For systems with the aboveground storage tanks, the HFS vessel can be filled by gravity feet through the modified bottom connections.

(d) An in-line monitor sample must be taken according to TO 42B-1-1 for HFS elements.

(e) Notify the base fuels management officer that the filter separator is ready to be put back into service and is awaiting quality control (QC) flushing and sampling. (This is necessary to make sure the fuel meets quality requirements.)

(f) After the cartridge (elements) are replaced and filter separator is ready to put back into service, the following is done:

1. Provide data decals with new elements. The bottom portion of the manufacturer's decal under the words, "Element Change Criteria" is cut off, and only the upper portion of the decal indicating element part number, national stock number (NSN) etc., is attached to the FS vessel.

2. Paint in black letters ¾ -inch or 1-inch high, next change date (month and year) and maximum allowable differential pressure taken from criteria prescribed in paragraph 10-17. If data decals are not provided with the new elements, only the next change data and maximum differential pressure will be stenciled on the FS vessel. A log book or wall chart is set up and kept in the LFM

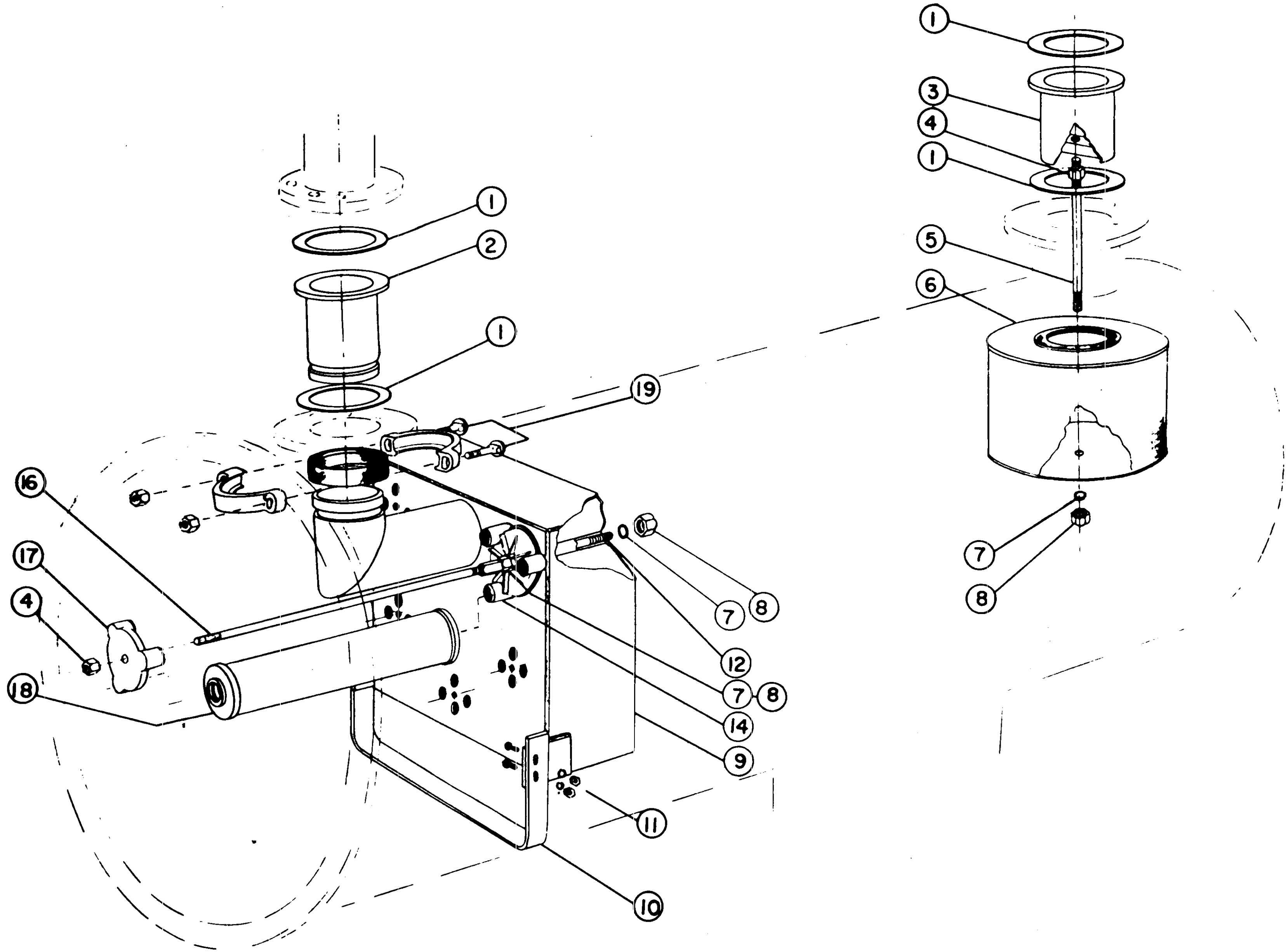


Figure 2-24. 300 Through 600 gpm Horizontal Filter Separator Modification Kit (KMU-416, 417F).

PARTS LIST FOR 300 GPM MODIFICATION KIT
KMU-416/F

Item No.	Description	Qty. Req'd.	Part No.
	Modification Kit Complete (Consisting of the following)	1	09038
1	Gasket, Flange	4	10252
2	Adapter, Inlet Flange	1	09046
3	Adapter, Outlet Flange	1	09047
4	* Nut, 1/2" - 13 NC	11 (5)*	11963
5	Rod, Separator Hold-down	1	11973
6	Separator Element	1	13020
7	* Seal	11 (10)*	10211
8	* Seal Nut	11 (10)*	10210
9	* Manifold	1 *	09041
10	Manifold Support	1	11957
11	Screw Support Mounting w/Hex Nut and Lock Washer	4	11967
12	*Rod, Adapter, Mounting	5 *	11970
13	*Washer, Starlock, Ext. 1/2"	5 *	11966
14	*Adapter, Cartridge	5 *	11923-1
15	*Seal O Ring	5 *	10208
16	Rod Assembly, Cartridge Hold-down	5	11972
17	Plate Cartridge Hold-down	5	11924
18	Filter Element	15	**C-2037-3
19	Coupling Assembly - consisting of	1	11983
	(1) Coupling (2 pc.)	1	11985
	(2) Gasket	1	11987
	(2) Bolt, Tee Head, 1/2" w/ (1) Hex Nut	2	11989
20	Spacer, Flange Bolt	36	11990

* These Items Come Pre-Assembled

**Banner Commercial Model CP-20452-0

Figure 2-24. Continued.

shop.

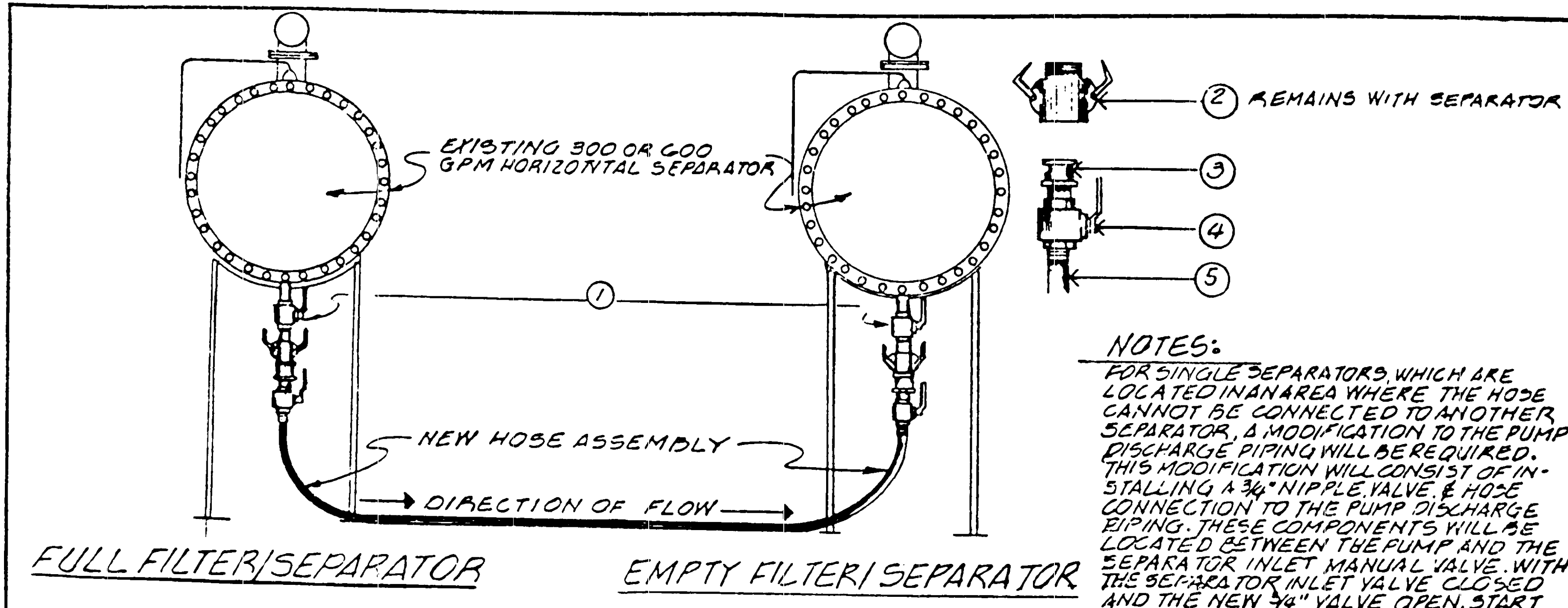
(g) The following information is recorded in the log book: pumphouse facility number; filter separator number; month and year the replacement cartridge were installed; national stock number of cartridge; and the manufacturer's cartridge number, if available.

2-15. Differential Pressure Gages. Filter separator vessels are fitted with a differential pressure gage for indicating pressure drop across the filter separator media.

2-16. Horizontal Filter Separator Modifications:

a. Over the years, the horizontal filter separators have been converted to accept various types and sizes of coalesce filter elements. Action was also taken to convert all horizontal filter separator vessels to accept one size coalescer element that is stock listed under NSN 4330-00-983-0998. This element has been adopted by the armed services as its standard element. It is not only used in fixed systems but it is also used in the AF/32R-9, AF/32R-5, AF/32R-8, and AF/32R-14 mobile fuel servicing system filter separator. One of the newest modification kits, type KMU-417/F, is shown in figure 2-24. This shows a 600-gpm unit and it uses 30 elements. There is also a 300-gpm filter separator modification kit type KMU-416/F, and it uses 15 elements (figure 2-24).

b. In order to obtain additional filtration life, nine extra filter elements were added to the above mentioned KMU-416/F (300 gpm) kit. This "add on" kit assembly was assigned Banner Engineering Company Part Number 09038-9. See figure 2-4.



NOTES:

FOR SINGLE SEPARATORS, WHICH ARE LOCATED IN AN AREA WHERE THE HOSE CANNOT BE CONNECTED TO ANOTHER SEPARATOR, A MODIFICATION TO THE PUMP DISCHARGE PIPING WILL BE REQUIRED. THIS MODIFICATION WILL CONSIST OF INSTALLING A 3/4" NIPPLE, VALVE, & HOSE CONNECTION TO THE PUMP DISCHARGE PIPING. THESE COMPONENTS WILL BE LOCATED BETWEEN THE PUMP AND THE SEPARATOR INLET MANUAL VALVE. WITH THE SEPARATOR INLET VALVE CLOSED AND THE NEW 3/4" VALVE OPEN, START PUMP AND ALLOW SEPARATOR TO FILL SLOWLY FROM BOTTOM.

BILL OF MATERIALS

ITEM	QUANTITY	NATIONAL STOCK NUMBER OR PART NUMBER	DESCRIPTION	COST $
1	1 PER SEPARATOR*	4820-00-052-4649	VALVE, BALL 3/4"	3.90 ea
2	1 PER SEPARATOR.	633 B OR EQUAL **	3/4 - ALUMINUM ADAPTER COUPLER-MALE NPT	3.45 ea
3	2 PER HOSE	633F OR EQUAL **	3/4" ALUMINUM ADAPTER MALE NPT	2.00 ea
4	2 PER HOSE	4820 00-052-4649	VALVE, BALL 3/4"	3.90 ea
5	1 PER BASE ***		HOSE, 3/4" SVC STATION TYPE WITH MALE NPT ENDS (WITH GRN. WIRE)	1.50 PER FT

* IF SEPARATOR HAS EXISTING VALVE, THIS VALVE WILL NOT REQUIRE REPLACEMENT

** KAMLOK QUICK COUPLERS SOURCE OF SUPPLY. OPW DIV. OF DOVER CORP. CINN. OH, 45225 OR LOCAL SUPPLIER.

*** ACTUAL LENGHT OF HOSE WILL VARY FROM BASE TO BASE

INITIAL FILLING OF HORIZONTAL AVIATION FUEL FILTER/SEPARATORS

Figure 2-25

Figure 2-25. Initial Filling of Filter Separator.

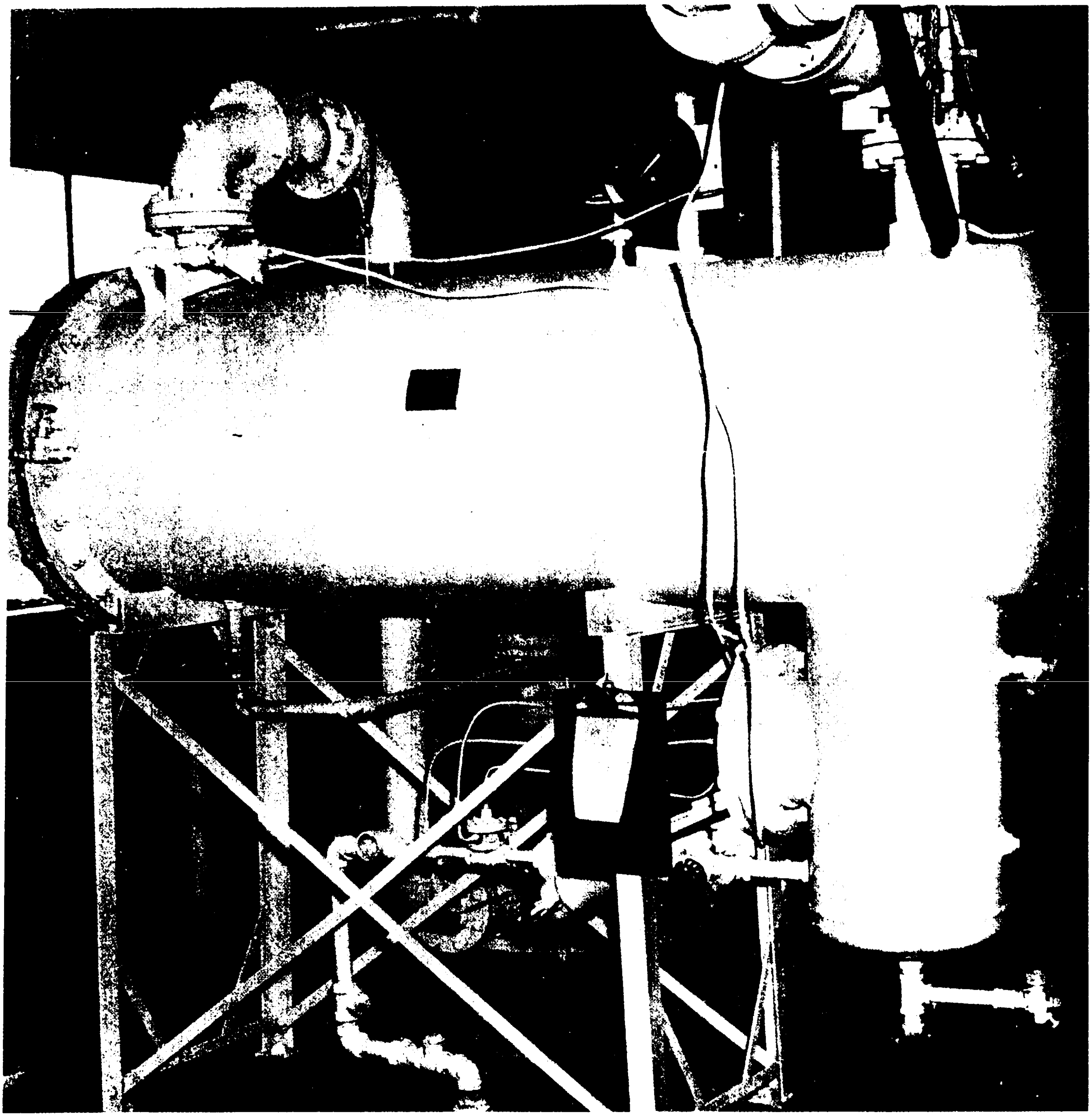


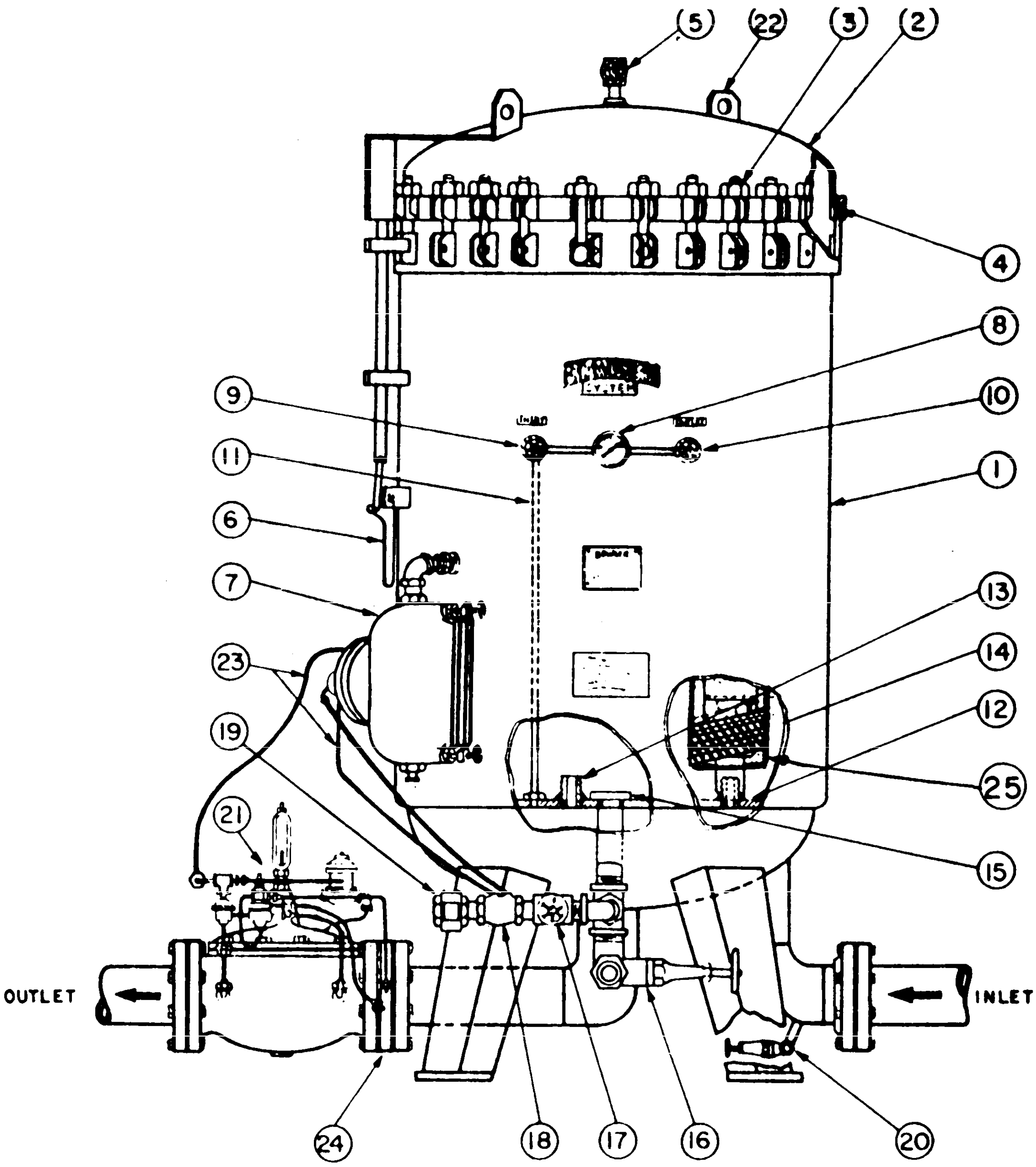
Figure 2-26. Sight Glass Conversion on Horizontal Filter Separators.

Complete installation instructions are furnished with each kit.

c. The liquid level gages on this existing horizontal filter separator, reference item 21, figure 2-21, do not extend far enough down to be able to read the amount of water contained in the lower level of the sump. To rectify this, convert the liquid level gages by extending them on down below the bottom of the sump and tying them in at the bottom gage valve (see item 21, figure 2-21). Also see figure 2-26 for a completed installation. This figure shows one method of modification, however, a shorter liquid level gage may be desired and can be connected where the bottom pipe plug is shown in figure 2-26. The installation of the liquid level gage conversions are optional but recommended because of the savings in fuel and work hours that was noted after they had been installed. Conversion can be done inhouse at a very low installation cost. Complete installation instructions can be obtained from HQ AFESC/DEMM.

NOTE: If the liquid level gage is modified as described above, and a density sensitive ball is installed as mentioned in TO 42B-1-1 paragraph 3-25, the sump is drained by operator personnel whenever water is detected (see paragraph 2-13a(6)).

d. The hot refueling servicing operation posed the dual problem of removing water and solids as close



1. Filter/Separator Vessel
2. Cover
3. Cover Eye Bolt and Nut
4. Cover Gasket
5. Manual Air Release Valve
6. Cover Lifting Handle
7. Float Chamber and Pilot Valve Assembly
8. Pressure Gage (Differential)
9. Inlet Pressure Valve (High)
10. Outlet Pressure Valve (Low)
11. Inlet Pressure Tube
12. Deck Plate
13. Deck Plate Nipple
14. Filter Element Assembly
15. Water Drain Connection
16. Manual Water Drain Valve
17. Shut Off Valve (Supply to Auto Drain Valve)
18. Automatic Water Drain Valve
19. Flow Indicator
20. Drain Valve
21. Main Discharge Valve and Cla-Val Controls
22. Lifting Eye
23. Cla-Val Control Tubing
24. Orifice Plate
25. Teflon Screen Cannister

Figure 2-27. Vertical Filter Separator Components and Accessory Equipment.

to the aircraft as possible, and doing it without the use of MH-2 series hose cart. After an investigation was made, it was concluded that a modified vertical type filter separator could be installed in place of the micronic filter. As a result, specification MIL-F-83243 (USAF) was prepared that covered seven configurations for the filter separators (FFU-18/E). This filter separator uses standard elements (NSN 4330-00-983-0998) and FF-24/E (NSN 4300-00-071-1218). Element change criteria has been established under Chapter 10, paragraph 10-17. Maintenance instructions are similar to other verticle filter separators.

2-17. Vertical Filter Separators:

a. **General Information.** Most vertical filter separators installed or procurred by the Air Force before 1962 were the Bowser, Inc., series 842-300 and 842-600. These units are equipped with coalescer elements NSN 4330-00-804-1502 and separator stage teflon screen canister NSN 4330-00-168-1703. Vertical filter separators installed after 1962 conform to specification MIL-F-27629 (FFU-1-300 GPM), MIL-F27630 (FFY-2-600 GPM), and MIL-F-83402 (FFU-25-1200 GPM). These filter separators use the standard coalescer elements NSN 4330-00-983-0998 and teflon screen canisters for the separator stage. A typical vertical filter separator is shown in figure 2-27.

b. **Description:**

(1) The filter separator is a vertical-standing tank of welded metal construction. The top of the tank has a pivoted cover, held in place by eye-bolt clamps. An inlet pipe, an outlet pipe, a water drain outlet pipe, and a cleanout flange are located on the bottom of the tank, as shown, figure 2-27.

(2) Penetrations through the walls of the tank are provided for inlet and outlet pressure gage connections and float chamber connections.

(3) The main discharge valve connected to the outlet pipe, and the automatic drain valve connected to the water drain outlet pipe are provided with connections to the control system (Cla-Val).

(4) The control system has a float chamber, a pilot valve and strainer attached to the float chamber, two auxiliary valves, and a rate of flow controller located on the main fuel discharge valve. The control system external tubing is the interconnecting lines for the hydraulic control of the main fuel discharge valve, and and the automatic water drain valve. The main fuel discharge valve is provided with a valve position indicator located on the valve bonnet, as shown in figures 2-28 and 2-29.

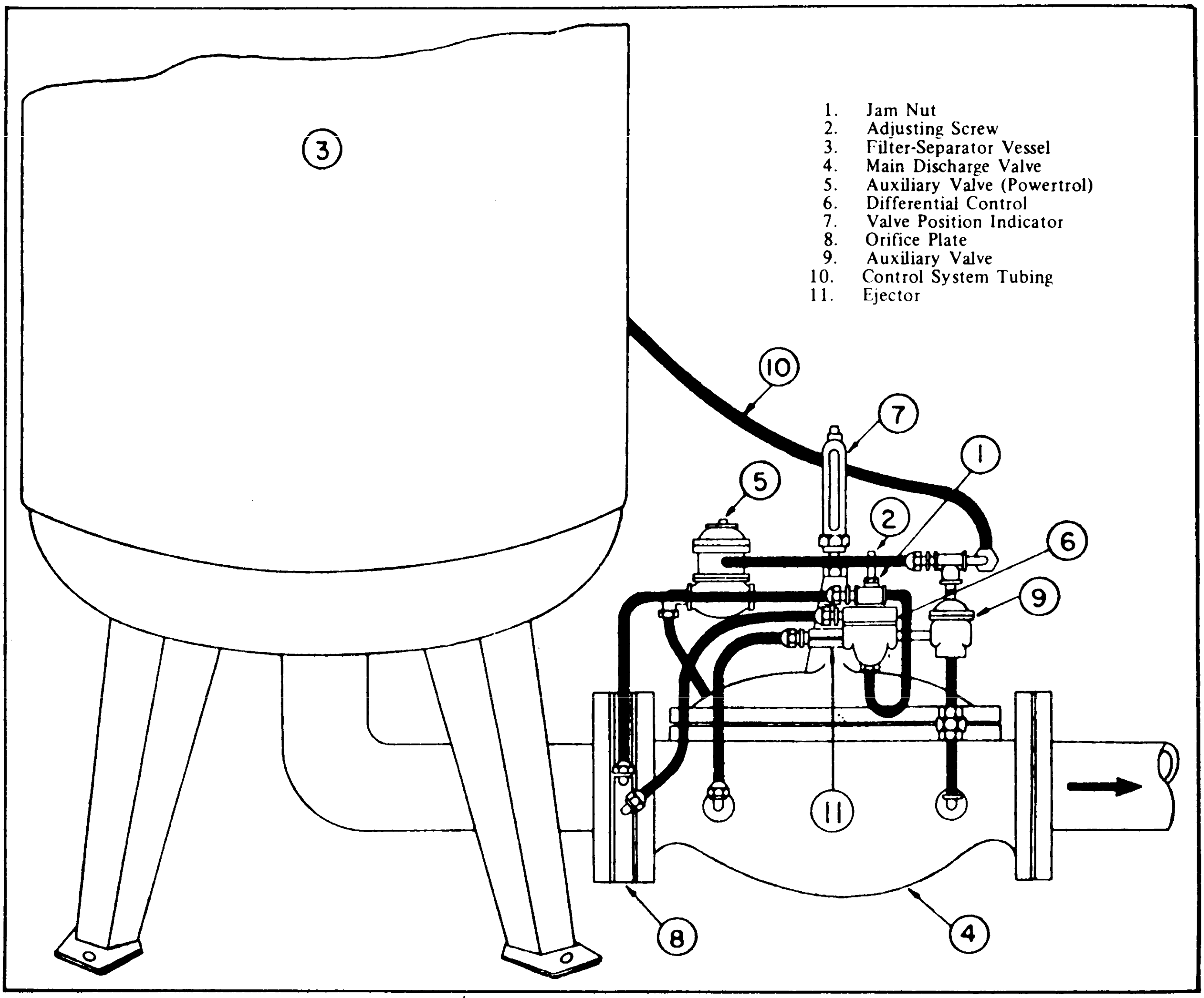


Figure 2-28. Main Discharge Valve.

(5) Manually operated valves (figure 2-27) include the air release valve located in the cover, a water drain valve located in the water drain outlet pipe, a shutoff valve located in the automatic water drain outlet pipe, a drain valve connection in the tank cleanout flange (figure 2-27), and a valve located in each side of the inlet and outlet pressure gage connections of the filter separator.

(6) The interior arrangements of the tank comprise a deck plate, filter element assemblies, separator canisters, a discharge riser pipe, an inlet pressure tube, and a water drain outlet pipe.

(7) The deck plate, located near the bottom of the vessel divides the interior of the vessel into a lower (inlet) portion and an upper (separation and discharge) portion. Openings through the deck plate between the lower and upper portions of the vessel are provided at nipples welded to the top of the deck plate on which are screwed the filter element and canister assemblies located in the upper portion of the vessel. The deck plate is also penetrated by the connection to the discharge riser pipe, located in the upper portion of the vessel, and leading from the top part of the upper portion to the exterior outlet pipe; by the connection in the deck plate to the inlet pressure tube, located in the upper portion of the vessel, and leading from the bottom portion of the vessel to the manual inlet pressure valve on the outside of the vessel; and by the water drain connection located in the deck plate leading from bottom of the upper portion of the vessel to the exterior water drain outlet pipe.

(8) The location of the float chamber connections to the side of the vessel is at the point at which the float, in its normal position, will be even with the normal water level in the vessel. The float is connected to the pilot valve that is bolted to the float chamber, by means of an arm that is inserted into the pilot valve disc (see figure 2-30).

(9) Cla-Val control system tubing extends from external connections in the pilot valve to the main discharge valve to the automatic drain valve, and to an atmospheric drain. A fourth tube connects the pilot valve inlet to the float chamber strainer outlet.

c. **Maintenance:**

(1) The procedures for performing preventive maintenance include inspecting the filter separator, cleaning the strainer screen, and cleaning the filter separator vessel. These procedures are necessary to ensure safe and effective filtration of aviation fuel.

(2) Inspection of the filter separator must be performed before and during filter separator filling operation to check for indications of conditions that affect the operation of the equipment. The strainer screen must be cleaned to ensure free flow of fluid through the strainer to the control system. The filter separator vessel must be cleaned periodically to remove dirt and corrosion from the interior of the vessel. If the filter separator operational check shows that the filter elements should be changed, replacement (paragraph 10-17) should be done along with the scheduled cleaning of the vessel.

CAUTION: Before performing filter separator maintenance work, be sure the valves in the filter separator supply pipeline are closed and the manual air release valve (5, figure 2-27) is open to remove all pressure from the vessel.

(3) The filter separator should be inspected for damage or missing parts, improper or loose connections, and evidence of corrosion or leakage. If any condition that affects safe and effective operation of the filter separator is detected, the condition should be remedied as soon as possible. When inspecting the filter separator, do the following:

(a) Check all valves and pipe fittings for evidence of leakage and corrosion.

(b) Check the ¼-inch control system tubing for kinks or loose connections.

(c) Check the gage glasses for damage.

(d) Make sure the cover lifting mechanism is not corroded.

(e) Check the area around the cover of the filter separator for evidence of leakage or gasket failure.

2-18. Cleaning the Vertical Filter Separator (figure 2-27):

a. Drain the filter separator.

b. Loosen the nuts on the eye bolts and swing the eye bolts out of the way.

c. Raise the cover by moving the lifting handle upward and over center. Swing the cover out of the way to gain access to the interior of the vessel.

d. Grasp the filter element assembly around the top with both hands and turn counterclockwise until the element unscrews from the nipple in the deck plate. Remove all filter element assemblies.

e. Loosen and remove the cleanout flange bolts.

f. Remove the cleanout flange with a 1-inch drain valve and nipple attached, and gasket.

g. With a cloth dampened in cleaning solvent, wipe out the upper and lower portion of the vessel. Reach in through the cleanout opening to wipe out the lower portion of the vessel below the deck plate.

h. Inspect the cleanout flange gasket. Discard the gasket if it is not in serviceable condition and replace with a new gasket of the same grade and manufacture as the old gasket.

i. Place the gasket in position on the cleanout flange screw in and tighten the flange bolts. Make sure that the gasket and flange are properly seated.

j. Check the adapter gasket and the adapter of the filter element assemblies to make sure that the gasket and the adapter threads are clean.

k. Lower each one of the filter elements assemblies into one of the deck plate nipples, making sure that each of the element assemblies is screwed down onto its deck plate nipple so that the gasket is properly seated for a tight seal.

l. Inspect the cover gasket. If the cover gasket is not in serviceable condition, replace with a new gasket of the same grade and manufacture as the old gasket.

m. Swing the cover back into position and lower the lifting handle.

n. Swing the eye bolts up into place and tighten the nuts, tightening diagonally opposite nuts equally and alternately so that the cover gasket and cover are properly seated. When tightening cover bolts and nuts on aluminum filter separators, a torque wrench is used. Tighten nuts with care or just enough to prevent leaking through dome cover seal (approximately 50 to 60 foot pounds of torque) to eliminate possible damage from overtightening.

o. Close the manual water drain valve.

p. Pressurize the vessel to inspect all gasketed and screwed connections for leakage. Tighten all loose connections.

NOTE: Remember once a system is opened for any reason, it must be flushed and sampled before servicing the aircraft. Follow instructions given in paragraph 2-17.

2-19. Replacement of the Filter Separator Cartridge:

a. Drain the filter separator completely.

b. Raise the cover and remove the filter cartridge assemblies using the procedure in paragraphs below.

c. Remove the outer canister.

d. Remove the canister from case and set it aside for reuse.

e. Remove the expendable cartridges and discard. Dispose of unuseable cartridges (filter separator elements) by burying or burning in an approved location (see paragraph 2-14c(5).

f. Insert a new expendable cartridge into the canister.

g. Fasten cartridge canister assembly in case.

h. Check the adapter gasket and the adapter to make sure that the gasket and the adapter threads are clean.

i. Complete the installation of the filter separator cartridge assemblies, using the procedures in paragraph 2-18k through 2-18p.

j. Notify the Base Fuel Management office that the filter separator is ready to be put back into service and is awaiting QC flushing and sampling. (This is necessary to ensure the fuel meets quality requirements.)

k. After the cartridges (elements) are replaced and filter separator is ready to put back into service, the following is done:

(1) Data decals are provided with new elements, the bottom portion of manufacturer's decal under the words, "Element Change Criteria" is cut off, only the upper portion of the decal indicating element part number NSN, etc., will be attached to the filter separator vessel.

(2) Paint in black letters ¾-inch or 1-inch high, the next change date (month and year) and the maximum allowable differential pressure taken from criteria prescribed in paragraph 10-17. If data decals are not provided with the new elements only the next change data and maximum differential pressure will be stencilled on the FS vessel. A log book or wall chart is set up and kept in the LFM Shop. The following information is recorded in the log book: pumphouse facility number, filter separator number, month and year replacement cartridges were installed, NSN of cartridge, and manufacturer's cartridge number, if available.

NOTE: Cleaning procedures for the teflon canister screens are outlined in paragraph 2-23.

CAUTION: Explosions and fires can result from static discharge ignition of vapors when filter separators are rapidly filled after element change and other maintenance. Slowly filling the filter separator vessel after each element change reduces this hazard condition.

Table 2-2. Trouble Shooting (Filter Separators).

Trouble	*Cause*	*Remedy or Action*
Partial or stoppage of discharge	Manually operated valve on inlet side of automatic water drain valve closed.	Open valve to permit automatic water drain valve to discharge accumulated water.
	Setting of adjusted screw on flow rate controller changed.	Set adjusted screw to maximum flow setting.
	Air lock.	Open manual air-release valve; bleed off air.
	Inlet supply valves closed.	Fully open inlet supply valves to filter separator.
	Strainer screen clogged or corroded.	Clean strainer screen; replace strainer screen if damaged.
	Control system tubing connections loose; tubing kinked or damaged.	Tighten tube connections; straighten tubing; replace tubing if damaged.
	Float or pilot valve malfunctioning.	Replace float or pilot valve.
	Main discharge valve diaphragm failure.	Replace main discharge valve diaphragm.
Excessive pressure differential across inlet-outlet.	Filter elements clogged.	Replace filter elements.
Leakage; malfunctioning of manually operated valves.		Refer to Valves—Gate, Globe, and Check, and manufacturer's literature.

2-20. Replacement of the Pilot Valve or Float:

a. Close inlet valve and place a danger tag on control panel to make sure the pump will not be operated. Then drain the top part of the filter separator.

b. Tag and disconnect the four tubing connections at the pilot valve and housing assembly.

c. Unscrew and remove the eight cap bolts holding the pilot valve and housing assembly to the chamber body. Be careful not to drop the cap gasket or damage the float.

d. If the pilot and housing assembly or the float is to be replaced, unscrew the float and the float arm from the pilot and housing assembly. Replace a damaged float with a new float of the same size and manufacture as the old float. Replace a damaged pilot and housing assembly with a new assembly.

e. If the cap gasket is not serviceable, replace it with a new gasket of the same size and material as the old gasket.

f. To assemble the float arm, the float, and pilot and housing assembly, screw the float onto the float arm and screw the float arm into the pilot and housing assembly.

g. Test the action of the pilot valve by moving the float through its arc. The action should be free and easy.

h. Place the cap gasket against the flange of the pilot and housing assembly; insert the top and bottom cap bolts through the flange and gasket; and place the flange of the pilot and housing assembly against the flange of the chamber body. Carefully guide the float into the chamber so that it is not damaged.

i. Screw in and tighten the top and bottom cap bolts.

j. Tighten the remaining cap bolts, making sure that the cap gasket and flange seat evenly all around.

k. Reconnect the four tubing connections.

l. Check all screwed and bolted connections for tightness.

2-21. Replacement of the Main Discharge Valve Diaphragm (See figures 2-28 and 2-29):

a. Before disassembling the filter separator main discharge valve, make sure that all valves in the aviation fuel pipeline to the filter separator are closed, and danger tag the control panel to make sure the pump will not be operated. Then the system discharge pipeline from the filter separator can be drained by removing the orifice plate from the filter separator discharge valve in the system pipeline, and opening the value to drain the discharge line. Then proceed as indicated below:

(1) Tag and disconnect the control system tubing connections. Be careful not to change the setting of the flow rate adjusting screw.

(2) Unscrew and remove the eight bonnet nuts (1).

(3) Lift off the bonnet assembly (2).

(4) Lift off the spring (3) and the disc-stem-diaphragm assembly (4, 5, 6, 7, and 8).

(5) Unscrew and remove the diaphragm holding nut (4) and holding disc (5) from the stem (6).

(6) Remove and discard the damaged diaphragm (7).

(7) Inspect the seating disc (8). Replace with a new disc if in unserviceable condition.

(8) Place a new diaphragm (7) of the same grade, material, and manufacture as the old diaghragm over the stem (6) onto the top of the seating disc (8).

(9) Place the diaphragm holding disc (5) over the stem (6) against the diaphragm (7).

(10) Screw the diaphragm holding nut (4) onto the threaded shoulder of the stem (6).

(11) Insert the disc-stem-diaphragm assembly (4, 5, 6, 7, and 8) into the valve body (9), making sure that the seating disc (8) and diaphragm (7) are properly seated.

(12) Set the spring (3) over the stem (6).

(13) Place the bonnet assembly (2) over the stem (6), taking care to guide the position indicator stem (10) into the indicator glass housing (11).

(14) Screw on all the bonnet nuts (1) hand tight. Tighten all bonnet nuts with a wrench, tightening diagonally opposite nuts alternately and equally.

(15) Reconnect the control system tubing connections.

(16) Check all connections for tightness.

2-22. Replacement of the Liquid Level Gage Glass (figure 2-30):

a. Close the top and bottom gage cocks (11).

b. Unscrew and remove the top and bottom "U" clamp nuts (12) and the "U" clamps (13).

c. Remove the gage glass protector assembly (14).

d. Unscrew and remove the gage glass holding nut (15) from the top and bottom gage cocks (11).

e. Remove and inspect the gage glass gaskets (16). If in serviceable condition, set the gaskets aside for reuse; if not, discard the gaskets and replace with gaskets of the same grade and materials as the old gaskets.

f. Cut a piece of glass tubing to the correct length.

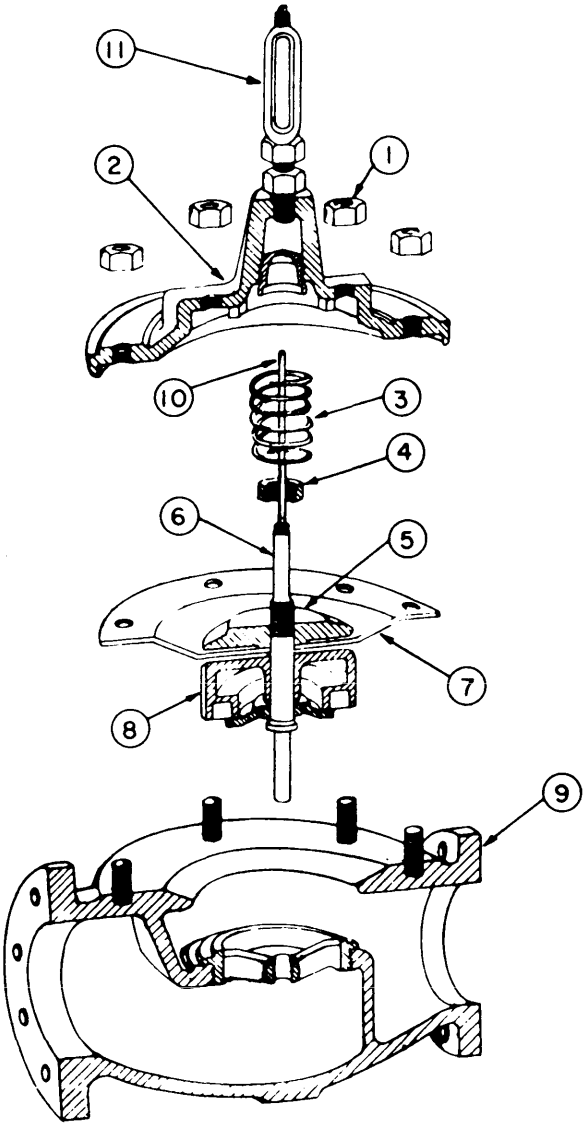
g. Slip the top and bottom gage glass holding nuts (15) onto the glass tubing (17).

h. Slip the top and bottom gasket (16) onto the glass tubing (17).

i. Hold the glass tubing in place and tighten the top and bottom holding nuts (15), making sure that the gaskets (16) are properly seated.

j. Open the top and bottom gage cocks (11) and inspect for leakage; tightening the holding nuts (15) if leakage occurs.

k. Slip the gage glass protector assembly (14)



1. Bonnet Nut
2. Bonnet Assembly
3. Spring
4. Diaphragm Holding Nut
5. Diaphragm Holding Disc
6. Stem
7. Diaphragm
8. Seating Disc
9. Valve Body
10. Position Indicator Stem
11. Position Indicator Glass Housing

Figure 2-29. Main Discharge Valve, Exploded View.

around the glass tubing (17), insert the "U" clamps (13) around the glass tubing and through the lugs. Tighten the "U" clamp nuts (12).

l. Open the top and bottom gage cocks (11).

2-23. Filter Separator Teflon Coated Screens-Cleaning, Repairing, and Handling:

a. Cleaning. The teflon coated screens, when new, operate in a satisfactory manner, but after processing millions of gallons of fuel that contain additives and contaminants they gradually become less effective. Everytime the coalescer elements are changed the second stage teflon coated screens should be inspected and cleaned according to the following procedures:

(1) Connect a water hose to a hot water supply. Attach a nozzle to the hose and direct a high velocity stream of water at a downward angle against the outer surface of the teflon coated screen. Hold the screen assembly vertically by the end and begin at the top and work downward along the length of the screen. Rotate the screen slowly so that the entire surface is subject to a jet of hot water. Repeat as necessary until screen is clean.

(2) After cleaning shake loose water from screen and allow the remaining water to evaporate normally or use a jet of clean dry, oil-free compressed air. Air quality must be very clean. If the air quality is doubtful, do not

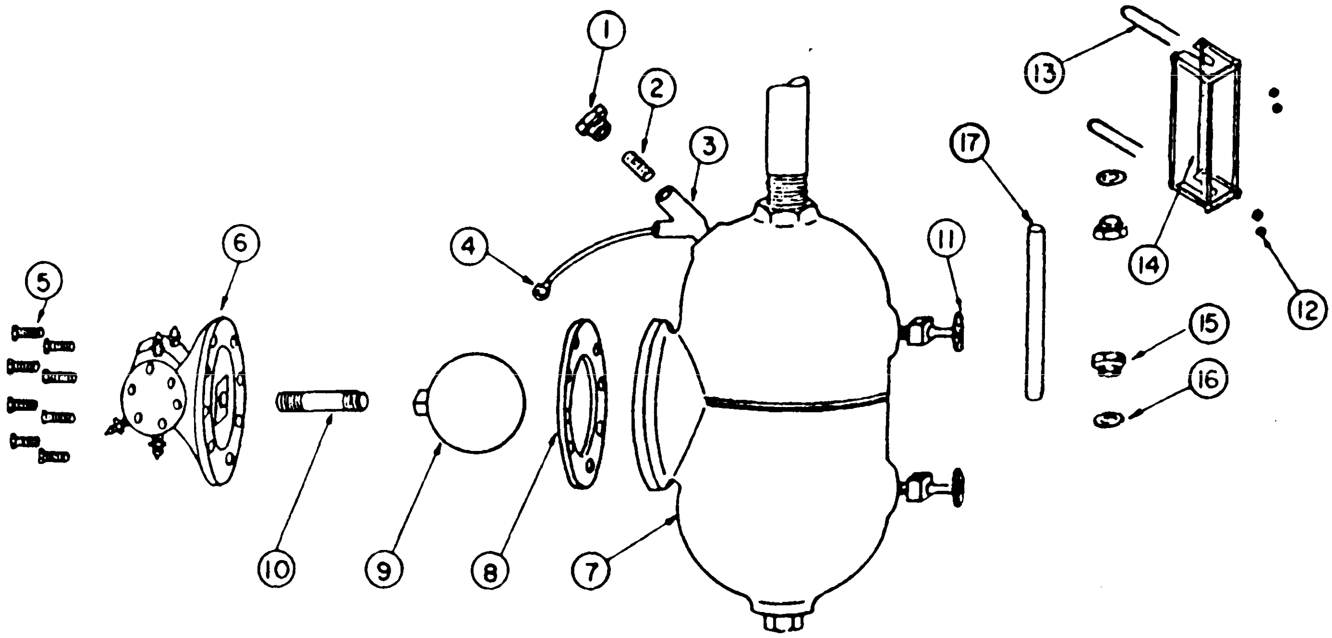
(3) After each screen is dry, hold it by the end in horizontal position 2 inches below a dripping cold water hose. Move the hose back and forth along the entire length of the screen while slowly rotating the screen. Under test, observe the way the water appears on the surface of the teflon coated screen. Any water that does not either "roll off" or "bead up" but soaks into the teflon coated screen, indicates recleaning of the separator elements is necessary.

(4) The teflon coated screen must be visually inspected for small cuts and breaks. Small breaks in the teflon coated screen can be repaired for temporary service by patching with a fuel resistance sealant, epoxy adhesive, or epoxy base putty. If major holes appear in the teflon coated screen, it would be impractical to repair, the screen should be replaced.

b. Installing and Handling. Just before installing the teflon coated screens, agitate briefly in a container of clean fuel to flush all remaining water. (Type of fuel to be used depends on what product (fuel) is to be filtered.) Extra care must be taken during installing to make sure they are not damaged. Screens must be installed very carefully to prevent any physical damage to the teflon coating. When installing the teflon coated screen assembly, the securing nut should not be overtorqued, because this can damage the screen assembly.

Section E—Meters

2-24. General Information. Two types of meters are installed in fixed petroleum plants and systems: One-way flow or two-way flow. Both are the displacement type. One-way flow meters are installed on truck fill- stands and measure fuel stream in one direction only. The two-way flow meters are installed in the filter meter pit of hydrant refueling systems (design system I). This meter is also a displacement type designed to measure the fuel



1. Strainer Plug
2. Strainer Screen
3. Strainer Body
4. Tubing Connection
5. Cap Bolts
6. Pilot and Housing Assembly
7. Chamber Body
8. Cap Gasket
9. Float
10. Float Arm
11. Gauge Cock
12. "U" Clamp Nut
13. "U" Clamp
14. Glass Protector Assembly
15. Gauge Glass Holding Nut
16. Gauge Glass Gasket
17. Glass Tubing

Figure 2-30. Float Chamber Components, Exploded View.

stream in either direction. The latter meter shows total delivery and subtracts the amount defueled from the dispensing hose and pipeline at the end of the refueling operation to show the actual amount of fuel delivered to the aircraft.

2-25. Testing and Calibrating Meters. Since moving parts are subject to wear, and solids can accumulate, periodic calibration is necessary. Check and calibrate meters installed in fixed petroleum plants and systems according to the method and frequency outlined in chapter 10.

a. Certified master meters are used in meter calibrations by connecting hoses from the hydrant outlet to the master meter and from the master meter to a tank truck or servicing vehicle. Master meters must be calibrated after a flow log of 1,200,000 gallons as indicated on the totalizer (or every 6 months, whichever occurs first). Calibration is made at normal flow rates and operating pressures.

b. Meters are considered satisfactory for further operation when: for any one predetermined flow rate and calibration setting between 20 and 100 percent of rated capability, the error of the meter in normal flow direction does not exceed 0.2 percent of actual quantity delivered (1.2 gallons in a 600 gallon test); for other flow rates in the range from 20 to 100 percent of rated capacity, and without readjustment of calibration setting, the error of the meter in normal flow direction does not exceed 0.2 percent and in reverse flow does not exceed 0.3 percent of the actual quantity delivered.

2-26. Meter Adjustment. When a check of the master shows amount of fuel delivered is different from amount indicated, the installed meter may have to be adjusted. In some instances, meter adjustment is made only by replacement of complete "Change-Gear" sets. Meters of this type (and meters for which proper adjustment cannot be made because of wear) are removed and replaced. The old meter is returned for overhaul. Adjust others according to the manufacturer's instructions or as follows:

a. For Pittsburgh Meters:

(1) Remove the wire seal from the two fillister head screws holding the cover plate over the counter adjuster.

(2) Place a screw driver in the slot on the counter adjuster, and turn clockwise to increase fuel flow thorugh the meter (counterclockwise to decrease it.) Graduations as indicated on the counter adjuster represents about 0.1 gallon.

b. For Neptune Meters:

(1) Remove seal from screws holding the top

cover plate to meter base.

(2) Remove the four screws holding the top cover plate. Slide plate back about ½-inch to free it from the turned-over edge of the dial face, and lift off.

(3) Lift gear changer and adjust for fuel flow through the meter according to the manufacturer's instructions.

(4) There is a series of holes in the plate into which the guide pin enters at different settings. Altering the setting by one hole changes the calibration about 0.15 percent or 0.15 gallons per 100 gallons.

c. **For Brodie Meters:**

(1) Calibration and fuel flow adjustments of Brodie meters are made according to manufacturer's instructions.

(2) After completing the calibration of meters, the cover plates will be fastened securely to prevent tampering.

d. **For Granco Meters:**

(1) Remove screws holding the adjustment cover cap over the precision adjustment dial.

(2) Place a screw driver in the slot in the precision adjustment dial pointer screw and adjust for fuel flow through the meter according to the manufacturer's instructions.

e. **For Smith Meters:**

(1) The SA-60/R uses levers for adjusting.

(2) Adjust the fuel flow according to the manufacturer's instructions.

(3) Course adjustment—1 notch equals 138.8 cubic inches per 100 gallons.

(4) Fine adjustment—1 notch equals 11.5 cubic inches per 100 gallons.

(5) Pull the levers out to lower the level of fuel in the prover tank, or push the levers in to raise the level of fuel in the prover tank.

2-27. Maintenance of Meters:

a. Maintenance on meters in the field is limited to minor repairs (such as replacement of gaskets, counters, and packing glands). Disassembly of a meter must never be undertaken unless personnel are experienced in repair of this type of equipment. Also, complete instructions for disassembly and assembly must be available. Do not take a meter apart until it has been determined that the trouble is in the meter.

b. Gaskets used on meters are usually of a special material and thickness. When replacing gaskets, care must be taken to obtain gaskets of the proper type and thickness, preferably the manufacturer's gaskets; this guards against variations in the clearance between rotors, disks, and measuring chamber. Such variations can result in meter inaccuracy.

c. Operator personnel will remove meter drain plugs and drain water or sediment from the meter weekly. If a meter has been idle for a prolonged period, remove plug and drain the meter before placing it in service.

NOTE: Drain lines should also have a valve installed to permit easy draining.

2-28. Troubleshooting. Before removing a meter from the fuel system, all possible causes of the meter malfunctioning should be checked to determine whether the meter is the cause of the trouble:

a. **Erratic Recording.** Meters are normally constant in their action. They constantly measure over, under, or accurately, whichever the case may be. It is not the natural performance of a meter to go erratic all at once unless the meter is operating under:

(1) Dirty conditions.

(2) Poor air elimination.

(3) Liquid locked vent line.

(4) Great variation in velocity.

(5) Excessive head. To eliminate erratic meter operation, first check pump suction piping, valves, and connections for air leaks; proper seating of valves; dirty strainers or filters; and operation of air eliminators, where installed. Check counter drive for slipping gears or gears not meshing properly. Remove, clean and check meter only as a last resort.

b. **Slow Meters.** A slow meter is often misunderstood to be a dirty meter. A meter that is sufficiently dirty generally stops and locks rather than slows down. Therefore, check the possibility of defective valves, dirty strainer, or filter-restricted line or hose. Before working on meter determine whether the trouble is in the meter.

c. **Ineffective Adjustment.** When adjustment is ineffective, the usual cause is a dirty meter or air condition in the liquid. Therefore, check for possible line leaks and condition of filters and strainers. If final diagnosis shows the meter is at fault, the meter adjuster should be removed, checked, and replaced if damaged. Remove and clean meter.

SECTION F—MANUAL VALVES

2-29. Plug Valves:

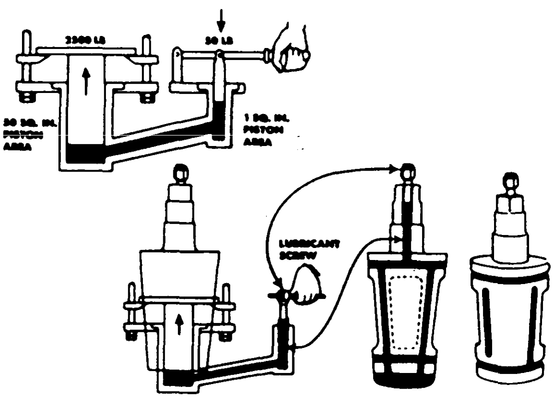
a. **Lubricated Plug Valves.** Plug valves, MIL-V-12003, primarily have three components: the housing provides a leak proof seat for the plug; the tapered plug is seated in the housing and can be positioned to block the flow of fuel or pass the full capacity of the line; and a device raises the plug away from its seat to permit ease of turning. Plug valves are divided into two classes: lubricated and nonlubricated.

(1) Using Valves. Lubricated plug valves are used as stop (block) valves in various parts of the system, such as in piping to hydrant outlet, between pump and pump header, and between pump header and filter separator.

(2) Operating Valves. The lubricant in a lubricated plug valve serves three functions. The primary function is to lift the tapered plug away from its seat. The principle involved in the operation is illustrated in figure 2-31. The second purpose of the lubricant is to form a high pressure seal between the plug and seat. Two pieces of metal clamped together to form a pressure vessel will not hold pressures in excess of 100 psi. When coated with lubricant, these surfaces will hold pressures in excess of 30,000 psi. The third function of the lubricant is to lubricate the surface of the plug for ease in turning. A typical lubricated plug valve is shown in figure 2-32.

(3) Maintenance.

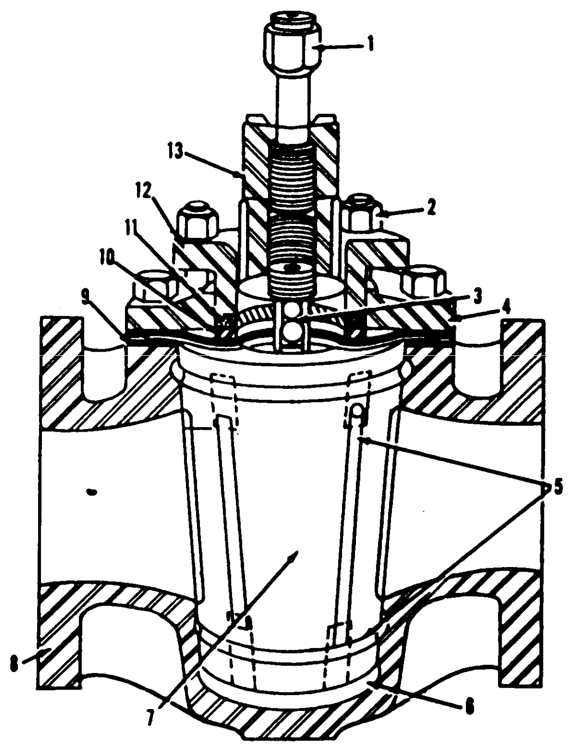
PASCAL'S LAW OF HYDRAULIC PRESSURE



Pressure applied to a confined fluid is transmitted uniformly to all areas of the confining surface

Figure 2-31. Lubricated Plug Valves—Principle of Operation.

(a) At least once a week turn plug valves and lubricate to ensure freedom from seizure and smooth operation. Refill grease chamber as required with recommended lubricant. MIL-G-6032 lubricant or equal is used for all lubricated plug valves.



1. Lubrication fitting	8. Body
2. Cover cap screw	9. Sealing diaphragm and gasket
3. Lubricant check valve	10. Metal packing ring
4. Cover	11. Resilient packing ring
5. Lubricant grooves	12. Adjustment gland
6. Lubricant chamber	13. Wrench flat
7. Tapered plug	

Figure 2-32. Lubricated Plug Valve.

(b) To ensure proper lubrication, be sure the packing gland is snuggly adjusted. Pump lubricant into the valve until the plug lifts. This is indicated by a sudden release of back pressure. The plug must be lifted from its seat to ensure complete lubrication.

(c) As a rule, properly adjusted plug valves require approximately 50 pounds pull on the proper size wrench for the valve. Adjustment is made by loosening or tightening the packing gland adjustment.

(d) If the plug becomes stuck or inoperable, tighten the packing gland and pump lubricant into the valve. Develop as much pressure as necessary to lift the plug. This lifting can usually be detected by a sudden reduction in back pressure, and usually, it is possible to hear a click when the plug lifts. Loosen the packing gland one-half turn and adjust the valve as in (c) above.

(e) Under normal maintenance conditions a defective plug valve should be returned to the manufacturer for repair. However, if time and replacement factors dictate that the valve must be repaired by base LFM personnel, the six steps illustrated in figure 2-33 should be followed. Step 1 is wire brushing to remove deposits from corroded areas. Abrasive blasting might also be used. In step 2 the depth of lubricant groove is checked. The taper is checked with feeler stock in step 3 and valve bodies can be remachined. Step 4 is applying lapping compound to the bearing surface of the plug. In step 5 the accuracy of fit is checked by examining the plug, that has been blued, inserted into the body, and rotated one or two turns under light pressure. In step 6 the valve is lapped by hand. This is the final step in making a close body-and-plug fit.

(f) As a matter of policy lubricated plug valves are replaced by Air Force approved nonlubricated plug or ball valves when replacement becomes necessary.

b. **Nonlubricated Plug Valves:**

(1) Use. In current new systems or when existing lubricated plug valves require replacement, approved nonlubricated plug valves conforming to MIL-V-12003 or ball valves conforming to Federal Specification WW-V-35B (Ball Valve Type II, Style 3) are specified. Nonlubricated plug valves or ball valves are used as (block) valves or where quick shut-off is required in various parts of the system, such as in piping downstream from the filter.

(2) Types. Nonlubricated plug valves vary in design but generally fall into three classifications as follows:

(a) Lift Plug Type. This type of plug valve incorporates a mechanical screw jack or lever to lift the plug away from its seat. The lifting and reseating of the plug is done automatically during the opening and closing of the valve by integral gearing and locking devices. This prevents the plug from being turned in its seat and ensures seating of the plug after it has been repositioned. Figure 2-34 illustrates a typical lift plug type plug valve.

(b) Moveable Seat Type (figure 2-35).

1. The moveable seat or twin seal valve is a nonlubricated, resilient seal, plug type valve, that has a mechanical means of freeing the plug before it is rotated from the closed to the open position. In opening the valve, the center plug is raised, thus retracting the seating segments through their tapered dovetail connections. Only after the seating segments are fully retracted perpendicularly from the body seat, is the plug that is mounted on trunnions rotated to the open position.

2. In closing the valve, the plug and seating segments are rotated freely, with no plug-to-body contact, until the seating segments are positioned over the ports. Then the plug is driven down between the segments, and the tapered surfaces wedge out the seating segments for a positive upstream as well as downstream shutoff. For a maximum upstream sealing, it is important to torque the valve closed—do not back off.

3. The small moveable seat valves are handwheel operated, and require 2¼ turns to open and close. Two turns expand or retract the seating segments, while ¼ turn rotates the plug. A position indicator through the upper stem shows the exact plug position. Large valves operate in a similar manner, except that they have enclosed weatherproof worm gearing. The position indicator is on top of the gear housing.

4. Where moveable seats are used for double block and bleed service, the body bleed valve should be left open when the twin seal is closed and must be closed before the twin seal is opened. Since these valves do hold bubble tight it is important to prevent trapped body pressure from exceeding the working pressure of the valve.

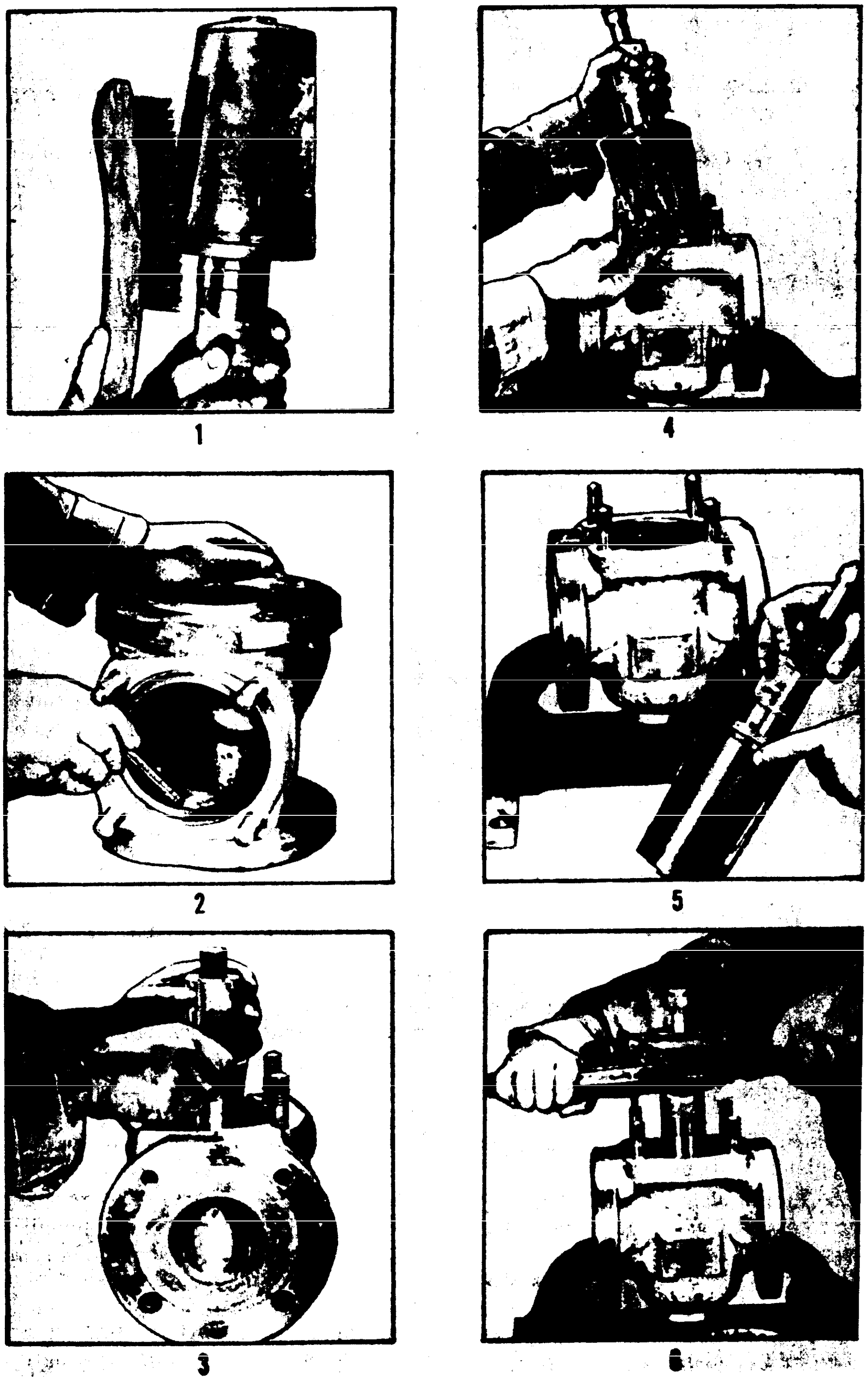
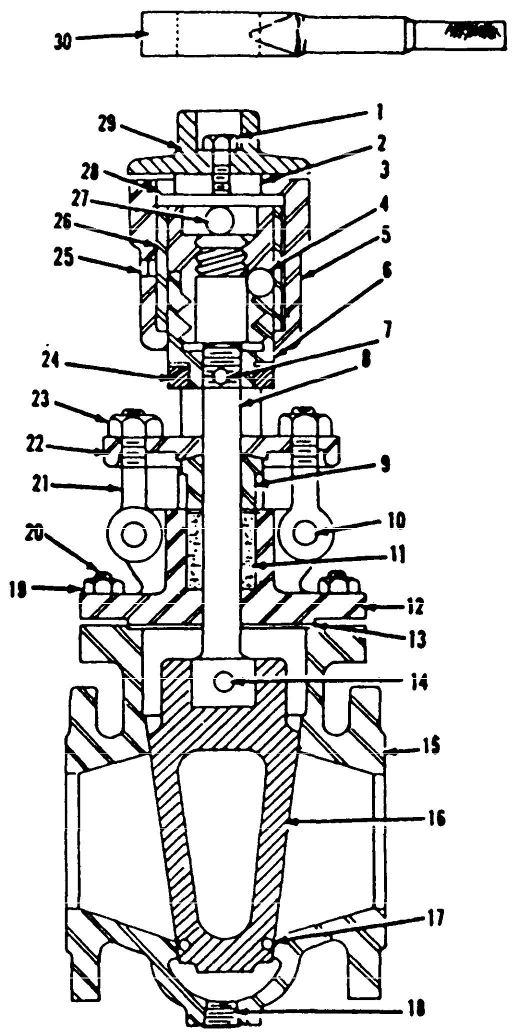


Figure 2-33. Plug Valves—Six Steps in Maintenance.



1. Operating nut capscrew
2. Operating screw
3. Intermediate nut
4. Lower indexing ball
5. Yoke
6. Indexing nut
7. Keeper pin
8. Valve stem
9. Gland follower body
10. Pin
11. Packing
12. 'Bonnet
13. Gasket
14. Pin
15. Valve body
16. Tapered plug
17. "O"-ring
18. Drain plug
19. Gland nuts
20. Stud bolts
21. Gland eyebolts
22. Gland follower head
23. Body nuts
24. Valve position indicator
25. Setscrew
26. Index race
27. Upper indexing ball
28. Retaining ring
29. Operating nut
30. Operating wrench

Figure 2-34. Nonlubricated Valve—Lift Plug Type.

5. On gear-operated models the handwheel position may be changed as follows:

a. Place valve in full open position.

b. Remove gear housing cap screws.

c. Turn handwheel to further open the valve, this will turn gear housing. Continue until handwheel comes to desired position and gear housing mounting holes are realigned.

d. Replace gear housing mounting cap screws. Be sure short cap screw is mounted below worn gear.

6. If it becomes necessary to replace packings and seals, follow the manufacturer's instructions.

(c) Resilient Liner Type (figure 2-36). This type of plug valve incorporates a resilient liner surrounding the plug that eliminates the possibility of the plug being wedged against the seal. Plug lifting devices or moveable gears are not required on this type of valve.

(d) Maintenance:

1. Nonlubricated plug' valves require little maintenance other than periodic inspection. These valves should be operated weekly to test operation and prevent binding.

2. If the stem leaks, tighten the packing gland until leakage stops.

3. Grease exposed gears monthly with lubricant conforming to specification VV-L-757, grade II.

4. In valves employing a resilient liner, seat leakage can usually be stopped by tightening the adjusting nut at the top of the valve. This forces the tapered plug into more intimate contact with the liner.

5. In cold climates, before freezing weather sets in, any accumulation of water below the plug or plug trunnion is drained out through the bottom plate drain plugs.

6. If it becomes necessary to replace packings and seals, follow the manufacturer's instructions.

2-30. Ball Valves (See figure 2-37):

a. Use the current new systems, or whenever existing lubricated plug valves require replacement, approved ball valves conforming to Federal Specification WW-V-35B (Ball Valve Type II, Style 3) or nonlubricated plug valves conforming to MIL-V-12003 are specified. These type valves are used as stop (block) valves where quick shut-off is required, such as in piping to hydrant outlets, between pump and header, and between pump header and filter separator.

b. Maintenance. Ball valves are nonlubricated, and generally feature a self-cleaning, self-adjusting floating ball that compensates for wear. Seat rings are made of tetrafluoroethylene (TFE) resin or other materials that are set into deck metal grooves to protect them from pressure distortion, mechanical damage, or the erosive effects of flow through the valve. No lubricant or preventive maintenance is required, but regular inspections are made according to the requirements in chapter 10, to determine whether packing requires adjustment or replacement, or the seat needs to be replaced.

2-31. Gate Valves:

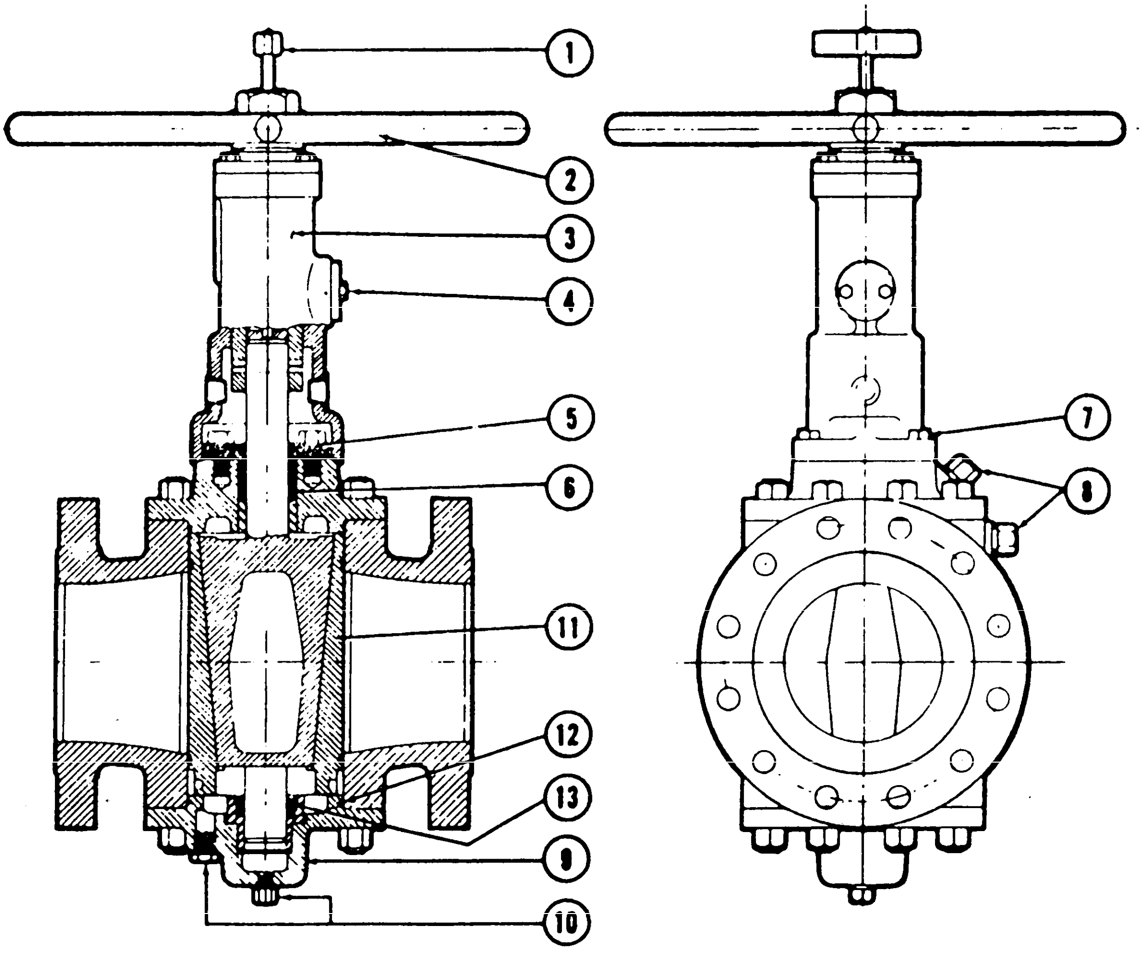
a. **Use.** The current new system gate valves are used for shutoff applications whenever rapid closure or flow regulation is not required.

b. **Types.** Gate valves will either be the double disc type or conduit disc type and will conform to the applicable performance requirements of specification MIL-V-12203. The conduit full-open type will be used whenever it is necessary to pass scrapers. Nonrising stems are used for outside application and rising stems for inside pumphouses or other locations where a visual indication of the valves position is desired.

c. Maintenance. Gate valves do not depend on grease to give a good seal. They are a nonlubricated valve, but do require a minimum amount of lubrication maintenance. Valves are usually equipped with Alenite grease fittings for stem and stem bearing lubrication, see figures 2-38 and 2-39 for location of fittings. On valves equipped with level or spur gear operators, the gear housing cover should be removed for inspection and lubrication. The gear housings are filled at the factory with lithium-base grease that is considered best for average climate conditions. If gear operated valves are hard to operate in cold weather due to stiff grease, operation may be improved by using a lighter grease. Frequency of performing these maintenance requirements is covered in chapter 10.

Section G—Miscellaneous Components

★2-32. Sump Pumps. Sump pumps, manual or automatic, are installed in some pits to evacuate any water or fluid accumulating in the pit. Most pumps are float actuated. The float controls a single-pole, spring-loaded switch that starts the pump at a predetermined high liquid level and shuts the pump down when the level drops to a predetermined low point. All electrical components of these pumps, including switch and motor, are explosion proof and comply with requirements of the National Electrical Code for class I, division 2, group D locations. Maintenance includes normal oiling and greasing, cleaning of inlet strainer and inspection of float switch and mechanism. See AFR 91-26 for a full discus-

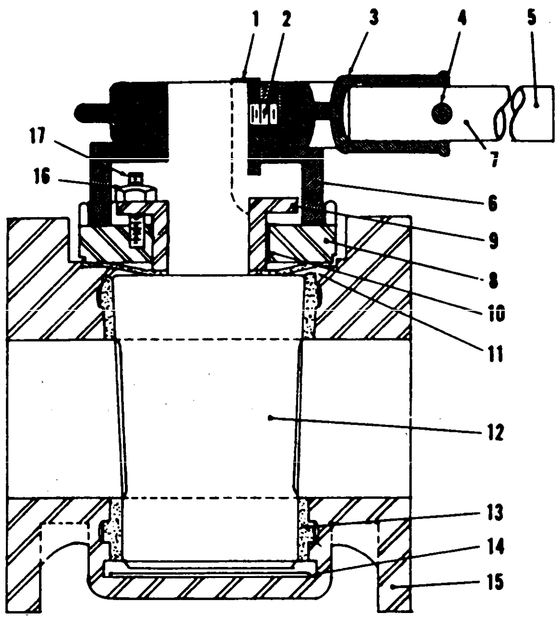


1. Indicator flag
2. Handwheel
3. Operator
4. Guide pin boss
5. Packing gland
6. Packing—O-rings and chevron
7. Housing mounting bolts
8. Body bleed connection
9. Bottom access plate
10. Bottom plate drain plugs
11. Seating slip
12. Bottom plate O-ring seal
13. Bottom trunnion U-cup

Figure 2-35. Nonlubricated Plug, Valve—Movable Seat Type.

sion of sump pump maintenance. Sump pumps are not required in lateral control pits of system II (as noted in paragraph 1-19c) unless justified by local conditions.

2-33. **Line Strainers.** Line strainers are installed in the transfer and unloading of pipelines, upstream from the



1. Hub key
2. Hub set screw
3. Wrench head
4. Wrench pin
5. Wrench handle
6. Wrench hub
7. Wrench
8. Cover
9. Gland flange
10. Gland
11. Resilient diaphragm
12. Plug
13. Resilient sleeve
14. Resilient thrust disk
15. Body
16. Gland stud
17. Gland nut

Figure 2-36. Nonlubricated Plug Valve—Resilient Liner Type.

pumps to prevent foreign matter from being carried into the pumps. Line strainers are also installed in dispensing lines upstream of meters unless there is a filter separator within 100 feet of the meter. Filter separators require line strainers upstream to protect the elements from damage by stones and trash. Strainers are not required when deep well turbine pumps, in underground tanks, discharge directly into adjacent filter separators. Block valves are installed on either side of strainers if contour of strainer cover does not allow removal without loss of

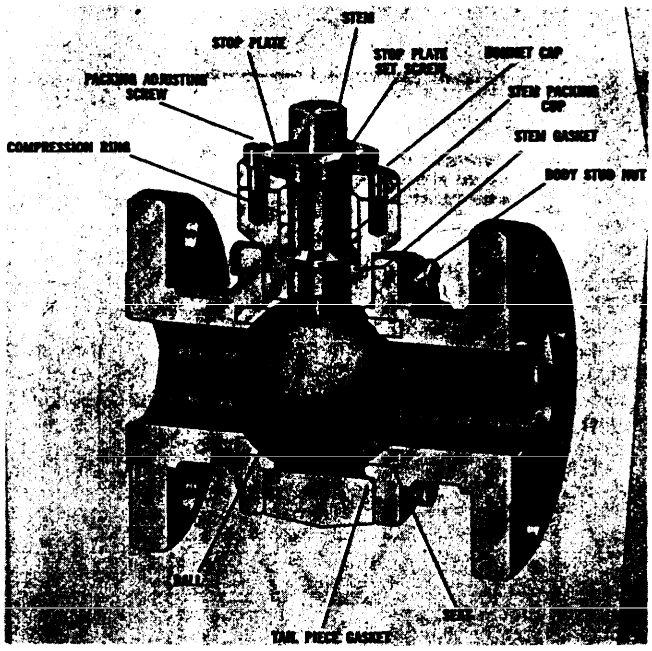


Figure 2-37. Ball Valve, Cutaway View.

product. Strainers are usually cleaned by fuels management office (FMO) personnel. The fill or transfer line strainers are cleaned according to the requirements in TO 37-1-1.

2-34. Air Eliminators. Air eliminators (figure 2-40) are installed in the discharge line between the pump (usually on filter separator or micronic filter vessels) and the meter on truck fill lines to discharge all air from the fuel to atmosphere. The eliminator has a tank with a float-operated air valve in the top. Air will be continuously discharged through the vent to atmosphere until the tank is filled with liquid. The float then closes the air port. Maintenance involves checking for fuel leakage through the vent, which indicates that seat and float assembly must be taken out of the tank and repaired or replaced with a new assembly. Air eliminators are also installed on tank car and tank truck unloading pumps.

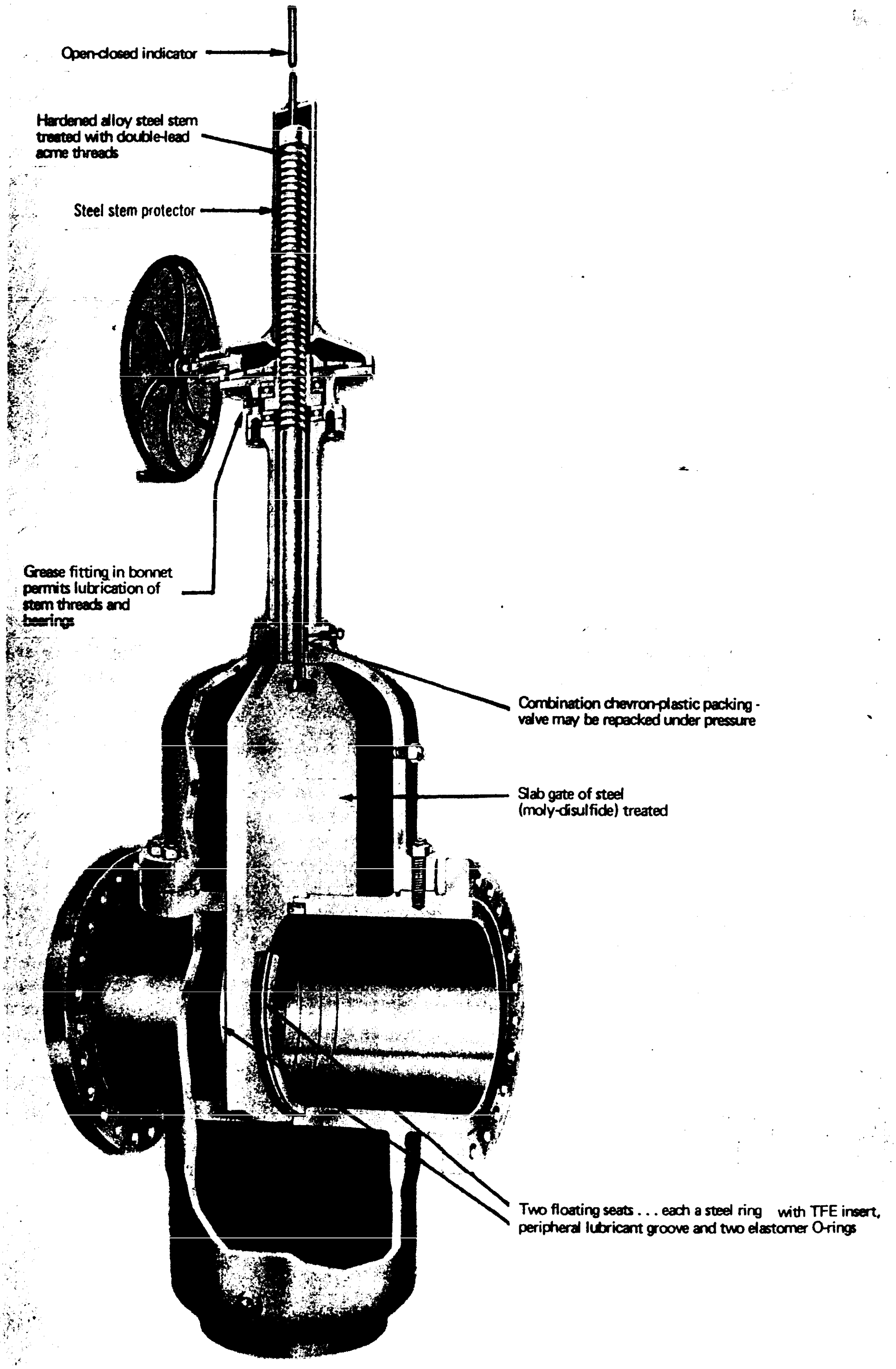


Figure 2–38. Gate Valve—Through-Conduit Single Gate Type.

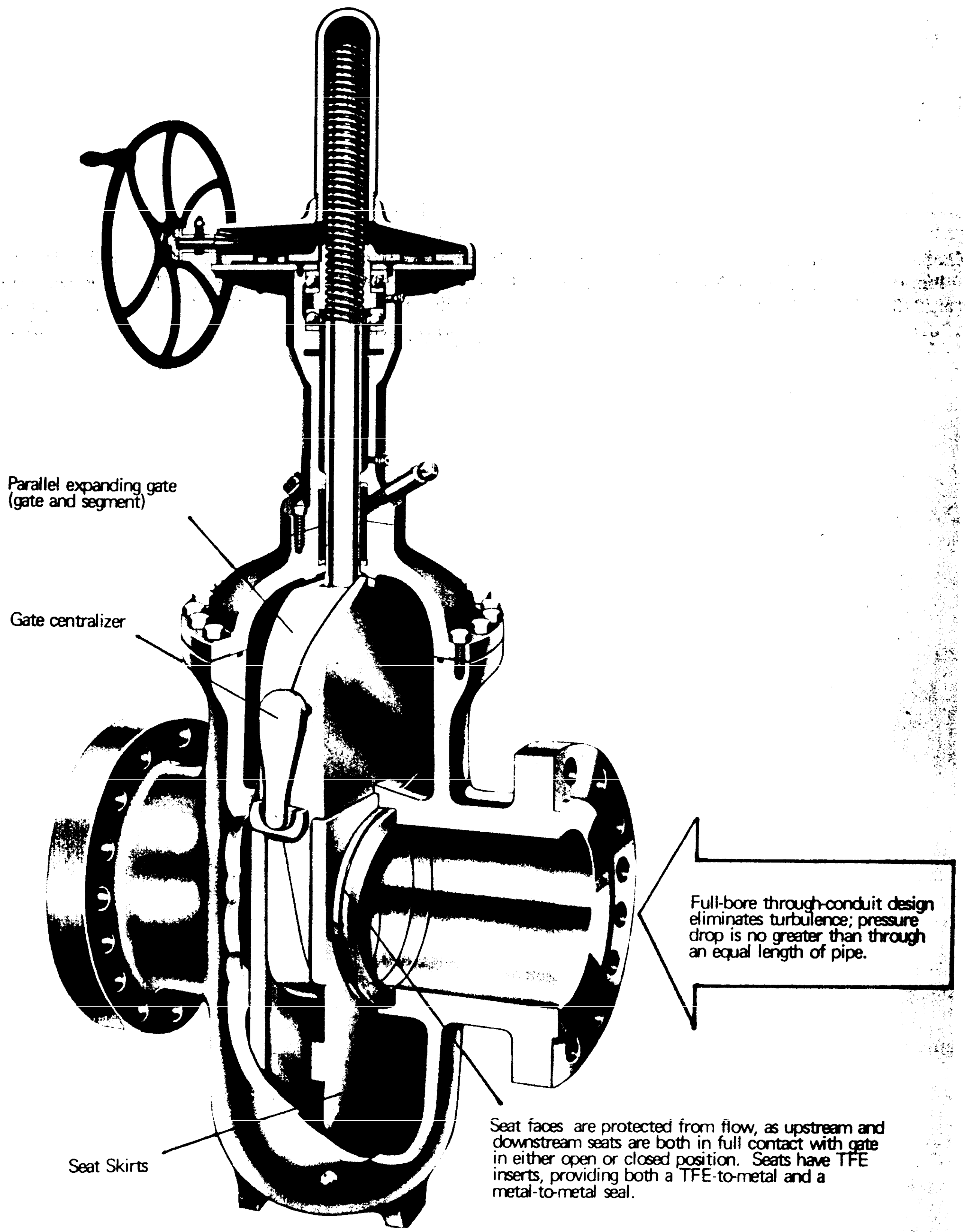
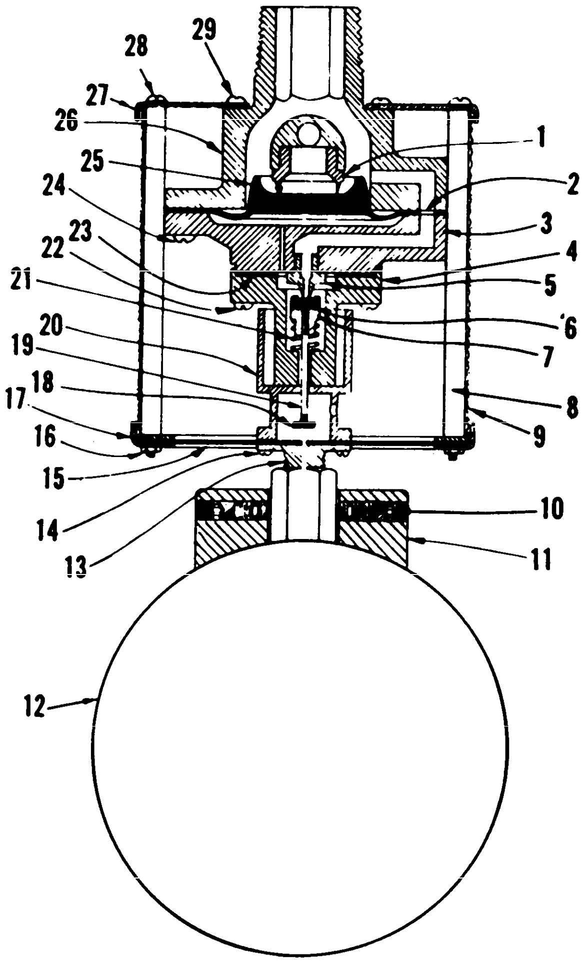


Figure 2-39. Gate Valve—Through Conduit—Parallel Expanding Gate Type.



1. Orifice valve (½-in)
2. Diaphragm
3. Valve and diaphragm cap
4. Bleed valve housing
5. Orifice valve (1/6-in.)
6. Valve disk
7. Disk retainer
8. Screen support
9. Screen
10. Setscrews
11. Counter weight
12. Float ball
13. Flanged stud
14. Machine screws
15. Diaphragm protector
16. Hex nuts
17. Bottom screen plate
18. Hex nut
19. Valve stem
20. Stem housing and lift
21. Compression spring
22. Machine screws
23. Bleed valve housing gasket
24. Machine screws
25. Valve disk
26. Upper valve body
27. Top screen plate
28. Machine screw
29. Machine screw

Figure 2-40. Air Eliminator.

Chapter 3

HYDRANT FUELING SYSTEM, TYPE I (PANERO)

Section A—General

3-1. General Information. All hydrant fueling systems installed before 1955 are identified as Type I (Panero) hydrant systems (see figure 3-1). Modifications made in this system since it was originally designed, together with a description of the system's major component and procedures for their maintenance, are discussed in this chapter.

Section B—System Components

3-2. Deep Well (Vertical) Turbine Pump. See section B, chapter 2, for description and procedures covering the maintenance of this pump.

3-3. Meters. See section E, chapter 2, for description and procedures for maintenance of meters.

NOTE: Most Air Force bases have modified their Panero systems (filter meter pits) to use MH2 series hose carts. This modification consisted of removing the meter (and micronic filter) from the pit and installing pipe spools in their place.

3-4. Three-Port, Two-Way, Automatic, Diaphragm-Operated Fueling and Defueling Valve:

a. General Information. Downstream from the manually operated valve in the filter-meter pit a remote controlled three-port, two-way valve (figure 3-2) is installed in the line to the hydrant outlet. To perform refueling and defueling functions, two valves are fabricated in one body. During normal fueling operations, the defueling valve is closed and the refueling valve functions as a pressure reducing valve to maintain constant delivery pressure. During defueling operations, the refueling valve is closed and the defueling valve is open. During fueling operations, the defueling valve will open to serve as a pressure relief valve when pressure on the downstream side rises above the setting of the

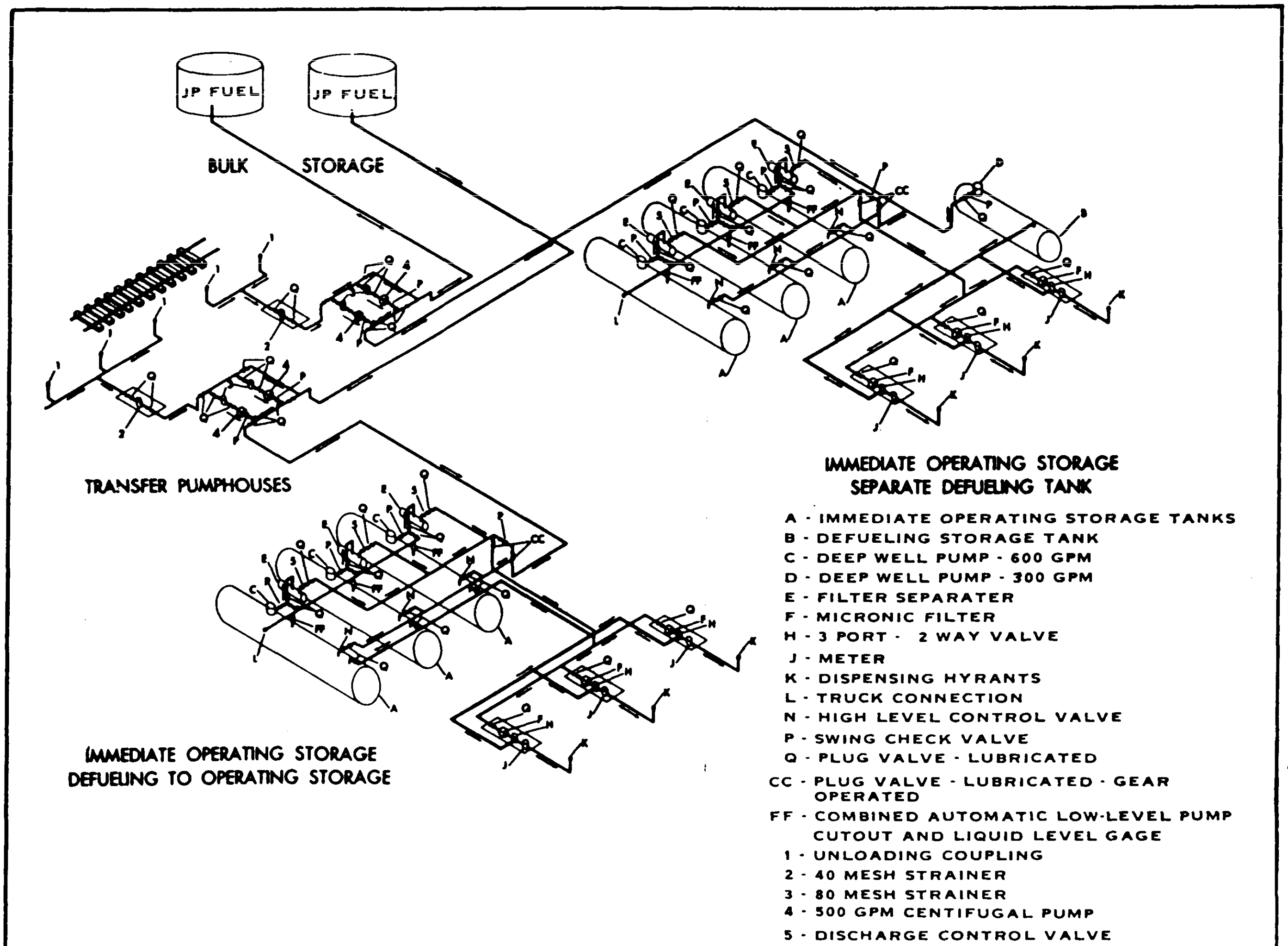


Figure 3-1. Isometric View of Hydrant Fueling System Installed Before 1955.

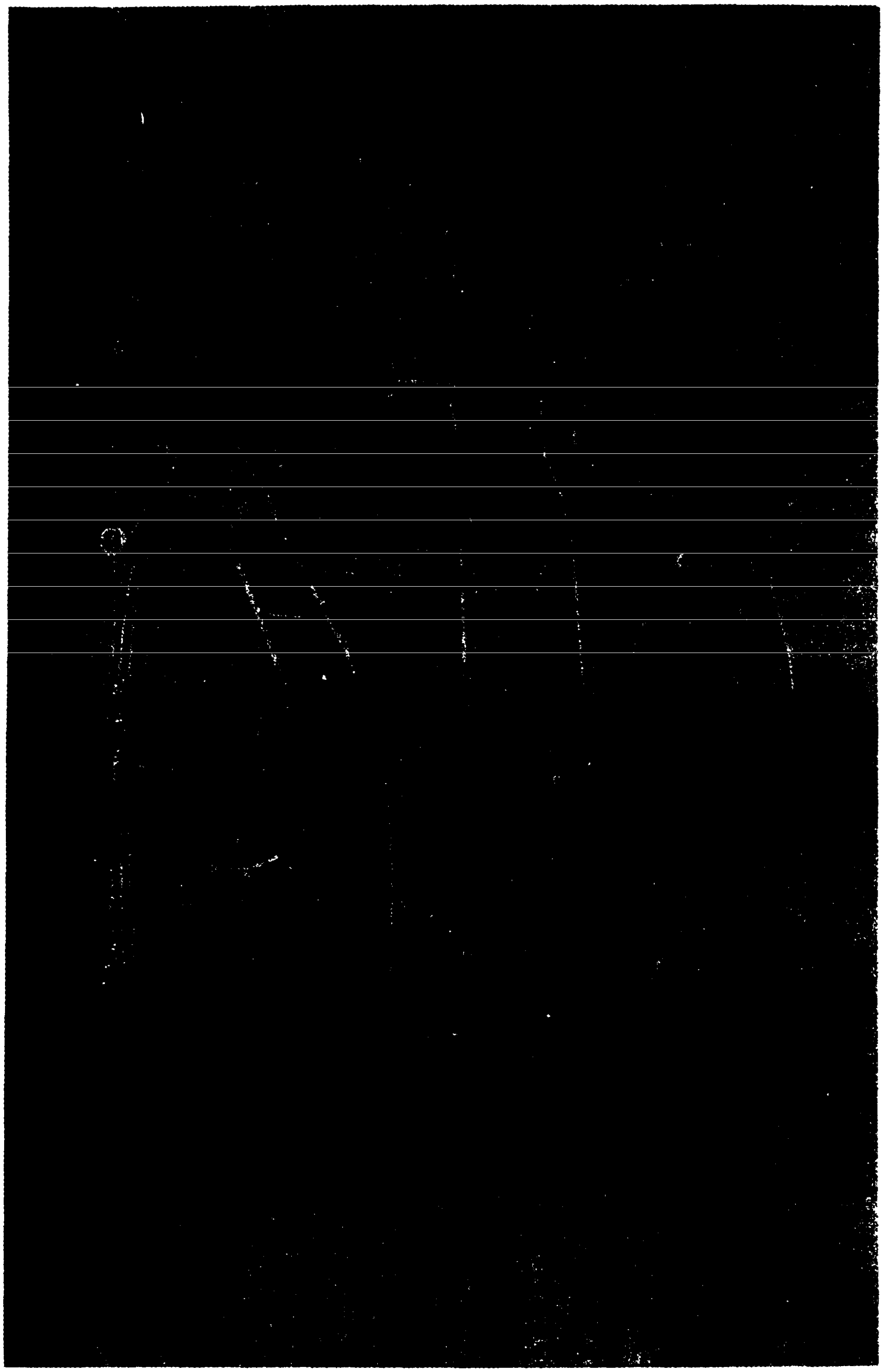


Figure 3–2. Three-Port, Two-Way, Automatic, Diaphragm-Operated Fueling and Defueling Valve.

pressure reducing pilot valve.

b. Fueling Operation. Figure 3-3 illustrates fueling operation of the two-way valve:

(1) When refueling, the solenoid valve is energized from the switch at the hydrant outlet; solenoid valve F opens, directing high pressure from main valve inlet to cover chamber of defueling valve R holding it closed.

(2) The solenoid valve also vents the cover chamber of the Hytrol valve B to defueling line. This opens the hydrol valve B, that permits pressure reducing pilot valve A to take control of fueling valve.

(3) When pressure reducing valve A goes into operation, high pressure fuel enters fueling valve H, and bypasses through ejector-strainer C to pilot valve, that is held open by pilot valve spring. With pressure on pressure-reducing valve A below ad-

justed setting, maximum flow is permitted through ejector-strainer C, thus creating reduced pressure in fueling valve cover chamber, that allows valve to open and build up pressure in the downstream system. Increasing downstream pressure is transmitted through the pilot control line to underside of pilot valve diaphragm. When pressure under the pilot valve reaches a point where it balances the loading of pilot valve spring, the pilot valve begins to close, thus restricting flow through ejector-strainer sufficiently to increase the pressure in the fueling valve cover chamber. The resulting increase in pressure on fueling valve diaphragm forces the disk toward the seat until the fueling valve is passing just enough fuel to maintain a downstream pressure that will balance the loading of the pilot valve spring. Any subsequent change in fuel demand tends to cause a slight change in downstream pressure with reducing pilot valve and fueling valve assuming new positions to supply the new demand.

(4) As long as normal fueling operation is in process and flow rate is not changed very rapidly, fueling valve will function as outlined above. If flow rate suddenly decreases, two things occur:

(a) Any pressure rise is offset by opening of the defueling valve.

(b) Fueling valve closes rapidly.

NOTE: To perform these two functions, pressure relief valves D and E are used.

(5) Figure 3-3 shows delivery pressure, directed under the diaphragm of both pressure relief valves, opposing force applied on springs:

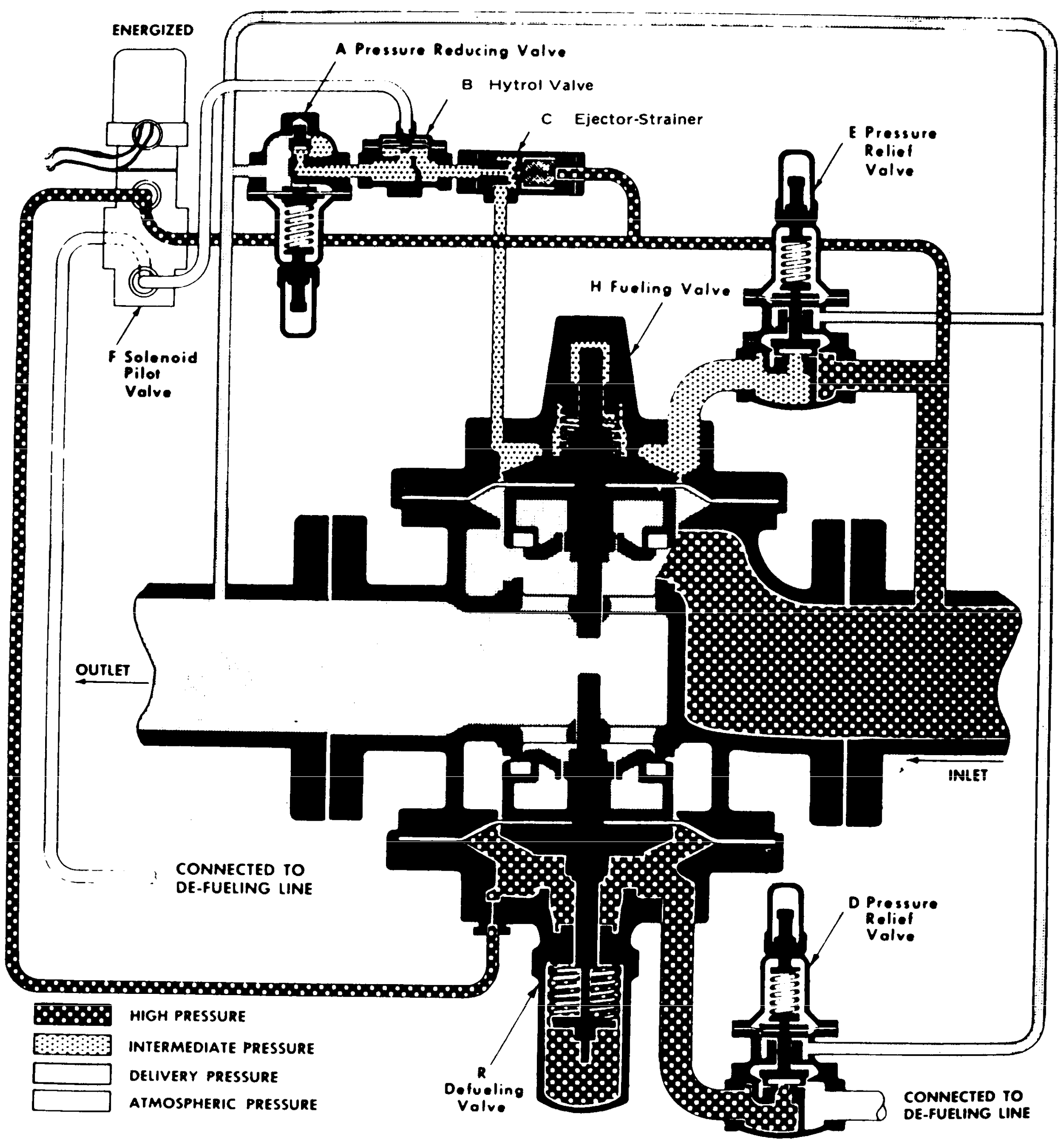


Figure 3-3. Fueling Position of Three-Port, Two-Way, Automatic Fueling and Defueling Valve.

(a) When downstream pressure rises high enough to overcome the spring force, the pressure relief valve D opens to relieve pressure from cover chamber and diaphragm of defueling valve R. This allows defueling valve to open, thereby relieving excess pressure into defueling lines.

(b) The function of relief valve E is to increase closing speed of fueling valve H. When there is a sudden rise in delivery pressure, this valve opens and admits upstream line pressure directly into fueling valve cover chamber to close it rapidly.

c. **Defueling Operation.** Figure 3-4 illustrates defueling operation of the two-way valve. The solenoid F is deenergized, directing pressure from main valve inlet into cover chamber of Hytrol valve B, holding it closed. This diverts high pressure through ejector-strainer C into cover chamber of fueling valve H, holding it closed. Solenoid F also vents cover chamber of defueling valve R to the defueling line. When pressure is released from cover, a spring pulls valve open and permits defueling.

★ **d. Pressure Setting Procedure for Fueling and Defueling Valve (see figure 3-2):**

(1) If a pressure gage is not installed downstream from valve, install a gage of not more than 0 to 160 psi range.

(2) Remove adjusting screw housing from valves 5, 6, and 8.

(3) Loosen jam nut and turn adjusting screw on pressure relief valves 5 and 8 clockwise until they bottom.

(4) While fueling, turn adjusting screw of pres-

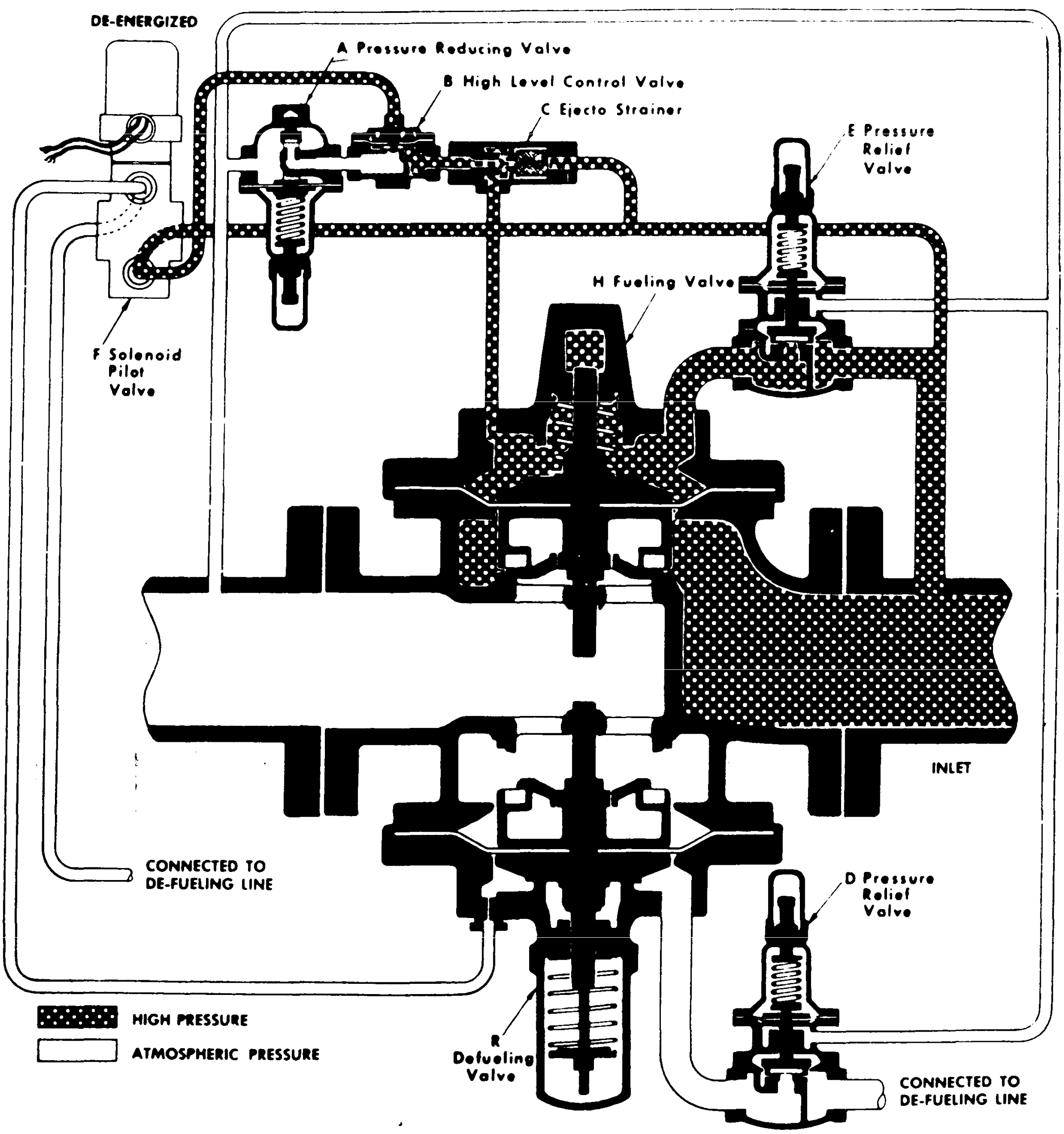


Figure 3-4. Defueling Position of Three-Port, Two-Way, Automatic Fueling and Defueling Valve.

sure reducing valve 6 until gage pressure is 10 psi higher than the desired setting. To increase pressure, turn screw clockwise. To decrease pressure, turn screw counterclockwise.

(5) Turn adjusting screw of pressure relief valve 8 counterclockwise slowly until you can hear fuel flow through the defuel portion of the valve. Then turn the adjusting screw back until fuel flow sound stops. Tighten jam nut.

(6) Turn adjusting screw of pressure reducing valve 6 counterclockwise until gage pressure reduces to a point five psi higher than desired delivery pressure.

(7) Turn adjusting screw of pressure relief valve 5 counterclockwise slowly until gage pressure begins to dip downward. Tighten jam nut.

(8) For final adjustment, turn adjustment screw of the pressure reducing valve 6 counterclockwise until gage pressure reaches a desired pressure setting. Tighten jam nut.

(9) Replace the adjusting screw housing on valves 5, 6, and 8.

e. Manual Operation of Solenoid Pilot Valve (see figure 3-5):

(1) Remove protective cap 29.

(2) With a screwdriver, turn stem 30 clockwise until stem stop ring 31 contacts stuffing box 26.

(3) Pilot valve is now in energized position.

f. Fueling Valve Fails to Open (see figure 3-2):

(1) Solenoid pilot valve 1 may not be operating properly:

(a) Energize solenoid, apply pressure at valve inlet.

(b) Loosen tube fitting of Hytrol valve cover 7.

(c) If fuel under pressure is present, solenoid pilot valve is probably stuck in deenergized position.

(d) Operate solenoid valve manually.

(e) If fuel under pressure at loosened fitting of Hytrol valve 7 is shut off when pilot valve is actuated, the solenoid valve must be replaced.

(2) Hytrol valve 7 may be failing to open:

(a) Loosen tubing nut at cover of Hytrol valve. No pressure should be present at this point.

(b) Make sure there is no pressure in downstream fueling line. Break union between Hytrol valve and pressure reducing valve 6.

(c) If no pressure is present at disconnected union, failure of diaphragm in Hytrol valve is indicated.

(d) Refer to figure 3-2. Remove cover screw and cover (taking care not to lose spring).

(e) Remove diaphragm assembly and replace diaphragm if damaged.

(f) Reassemble valve and reconnect union and tubing fittings.

g. Fuel Valve Fails to Close (see figure 3-2):

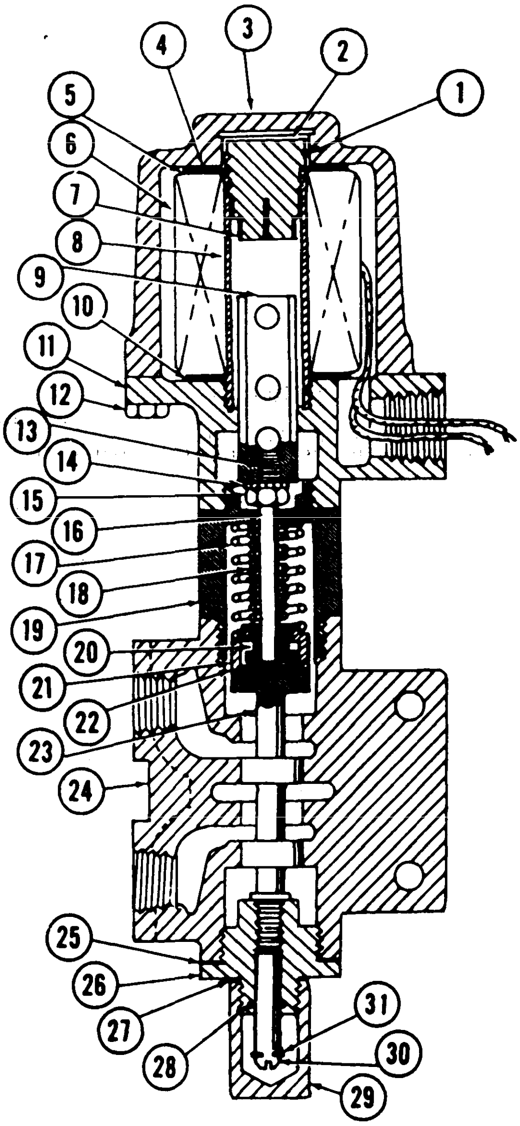
(1) Solenoid valve 1 may not be operating properly. With solenoid valve denergized and pressure at inlet:

(a) Loosen tube nut at cover of Hytrol valve 7.

(b) Fuel should flow from loosened connection.

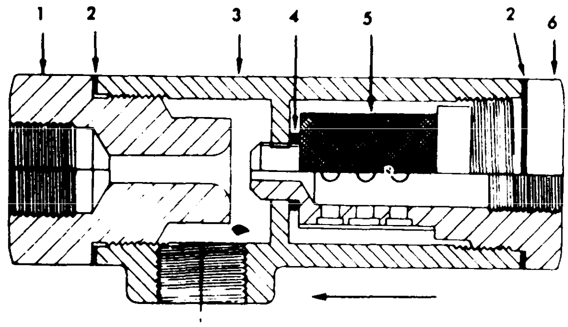
(c) If there is no fuel flow at connection, solenoid valve failure is indicated.

(d) Remove cap and operate pilot valve manually.



1. Plug nut ring
2. Plug nut
3. Solenoid cap
4. Coil clamping washer
5. Insulating washer
6. Coil
7. Shading coil
8. Core tube
9. Core assembly
10. Insulation
11. Solenoid base
12. Cup holding screws
13. Core pin
14. Stem lockwasher
15. Stem locknut
16. Valve stem
17. Piston spring
18. Stem spring
19. Valve bonnet
20. Stem end
21. Piston nut
22. Piston lock pin
23. ⅜ port piston
24. Valve body
25. Gasket stuffing box
26. Stuffing box
27. Gasket-cap
28. "O"-ring packing
29. Cap
30. Stem
31. Stem stop ring

Figure 3-5. Section of Solenoid Pilot Valve.



1. Secondary jet
2. Gasket
3. Housing
4. "O"-ring
5. Screen
6. Primary jet

Figure 3-6. Ejector-Strainer.

(e) If pressure evident at loosened connection when solenoid valve is operated manually, solenoid valve must be replaced or repaired.

(2) Ejector-strainer (figure 3-6) may be clogged:

(a) Loosen top tube nut on ejector-strainer.

(b) If flow is observed at this point, strainer is not clogged.

(c) If no flow is observed, disconnect inlet tubing and bend tubing clear, so tubing ell may be removed. Remove tubing ell.

(d) Remove primary jet 6; inspect and make sure it is not plugged.

(e) Remove screen 5. Inspect and clean screen if it appears to be clogged.

(f) Remove and inspect secondary jet 1 and make sure it is not plugged; and then

(g) Reassemble ejector-strainer, in reverse to disassemble, and reconnect tubing.

h. Fueling Valve Fails to Maintain Desired Reduced Pressure (see figure 3-2):

(1) The ejector-strainer may be clogged and can be checked by following the procedure in g above.

(2) Pressure reducing valve 6 may not be operating properly:

(a) Remove adjusting screw housing of pressure reducing valve 6.

(b) Loosen jam nut and turn adjusting screw clockwise.

(c) If the fueling valve opens during this procedure and delivers fuel at an increased and constant pressure, it indicates that the pressure adjustment of the pressure relief valve (5) is incorrect.

(d) To remedy, follow the entire procedure outlined in d above.

(e) If step (c) above did not indicate, the probable source of trouble, proceed to (3) below.

(3) Pressure relief valve (5) may be held open:

(a) Correct setting of this valve is 10 psi higher than the pressure setting of pressure reducing valve (6).

(b) If pressure relief valve (5) is adjusted to a pressure equal to or lower than the setting of pressure reducing valve 6, such an adjustment holds pressure relief valve open, allowing pressure to flow into cover chamber of fueling valve and hold it closed.

(c) If this appears to indicate the trouble, remove adjusting screw housing from pressure relief valve 5; loosen jam nut and turn adjusting screw until it bottoms.

(d) Step (c) should definitely close pressure relief valve 5 and, if this was the trouble, fueling valve should now function to maintain desire delivery pressure.

(e) Reset pressure relief valves 5 and 8 and pressure reducing valve 6 as outlined in d above.

(4) The fuel valve diaphragm may be ruptured. If all other steps have been followed and indications are that the main fuel valve is faulty, follow these steps, with reference to figure 3-7.

(a) Close valve immediately upstream.

(b) Remove all fitting from fueling valve cover 22.

(c) Remove all refueling valve cover nuts 20 and lift cover.

(d) Lift diaphragm assembly out of valve and examine diaphragm 13.

(e) Replace diaphragm with a new one if necessary.

(f) While diaphragm assembly is out of valve, inspect disk (15) to see that it is in good condition. Replace worn or defective parts.

(g) Reassemble valve in reverse order. Make sure stem string (2) fits into recess of cover (22).

(h) Replace and connect tubing and fittings.

(i) Open valve, start pump and, with pressure on system, loosen lifting lug to allow trapped air to be released. Tighten lug.

i. Defueling Valve Fails To Open (see figure 3-2):

(1) Solenoid pilot valve 1 may not be operating properly:

(a) Remove tube nut at fittings 2, 3, and 4.

(b) Force compressed air through fitting 4. There should be a clean passage of air through fitting 2, but no flow through fitting 3 if defueling valve is in a closed position.

(2) Delivery pressure setting on pressure reducing valve 6 may be higher than setting of pressure relief valve 8:

(a) To check this condition, remove adjusting screw housing from pressure relief valve 8.

(b) Loosen jam nut and turn adjusting screw clockwise until it bottoms. This should definitely hold pressure relief valve closed and, if this was the trouble, defueling valve will open.

(c) Reset pressure relief valves 5 and 8 and the pressure reducing valve.

j. Defueling Valve Fails To Close:

(1) The solenoid pilot valve may not be operating properly. To check this, proceed as outlined in i above.

(2) The diaphragm of defueling valve may be ruptured (see figure 3-7):

(a) Remove tubing and fittings from cover 10 of defueling valve.

(b) Remove spring lift housing 1.

(c) Remove two jam nuts (3) and then remove spring (5) and spring guide (4).

(d) Remove cover nuts holding cover and remove cover.

(e) Remove diaphragm assembly and check diaphragm (13) for breaks or holes.

(f) Replace diaphragm with new one if necessary. Inspect disk (15) to see that it is in good condition.

(g) Replace diaphragm assembly and valve cover 10. Replace spring (5) and spring guide (4). Compress spring as shown in figure 3-7.

(h) Lock spring guide in place with two jam nuts (3).

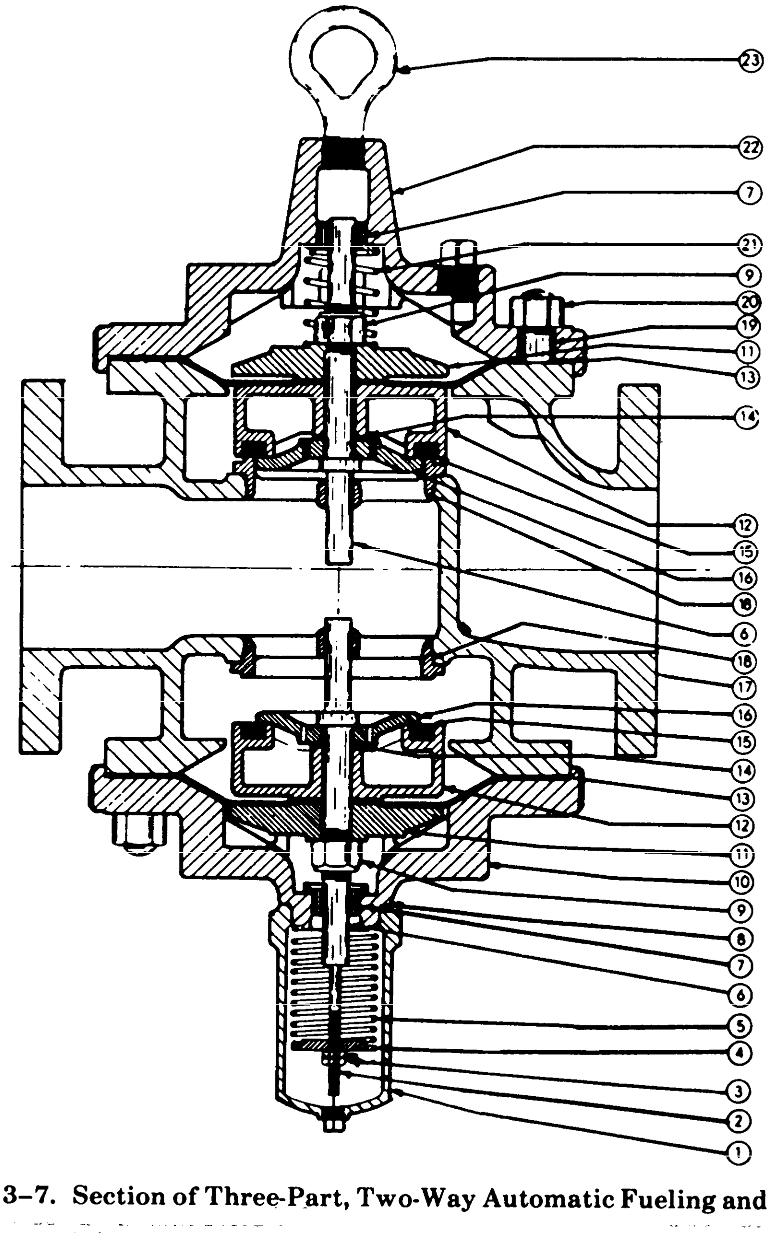
(i) Replace spring lift housing (1) and make sure it is pulled uptight.

(j) Replace tube lines and fittings.

k. General Trouble Shooting Procedures (see figure 3-2):

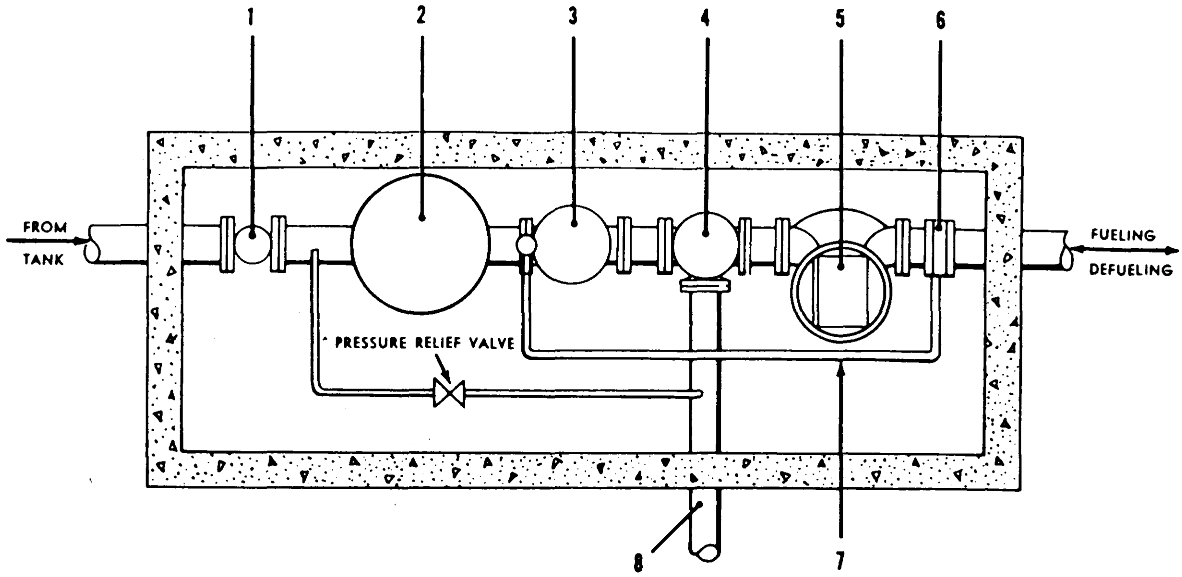
(1) Close off plug valve 1 (see figure 3-8) and bleed off downstream pressure either into a bucket of defueling line. Remove tube nuts from fittings 2, 3, 4, and 11. Force compressed air through solenoid valve opening 4. There should be no passage of air from opening 2 and 3 and a free passage of air from opening 11 when the solenoid valve is deenergized. In the deenergized position, defueling valve must be in an open position and fueling valve closed. There should be no passage of air from opening 3 and 11 and a free passage of air from opening 2 when the solenoid valve is energized. In an energized position, the fueling valve should be in an open position and defueling valve closed.

(2) If the air movement through the solenoid valve does not occur as indicated above, the valve



LEGEND
1. Housing
2. Stem—spring
3. Nuts—jam
4. Spring Guide
5. Spring (load to open)
6. Stem
7. Bearing—cover
8. Gasket
9. Nut—stem lock
10. Cover—bottom
11. Diaphragm washer
12. Disc retainer
13. Diaphragm
14. Washer, spacer
15. Disc
16. Disc guide
17. Body
18. Seat
19. Stud
20. Nut—stud
21. Spring (load to close)
22. Cover—top
23. Lug—lifting

Figure 3-7. Section of Three-Part, Two-Way Automatic Fueling and Defueling Valve.



1. Manually operated valve
2. Micronic filter
3. Excess shutoff valve
4. Three-port, two-way automatic fueling and defueling valve
5. Meter
6. Orifice plate
7. High and low pressure sensing lines
8. Defueling line

Figure 3–8. Filter Meter Pit With Combination Fueling and Defueling Valve, System I.

needs overhauling. In most cases the air removes foreign particles and the valve then functions properly.

3-5. Excess Flow Control Valve:

a. General. Excess flow controls are required in all dispensing systems as a safety factor. They prevent spillage of large quantities of fuel if the valve and nozzle fails or if the hose ruptures during fueling operations. Most fueling and defueling valves incorporate an emergency shutoff feature.

b. Description. Excess flow control shutoff has an orifice plate, producing a differential pressure in the main fueling line and, a pressure differential control that responds to the differential pressure and closes the two-way valve when the flow rate increases over a preset rate.

c. Installation. The manufacturer's instructions should be followed for detailed installation procedures. The following are general instructions for Air Force installations on the three-port, two-way automatic fueling and defueling valve as shown in figure 3-9. The same type of controls are also installed on the fueling valve of the type II system.

(1) Install orifice plate on the downstream side of refueling portion of the two-way valve.

(2) Mount the pressure differential control (CDHS-3) on, or as close to the two-way valve as possible.

(3) Install tubing from high and low pressure ports in orifice plate to respective ports in pressure differential control.

(4) Remove the existing tube connecting the Hytrol valve to the solenoid pilot valve. Install new tubing from the pressure differential control drain port to solenoid pilot valve, and, from pressure port in the pressure differential control to the Hytrol valve.

(5) Install a tube from the remaining pressure port in the pressure differential control into the ejector-strainer assembly. The ejector-strainer is modified by the addition of an elbow or tee to receive the new tubing.

(6) Disconnect the tubing leading from refuel cover chamber to the suction port of the ejector-strainer; remove brass fitting in ejector-strainer and install a flow control. Connect the tubing to the flow control thus diverting fuel from the cover chamber through the flow control into the ejector-strainer. NOTE: If a flow control is not installed, the pressure differential control will not operate properly.

d. **Adjustment:**

(1) Follow procedures outlined in attachment 4.

e. **Resetting Procedure.** If flow through the main line exceeds the setting of the pressure differential control, a snap action device in the pressure differential control diverts the high pressure flow to the lines leading to the ejector-strainer and hytrol valve. Pressure in these two lines causes both the fueling valve and defueling valve to close. When the condition causing the excess flow has been corrected, the pressure differential control must be reset as follows:

(1) Begin pumping operation to apply pressure at the inlet of fueling and defueling valve.

(2) Push the reset button on the pressure differential control and hold it depressed until normal flow rate is established.

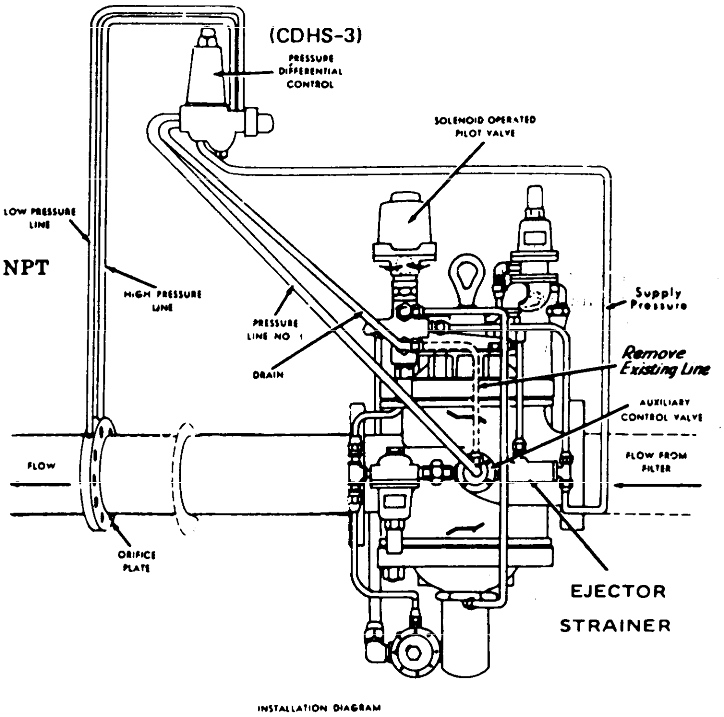
NOTE: The pressure differential control may be reset after the system is deenergized without starting the pump.

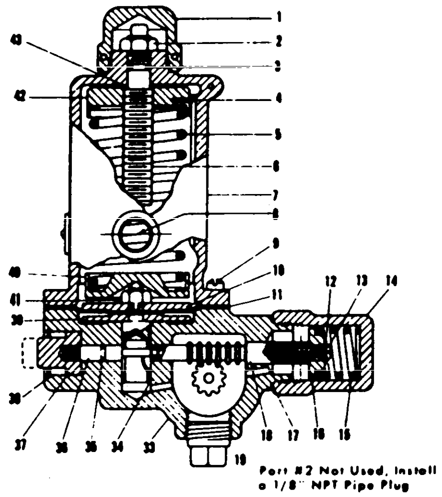
3-6. Wet Line Cutoff Modification:

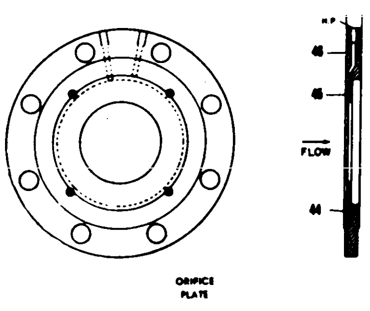
a. **General.** The purpose of a defueling cutoff is to provide the combination fueling and defueling valve with a device that maintains the downstream piping full of fluid at all times and keeps the meter flooded. This device is not standard equipment but a modification to the existing three-port, two-way, automatic fueling and defueling valve described in paragraph 3-4. In installations where defueling operations leave the meter and discharge lines dry, this modification should be made to decrease meter maintenance. Inverted "U" bends with vacuum breakers are also used to maintain a wetline. NOTE: If systems have been modified and have the meter and micronic filter removed, the wetline cutoff will no longer be required.

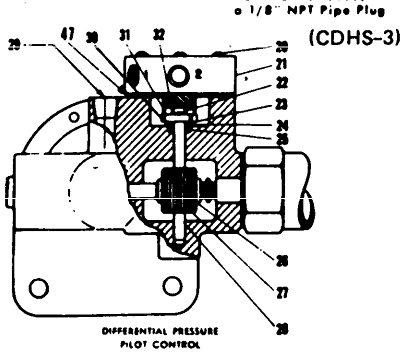
b. **Operations.** The defueling or wetline cutoff is a differential control installed in the control line to the defueling valve cover. It is actuated by the pressure in the main line between the meter and combination fueling and defueling

1. Adjusting screw cap
2. Jam nut
3. "O"-ring
4. Groove pin
5. Spring
6. Adjusting screw
7. Cover
8. Low pressure port, ¼ NPT
9. Machine screw
10. Diaphragm washer
11. Diaphragm
12. Lockwasher
13. Machine screw
14. Spring cap
15. Pilot actuating spring
16. Spring guide
17. Gasket
18. Rack
19. Plug
20. Machine screw
21. Distributor
22. Pilot spring
23. Thrust washer
24. Thrust washer
25. "O"-ring
26. Lock pin
27. Gear
28. Stem
29. High pressure port (¼ NPT)
30. Driver
31. Skirt
32. Disk
33. Housing
34. Stem
35. "O"-ring
36. Reset stem
37. Reset button
38. Snap ring
39. Diaphragm washer
40. Lower spring guide
41. Jam nut
42. Upper spring guide
43. Washer
44. Machine screw
45. Orifice plate
46. Orifice plate holder
47. Gasket





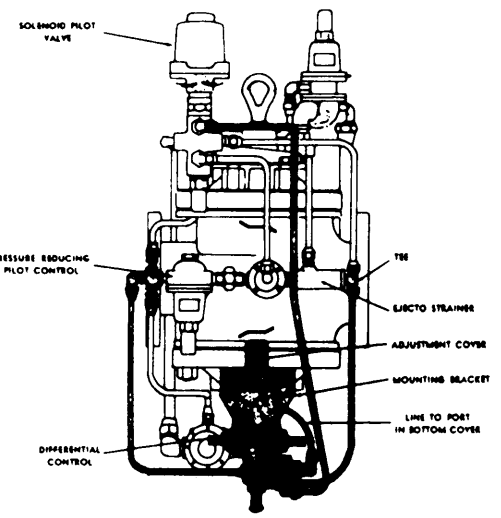




★Figure 3-9. Excess Flow Control Shutoff.

valve. During defueling operations, when pressure in the main line is higher than the differential control setting, normal operation continues; when the fuel level in the discharge line falls below the hydrant outlet, the pressure drops in the mainline between the meter and combination fueling and defueling valve. This pressure drop actuates the differential control and diverts the upstream pressure to the defueling valve cover, causing the defueling valve to close and trap a predetermined head of fuel (24 to 60 inches of aviation fuel) in the discharge line.

c. Installation. Modification kits that include all necessary controls, fittings, and detailed installation data are available through the valve manufacturers. A general installation diagram is shown in figure 3-10.



INSTALLATION

Figure 3-10. Wet Line Cutoff.

d. Adjustment:

(1) Some means must be devised to observe the head of fuel in the discharge. A sensitive low pressure gage, an open manometer, or direct observation at the hydrant can be used to observe this head.

(2) Remove adjustment cover on the differential cover and defuel a container of sufficient size to fill the discharge line to the hydrant. Observe the shutoff level.

(3) Turn adjustment clockwise to raise the shutoff level and counterclockwise to lower the shutoff level.

(4) Repeat the above procedure until the desired shutoff level is reached.

★3-7. Individual Fueling and Defueling Valves With Common Pilot Valve. Some hydrant systems have two diaphragm-operated valves to perform fueling and defueling operations (figure 3-11). One valve is installed in the fueling line to the meter (see paragraph 3-3), and the other is installed in the defueling line. The two separate valves share a common pilot valve system and are identical in operating principle, function, and operating sequence to the three-port, two-way, automatic fueling and defueling valves described in paragraph 3-4.

a. Pressure Setting Procedures (See Figure 3-11):

(1) If a pressure gage (0-160-psi) is not already installed downstream from the valve (beyond the connection of fueling pit piping), install one.

(2) Remove adjusting screw housing from pressure reducing pilot valve (4) and pressure relief pilot valve (3).

(3) Loosen jam nut and turn adjusting screw of pressure relief pilot valve (3) clockwise until it bottoms. Do not force. Back off this screw two full turns.

(4) While fueling, turn adjusting screw of pressure reducing pilot valve (4) until discharge pressure is 5 psi higher than desired setting. To increase pressure, turn adjusting screw clockwise; to decrease pressure, turn adjusting screw counterclockwise.

(5) Turn adjusting screw of pressure relief pilot valve (3) counterclockwise until you hear fuel flow through the valve. Then turn the adjusting screw back until the fuel flow sound stops. Tighten jam nut, cap and seal.

(6) Turn adjusting screw of pressure reducing pilot valve (4) counterclockwise until pressure gage shows desired delivery pressure. Tigthen jam nut, cap and seal.

(7) Replace adjusting screw housing.

b. Trouble Shooting Procedure. Before attempting to make any mechanical adjustments, make sure that:

(1) Solenoids are receiving power when control switch is closed. They deenergize when switch is open.

(2) Inlet pressure is sufficiently high to maintain desired delivery pressure.

c. Fueling Valve Fails To Open:

(1) Solenoid valve may not be opening. Loosen union between solenoid pilot valve (5) and pressure reducing valve (4) with solenoid energized. There should be fuel discharged through union.

(2) If no flow is noticeable, deenergize solenoid and repair or replace solenoid valve.

d. Fueling Valve Fails To Close:

(1) Check solenoid by cracking union with solenoid deenergized. There should be no fuel flow at union. If flow is detected, solenoid valve is not seating and should be repaired or replaced.

(2) Ejector-strainer (6) may be clogged. Loosen tube from ejector-strainer to main valve cover. If there is no flow of fuel through strainer at this point, strainer must be removed and cleaned.

e. Fueling Valve Fails To Maintain Pressure:

(1) Ejector-strainer may be clogged. Clean as directed in d(2) above.

(2) Pressure reducing pilot valve 4 may not be operating:

(a) Remove adjusting screw housing.

(b) Loosen jam nut and turn adjusting screw clockwise..

(c) If fueling valve opens and delivers fuel at an increased and constant pressure, it indicates that adjustment of pressure reducing pilot valve is incorrect.

(d) To remedy this, adjust as outlined in a above.

(3) Pressure relief pilot valve 3 may be open:

(a) Remove adjusting screw housing.

(b) Loosen jam nut and turn adjusting screw clockwise. This should definitely close pressure relief pilot valve and permit fueling valve to function properly.

(c) If this is found to be the trouble, follow pressure setting procedures outlined in a above.

(4) Diaphragm of fueling valve may be ruptured:

(a) If corrective measures given in steps 1 through 3 fail to reveal the trouble, proceed as follows:

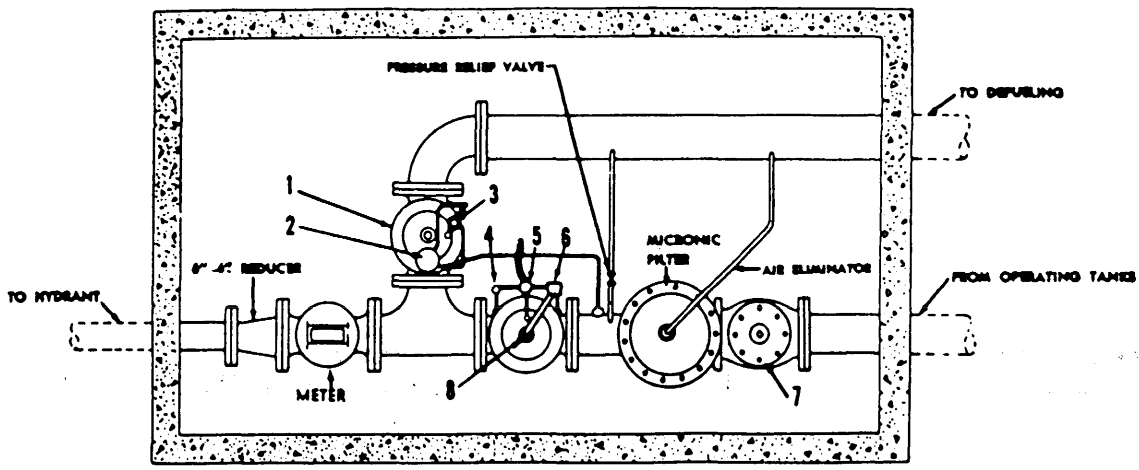
(b) Close manually operated valve 7.

(c) Remove tubing and fitting from cover of main fueling valve 8.

(d) The Main fueling valve is identical to high level control valve shown in figure 2-15.

(e) Remove cover nuts and lift cover off, taking care not to lose spring.

(f) Lift out diaphragm assembly and examine diaphragm for breaks or holes.



1. Defueling valve
2. Solenoid pilot valve
3. Pressure relief pilot valve
4. Pressure reducing pilot valve
5. Solenoid pilot valve
6. Ejector strainer
7. Manual Operated valve
7a. Extension rod (not shown)
8. Fueling valve and pressure regulator
8a. Excess flow control (not shown)

Figure 3-11. Filter Meter Pit With Separate Fueling and Defueling Valves and Bypass, System I.

(g) Replace diaphragm if necessary.

(h) Examine valve disk and replace disk if it shows signs of deterioration or wear.

(i) Reassemble fueling valve in reverse order to disassembly.

(j) Replace fittings and connect tubing.

(k) Open manually operated valve 7 (figure 3-11).

f. **Defueling Valve Fails To Open:**

(1) Solenoid pilot valve 2 (figure 3-11) may not be opening and draining cover chamber of defueling valve 1.

(2) Disconnect tubing between solenoid pilot and defueling valve cover. If fuel is discharged through tubing at this point repair or replace solenoid pilot valve.

g. **Defueling Valve Fails To Close:**

(1) Check solenoid valve, as described in f above. If fuel does not flow from disconnected tubing, solenoid pilot valve is defective; repair or replace solenoid pilot valve.

(2) Main defueling valve 1 (figure 3-11) is identical in construction to fueling valve 8. Proceed to check for ruptured diaphragm, as outlined in e above.

NOTE: Defueling valves not equipped with self-cleaning strainers in sensing lines should be modified to include these strainers.

3-8. Nonsurge Check Valve:

a. **General.** A nonsurge check valve (figure 3-12) must be provided in the discharge line of each deep well fuel pump installed in each operating tank when check valve replacement is required. Discharge lines not provided with nonsurge check valves are inspected during operation for shock and vibration to determine the necessity for replacing existing check valve. Leaky swing type check valves and initial surge of fuel into filter separator during pump startup can cause elements to rupture. In systems that do not have a nonsurge check valve on the downstream side of the pump, it is important to establish starting procedures. Do not open the system all the way before starting the pumps. To reduce shock and prevent air locks, start system pump and proceed to slowly open all valves in sequence from pump to outlet to eliminate element rupture due to shock or air lock of automatic valve.

b. **Installing Valves.** When the need for a nonsurge check valve exists, the nonsurge check valve should be installed in the pump discharge line as a replacement for the existing check valve. If conditions permit, manual shutoff valves should be installed immediately before and after the nonsurge check valve.

c. **Operation.** The nonsurge check valve is installed on the discharge of the deep well turbine refueling pump. It automatically prevents reverse flow and opens at a controlled rate to keep pump starting surges from shocking downstream equipment. The main valve is identical to the one shown in figure 2-29 and is operated hydraulically by line pressure. There is also a provision for manually actuating the valve by inserting a pull rod into the valve stem. The valve operates satisfactorily on a minimum line pressure of 4.5 psi. The spring-loaded CV flow control in the pilot control system allows for adjustment of valve opening rate within a range of 5 to 60 seconds. Auxiliary swing check valves in the pilot system apply downstream pressure to the main valve cover chamber for rapid closing the instant a pressure reversal occurs. The valve fails "safe" because it closes tight if the diaphragm becomes ruptured.

d. **Maintenance** (see figure 3-12):

(1) Adjustment. Remove cap from CV flow control and screw adjustment clockwise to the extreme position. The valve is now adjusted for its slowest rate. Begin pumping operations and observe pressure condition.

(2) Test:

(a) Shut off pump and turn adjusting screw counterclockwise. Start pump and observe opening rate. Make sure there is no shock to the system when the valve opens.

(b) Be sure all manually operated valves are open, and start pump. Note the valve position indicator on top of the main valve. Main valve should be wide open at preselected rate.

★(c) Shut off pump, the main valve closes completely.

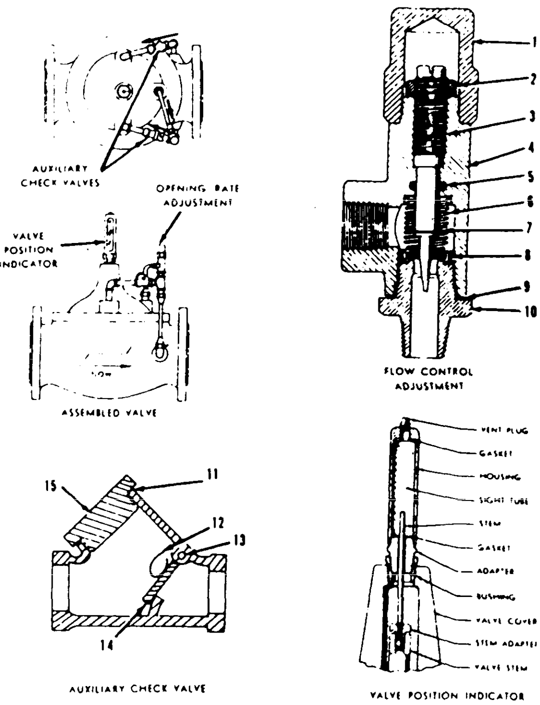
(d) Apply 3 to 5 psi pressure at the downstream side of the main valve. Remove plug from upstream side of main valve body. No continuous flow should come from this port.

(3) Main Valve Fails to Open. Failure of the main valve to open can be caused by obstructions in the flow control strainer and tubing, ruptured diaphragm, or a closed valve in the downstream line. Be sure all manually operated valves are open. Dissassemble CV flow control and tubing, and check for obstructions. If main valve still fails to open, overhaul components according to the manufacturer's instructions.

(4) Main Valve Fails to Close. Failure of the main valve to close can be caused by defective auxiliary check valve; mechanical obstruction in main valve; or clogged, broken, and leaking tubing or strainer. Check tubing for loose connections and breaks. Dissassemble tubing and check for obstructions. If main valve still fails to close, overhaul components according to manufacturer's instructions.

(5) Pulsations. Pulsating is caused by air in the main valve cover chamber. Loosen plugs in top of valve positioning indicator to bleed air.

(6) No Control of Opening Rate. CV flow control failure is caused by obstruction or mechanical failure holding the CV flow control in the open position. Disassemble CV flow control and clean or replace components.



1. Cap
2. Jam nut
3. Stem
4. Housing
5. "O"-ring
6. Spring
7. Snap ring
8. Disk
9. Gaskets
10. Seat
11. Gasket
12. Spring
13. Pivot pin
14. Flapper check valve
15. Cap

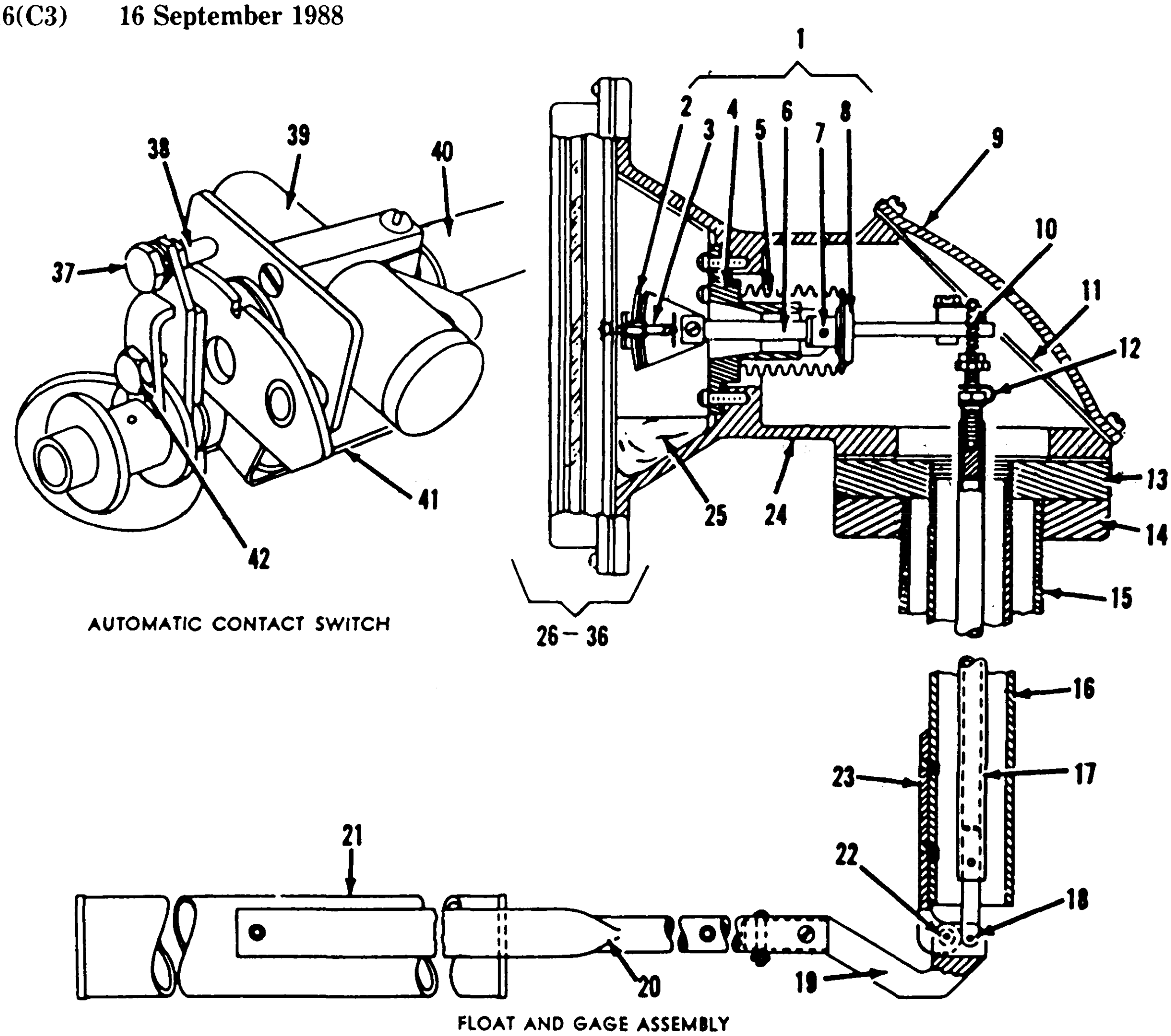
Figure 3-12. Nonsurge Check Valve.

3-9. Liquid Level Gage and Low Level Control:

a. **Use.** A liquid level gauge and low level control (figure 3-13) is installed to shut down the pump automatically. This prevents withdrawal of fuel from the tank below a predetermined level, prevents the pump from running dry, and indicates quantity of fuel in tanks.

b. **Operation.** The liquid level gage and low level control (figure 3-13) has an explosion-proof housing (24) installed just above the floor of the pumproom on a steel pipe extension (15) from the top of the tank. A dial type direct reading gage (26 through 36) and control switch (37 through 42) are mounted on the housing. The float (21) within the tank is attached to a push rod (17) extending through the fulcrum tube (16) to the adjuster block assembly (10) where it is geared to turn the sector arm (6) and switch control shaft (40). The sector arm controls the movement of the pointer to indicate quantity of fuel in the tank. When the float reaches a predetermined low level, the contact lever (38) on the switch control shaft engages in the notched cam (41) of the single-pole, single-throw mercury switch (39), actuating the mercury switch and shutting down the pump. The pump remains inoperative until the fuel level in the tank rises to a point where the float moves off the low level positioner.

★c. **Maintenance.** A telltale located on the dial face of some gages indicates the presence of moisture in the gage. A cracked window or broken seal admits moisture, causing the telltale to change from blue to pink. If moisture is present in the dial, the dial assembly (26 through 36) should be disassembled. Wash mechanism with alcohol and blow out with dry nitrogen (dry air may be substituted if nitrogen is not available). Apply light machine oil sparingly



1. Bellows and pinion shaft assembly
2. Pivot
3. Rack and sector assembly
4. Bellows body
5. Bellows body
6. Sector arm
7. Bearing
8. Bellows head
9. Adjustment cover
10. Adjustment block assembly
11. Gasket
12. Spring tension adjustment
13. Fulcrum pipe flange
14. Standpipe flange
15. Standpipe
16. Fulcrum pipe
17. Push rod
18. Bearing pin
19. Float arm lever
20. Float arm
21. Float
22. Float arm pivot pin
23. Fulcrum bracket
24. Housing
25. Dehydrating bag
26. Dial back plate
27. Dehydrating bag cover
28. Cover gasket
29. Dial
30. Telltale
31. Retaining ring
32. Pointer assembly
33. Backing ring
34. Window gasket
35. Glass window
36. Cover rim
37. Adjustment screw (factory set)
38. Contact lever
39. Mercury switch
40. Switch control shaft
41. Notched cam
42. Adjustment screw (low level)

Figure 3-13. Liquid Level Gage and Low Level Control.

to pivot pin (2), inside bellows (5), and other bearing surfaces. Install the new dehydrating bag (25) and reassemble dial, using new gaskets and, if necessary, new glass window. The low level control should be checked quarterly for accuracy of point of shutoff. Lower the fuel level in the tank to 13 inches (gage manually). Check dial reading and pump operation; the pump must be inoperative. Raise the fuel level in the tank to 15 inches (gage manually) and check the dial reading and pump operation; the pump should operate. Refer to the manufacturer's instructions for adjustment of dial and shutoff switch; dial adjustment is controlled by the adjustment block assembly (10); low level cutoff is controlled by the adjustment screw (42) on the switch assembly. The mercury should be inspected for cracks or a cloudy appearance that indicates oxidation of the mercury in the tube. If these conditions are observed, replace the tube.

CAUTION: It is imperative that all parts of the liquid level gage and low level control be checked for electrical continuity after maintenance and before testing.

3–10. High Level Control Valve Assembly:

a. Operation. Operation of the high level control valve is such that when pressure is directed through ⅜-inch tubing to the connection in the top of the valve and, in turn, to the diaphragm of the Hytrol main valve, the valve closes against incoming fuel from the bulk storage area. This is done by a hydraulic principle, the area of the diaphragm being greater than the area of the valve seat opening. When the pilot valve changes position because of float level changes, pressure is relieved from the diaphragm through ⅜-inch tubing, permitting fuel pressure in the fill line to open the valve. The valve is spring-loaded so it can remain closed when fuel is not being pumped into the tanks. Figure 3–14 shows the high level control valve assembly with pan type float. This type was most commonly used in the Panero (Type I) systems. An exploded view of the high level control valve is shown in figure 3–15 and a similar view of the float mechanism in figure 3–16. Figure 3–17 illustrates a high level control system with ball type float and modified hydraulic control found in hydrant refueling systems of recent design. The main valve is the same for both installations with the exception of the ejector-strainer (figure 3–6) installed on the later model. Also, a discharge elbow (½-inch brass or copper) from outlet port to approximately 12 inches from bottom of tank is not shown.

b. Tests. The following tests should be performed according to guidance outlined in chapter 10 by LFM personnel to make sure that the high level valve is closing:

(1) Fill operating tank with fuel until high level control valve closes. Closely observe reading of tank gage to prevent overflow.

(2) To prevent overflow of fuel through the tank vents if valve fails to close, the liquidometer is closely observed so that the filling operation may be stopped if necessary.

(3) Stick gage tank.

(4) Valve should close when fuel level is approximately 11 inches from the top of the tank.

(5) If tests indicate valve closes with less than required level of fuel in tank, or valve fails to close, adjustment or repair is necessary. First inspect strainers and control tubing for obstructions. If valve still fails to close, remove valve for overhaul.

c. Removal of High Level Float Control:

(1) Isolate tank from test of system by closing valves.

(2) Remove bolts and nuts holding cover plate to tank nozzle flange.

(3) Remove supply tubing and control tubing at high level control valve and at tank cover plate.

(4) Raise cover plate and pilot valve assembly out of tank nozzle and place on suitable work bench. Care should be used to prevent damage to float and linkage from bumping sides of tank nozzle.

d. Liquid Level Adjustment (Pan Type) (see figure 3–16):

(1) If closing level is too high, allowing tank to overfill, top stop (4) should be lowered on float rod. Loosen screw (5) and slide stop down rod to desired level and tighten.

(2) If opening level is too low; bottom stop (8) should be raised. Loosen screw (9) and slide stop up float rod to desired position and tighten screw.

e. High Level Control Valve Fails to Close (Pan Type) (see figure 3–16):

(1) Check to see that the counterweight (21) has been properly set. Place float control on suitable work bench.

(a) Unscrew lower section of float rod (6).

(b) Slide float (7) off float rod section.

(c) Screw two sections of float rod (6) together with float removed.

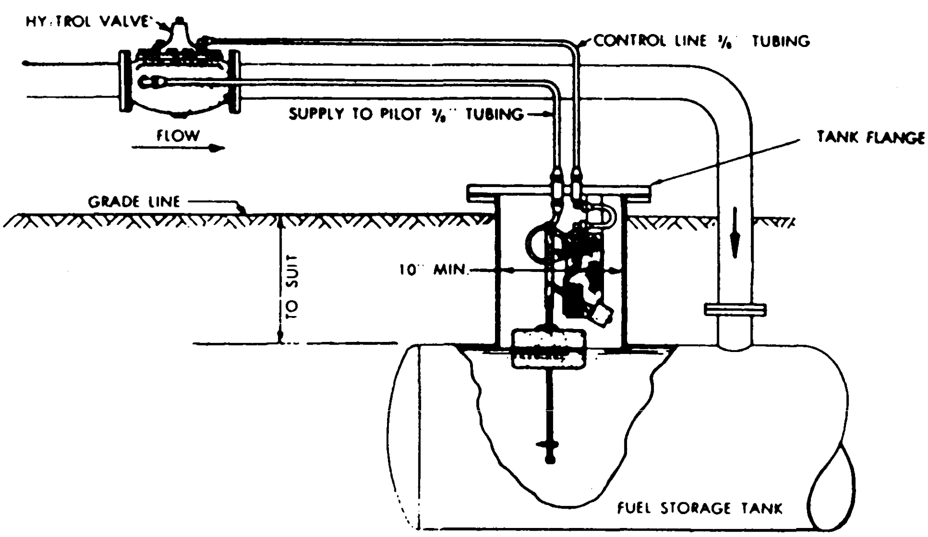


Figure 3–14. Assembly of High Level Control (Pan Type Float).

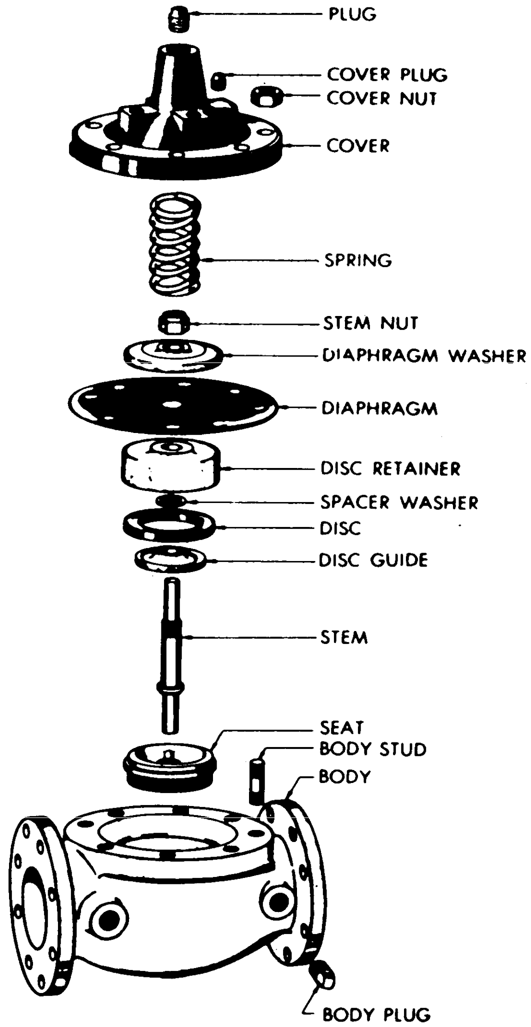


Figure 3-15. High Level Control Valve (Exploded View).

(d) Counterweight (21) should balance float rod and stops. Balancing is done by loosening counterweight setscrew (22) and moving counterweight along counterweight balance level arm (15) until desired position of counterweight is determined. Then, tighten counterweight setscrew.

(e) Unscrew lower section of float rod (6) and slide float (7) on float rod section. Screw two sections of float rod together. Check to see that float slides freely on float rod without causing pilot arm to raise or lower until float actually contacts stops.

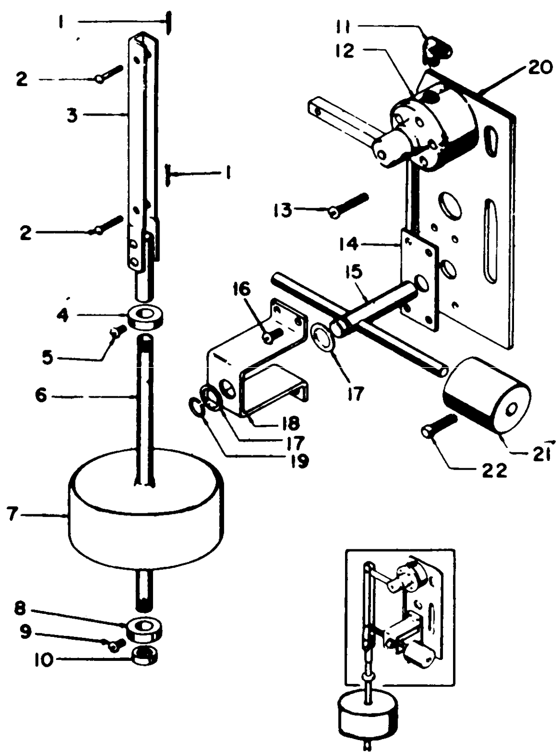
(2) Inspect tubing and pilot valve assembly for obstructions.

(a) Supply and control tubing previously removed is cleaned and inspected for obstructions.

(b) Raise float rod assembly to top position and apply approximately 25 psi air pressure to fitting. Removal of supply tubing will probably remove any restrictions in tubing or pilot valve. Use care, because air pressure escapes through fitting from which control tubing was removed.

(3) Check float for leaks. Shake float; if there is any liquid, a leak is indicated and float should be replaced.

(4) To disassemble high level control valve, see figure 3-15 and proceed as follows:



1. Cotter pin
2. Pin
3. Connecting link
4. Float stop
5. Float stop screw
6. Float rod
7. Float
8. Float stop
9. Float stop screw
10. End collar
11. Tube ell
12. Pilot valve assembly
13. Pilot valve assembly screw
14. Bearing plate
15. Counterbalance lever assembly
16. Counterbalance bracket screw
17. Thrust washer
18. Counterbalance bracket
19. Snap ring
20. Mounting bracket
21. Counterweight
22. Counterweight setscrew

Figure 3-16. High Level Float.

(a) Remove cover nuts.

(b) Lift off cover; care should be used not to lose spring.

(c) Remove diaphragm assembly and check for holes or breaks.

(d) Check for obstructions between valve seat and disk.

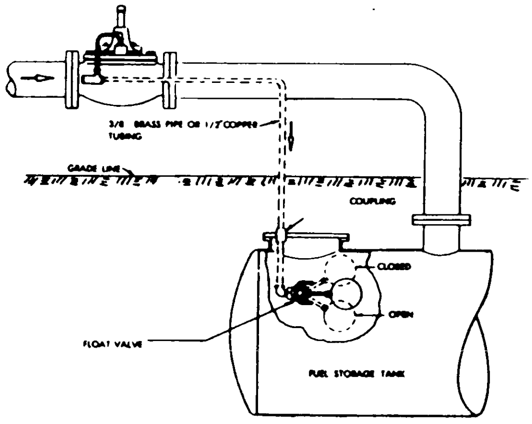
(e) After inspection, replace worn or damaged parts and reassemble in reverse order.

f. **High Level Control Valve Fails To Open:**

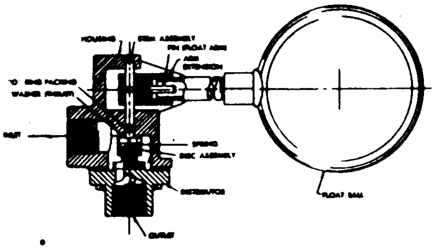
(1) Check to see that counterweight (21) (figure 3-16) is properly set and float lowers float rod assembly to bottom position.

(2) Disconnect supply tubing to pilot valve at tank flange.

(3) Raise rod assembly (6) to top position and apply air pressure to fitting at tank flange from which control tubing was removed, and air escapes from drainpipe on bottom of pilot valve. This operation should clear any obstruction in pipe or pilot valve.



INSTALLATION



FLOAT VALVE

Figure 3-17. Assembly of High Level Control (Ball Type Float).

g. **Installing High Level Float Control:**

(1) Check nozzle flange gasket to see that it is serviceable.

(2) Lower cover plate to position on nozzle flange.

(3) Align bolt holes in cover plate and replace bolts and nuts.

(4) Draw up and torque nuts and bolts evenly to prevent warping of cover plate.

3-11. Remote Controls (Electrical):

a. **Equipment:**

(1) Fixed Control Stations. The fixed control stations on Type I hydrant systems have two pushbuttons and duplicate the function of the portable control stations. The fixed control stations are located near the hydrant outlets on the apron. When not in use, each control station and its flexible connection cord is stored in the box located in the apron. Maintenance of the fixed control assemblies is the responsibility of the base civil engineer organization.

NOTE: These systems will be converted to the magnetic control switches (similar to those used in the Type II system mentioned in paragraph 4-14).

(2) Emergency Switches. The emergency switches are singlepole type and are connected in series with the power supply line to the control equipment in the operating pumphouse. The switches are provided so that operating personnel at any pit can stop all fueling operations in case of fire, or other mishap requiring the cessation of fueling at the respective pumphouse supplying the hydrant outlet in use. After operation of an emergency switch, the controls in the operating pumphouses must be manually reset in order to resume fueling.

(3) Pilot Valves. The valves are the solenoid-actuated pilot valves that are a part of the automatic fueling and defueling valves.

(4) Pit Control Equipment. This equipment has a transformer, circuit breaker, and relay, each in a separate enclosure. The transformer is provided to reduce the electrical system high voltage to 24 volts, for use by the portable control station circuits. The circuit breaker is provided to protect the transformer and low voltage control wiring from damage by short circuits. The relay is provided to isolate the 24-volt circuits from the high-voltage circuits.

b. **Operation.** To better understand the operation of electrical equipment, consider fueling at the hydrant outlet. When the operator at the hydrant presses the RUN button on the remote control station, the relay in the control equipment closes, energizing the pilot valve which, in turn, opens the automatic fueling port and closes the defueling valve port so fuel can flow to the hydrant. At the same time, the relay also energizes the electrical control line from the pit to the pump selector panel. This signal passes through the isolated relays in each control line to the selector switch associated with the hydrant. Depending on the setting of the selector switch, the control signal is connected to the selected motor controller and energizes the motor controller contactor to start the pump and deliver fuel to the dispensing hydrant. Emergency switches are located in or at the filter meter pit for the Panero (Type I) system.

3-12. Hydrant Quick Coupler and Adapter (One Type):

a. **Description.** The hydrant outlet pit has a cast iron housing set into the pavement of the refueling area. Figure 3-18 shows one type of hydrant fixed adapter and quick coupler valve. The top of the housing is flush with the pavement. A heavy bronze cover prevents water and dirt from getting into the pit when the hydrant is not in use. A 4-inch nonferrous hydrant adapter installed within the box, is companion-flanged to the riser portion of the supply pipeline.

b. **Operation.** When fueling or defueling, the quick coupler is coupled to the hydrant adapter. Both the adapter and coupler are fitted with poppet valves. The coupler poppet is operated by a cam or other mechanism. When the coupler poppet is opened, it bears on the spring-loaded adapter poppet, forcing the adapter poppet into the open position. When the coupler poppet is closed, spring pressure forces the adapter poppet into the close position, thus sealing both the hose and the pipeline and providing a "dry break." Both the adapter and the coupler are equipped with dust caps that must be kept in place when the equipment is not in use.

3-13. Filter (Micronic):

a. The filter (figure 3-19) has a large cylindrical vessel with a removable head containing filter elements, inlet and outlet connections, and differential pressure gage; all

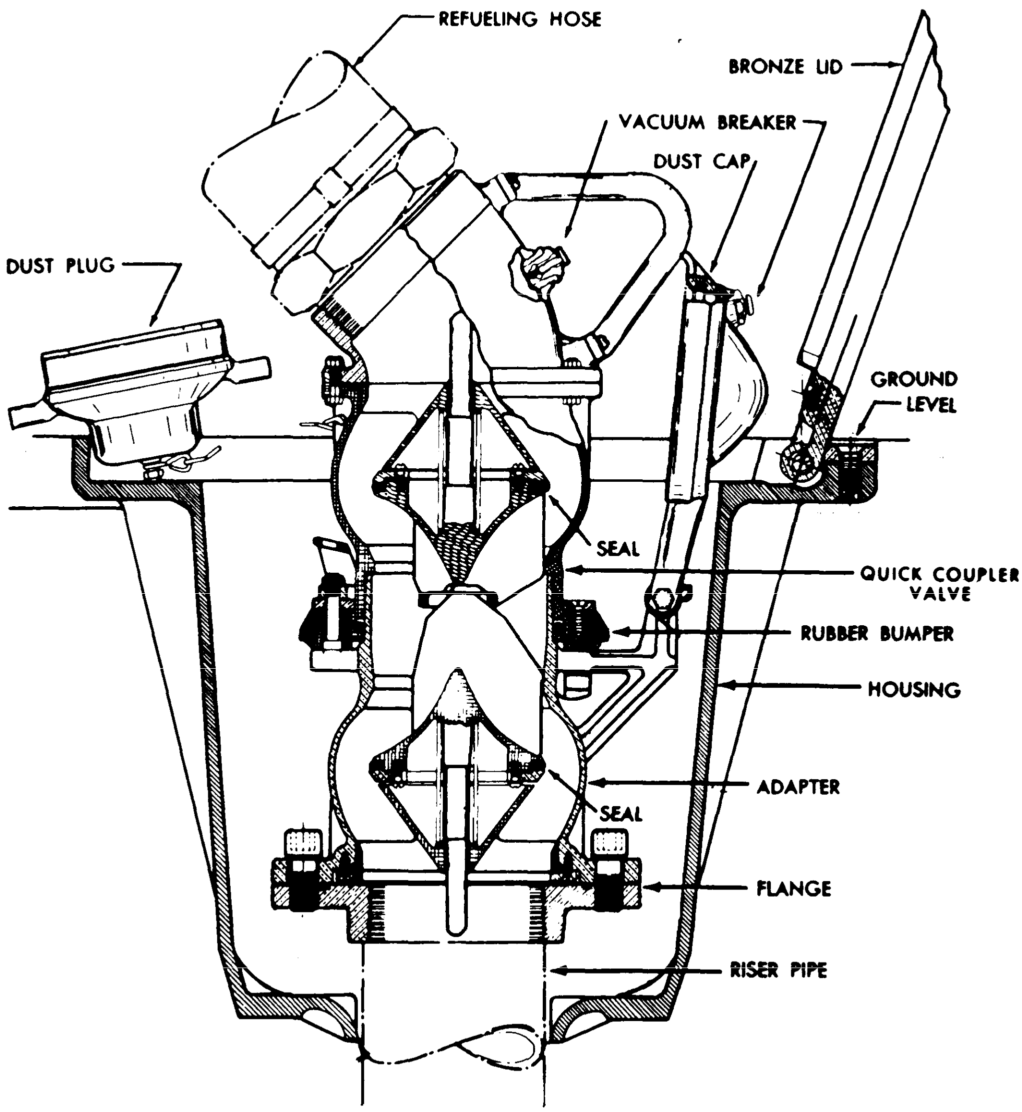


Figure 3-18. Hydrant Outlet, Fixed Adapter and Quick Coupler Valve (System I) (One Type).

combined as a single unit. The differential pressure gage is installed on each unit to determine resistance to flow of fuel passing through the vessel, and to aid in determining when filter elements are dirty. Valves or petcocks are installed in the bottom of vessels as a means of draining off water and sediment. The vessel is installed in the line to Type I hydrant system outlets for the primary purpose of removing contaminating particles from fuel being delivered to aircraft.

b. Many Air Force bases have modified their Panero hydrant systems to use MH2 series hose carts. This modification was originally recommended to provide for water and solids removal as close to the aircraft as possible because the standard Panero type system micronic filter could remove only fuel solids. The standard modification at these locations include removing the micronic filter and meter from the pit, installing pipe spools in their place, and making necessary adjustments to the control valves.

c. During the period that the MH2 series hose carts were being phased into the Panero systems, some of these systems were required to service certain fighter aircraft while one engine was running (hot refueling). For these operations, the aircraft were serviced directly by a hose from hydrant outlet to the aircraft without an MH2 series hose cart. The reasons for not using the hose cart for "hot refueling" operations were that it created congestion, increased the possibility of fuel spills, and intensified the danger of fire.

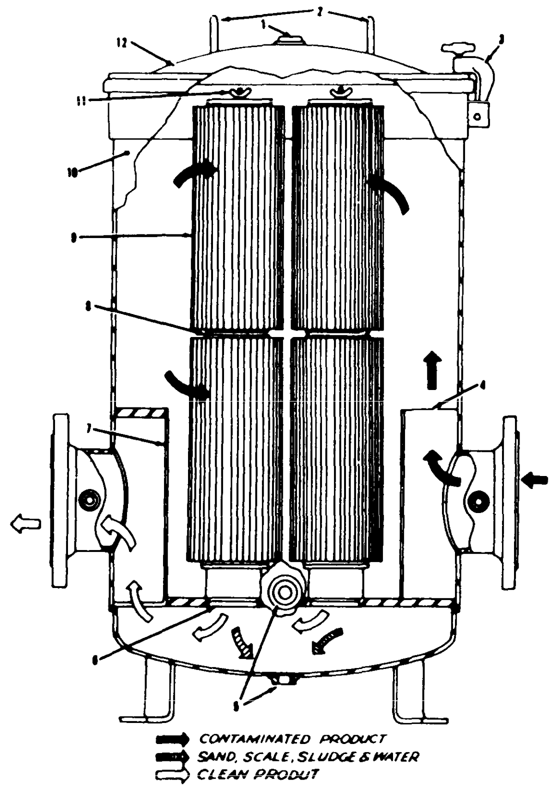
d. If micronic filters are still installed, then the following procedures will be followed. The filter elements should be replaced when the differential pressure across the vessel reaches the maximum limit as prescribed by the manufacturer's data plate located on the vessel, or after 2,000,000 gallons of fuel have been dispensed through the vessel. Filter elements have a shelf life of 3 years and should not be used if they are older.

(1) Close manually operated valves at inlet and outlet to filter.

(2) Place suitable container beneath drain valve and drain all fuel from unit. Return clean fuel to storage tanks.

(3) Remove flange bolts and lift off filter dome.

(4) Remove bolts that hold filter element holding plate in place.



1. Vent
2. Handles
3. Swing bolts
4. Inlet baffle
5. Drains
6. Cartridge adapters
7. Outlet baffle
8. Center seal
9. Filter cartridge
10. Case assembly
11. Cartridge mounting assembly
12. Removable cover

Figure 3-19. Micronic Filter, Vertical Type.

(5) Remove locking pins or other locking devices that retain elements on holding plate tubes. Remove springs and seals, slide old filter elements and seals off tubes, and dispose of old filter elements, as described in paragraph 2-14c(5).

(6) Wash all parts of element holding assembly with cleaning solvent. Carefully insert all seals, washers, and gaskets to be sure that there are no grooves, nicks, or breaks in seals and washers that would permit fuel to leak through unit without passing through filter elements.

(7) Carefully inspect filter elements to any type of damage. Do not install if damaged.

(8) Reassemble filter element holding assembly using new elements.

(9) Check gasket surfaces on element holding plate and casting flange. Install gaskets on holding plate. Install bolts and tighten evenly to ensure an even gasket seal. (Do not use cement, shellac, or other adhesive to hold this gasket in place, because it may contaminate the fuel.)

(10) Inspect filter dome flange and tank flange. Check dome flange gasket to see that it is in good condition.

(11) Place gasket on tank flange. Install bolts in dome flange and tighten bolts evenly.

(12) Partly open inlet valve to filter and allow to fill slowly; on units with no air eliminator, check air vent valve to allow air to escape as unit fills. As soon as unit fills, stop pump. Open inlet and outlet valve carefully. The unit is now ready for operation.

(13) Notify the base fuels management officer that the micronic filter is ready to be put back into service and is awaiting flushing and sampling. (This is necessary to ensure the fuel meets quality requirements.)

(14) On elements installed, the following must be done; paint in black letters ¾ or 1-inch high, the month and year of installation; put data decal (if provided with the replacement cartridge) over the original micronic filter data plate, removing the previous replacement elements data plate; and set up a log book. This log book is kept on hand in the LFM shop.

(15) The following information should be recorded in the log book: Filter or meter pit number; micronic filter number; date the replacement cartridges were installed; NSN of cartridge; and manufacturer's cartridge number, if available.

3-14. Defueling Tank. A deep well turbine pump is installed on the defueling tank to transfer the defueling product to bulk storage or operating tanks. (See paragraphs 2-4 and 2-5 for description and maintenance of this pump.) The defueling tank should be modified with a high level alarm to warn personnel that the fuel level in the tank is approaching the predetermined level.

Chapter 4

HYDRANT FUELING SYSTEM, TYPE II (PRITCHARD)

Section A—General

4-1. General Information. In 1955 a design was set up for all installed systems to improve operating characteristics in conventional hydrant fueling systems. The following paragraphs outline the general differences in the two systems. Figures 4-1 and 4-2 show the two different types of a typical hydrant lateral control pit; figures 4-3 and 4-4 show the general layout of the system II hydrant fueling system.

NOTE: At some bases that service KC-135 jet tankers, hydrant fueling systems (System II) have been modified to increase defueling rates from these aircraft. Such modifications affect the components of the lateral control pits and adapter and liquid level control. (See figures 4-2 and 4-14.)

Section B—System Components

4-2. Deep Well (Vertical) Turbine Pump. Pump design is the same for both Types I and II hydrant fueling systems. (See chapter 2, section B for description and maintenance.)

4-3. Nonsurge Check Valve. See paragraph 3-8 for description and maintenance of nonsurge check valves.

4-4. Filter Separator. Chapter 2, section D gives a description of, and outlines the maintenance procedures for typical filter separators. Filter separators and their components conform to latest Air Force standards.

4-5. High Level Control. See paragraph 3-10 for description and maintenance of high level controls.

4-6. Hydrant Hose Cart. Type MH2 series hose carts containing filter separator and metering equipment were incorporated in all Type II fueling systems and are recommended for use in Type I fueling systems.

NOTE: Model 351AF quick coupler valve (Top View, Figure 4-14) is a component of the MH2 Cost Cart. The civil engineer initially procures these valves for each hydrant system to ensure that they matchup with the hydrant outlet adapter. After installation it becomes a component of the hose cart and is thereafter maintained by the motor vehicle maintenance shop. All maintenance of hose carts and their components is the responsibility of the motor vehicle maintenance shop.

4-7. Refueling Control Valve:

a. General. The fueling control valve (figure 4-5) is a combination pressure reducing and emergency shutoff valve.

b. Description. The valve has a main valve (same as shown in figure 3-15); pressure reducing (CRD) solenoid pilot control (figure 4-5); pressure relief (CRL) control, ejector-strainer (figure 4-5); valve position indicator (figure 3-12); and CV flow control valve (figure 3-12), to permit adjustment of valve opening rate, Hytrol valve, and pressure differential (CDHS-3) (excess flow) control to shut off the valve automatically if rate of flow through the valve exceeds the setting of the shutoff control. The components and operation of the pressure differential (CDHS-3) (excess flow) control are the same as the excess flow control used to modify earlier valves (paragraph 3-5, figure 3-9).

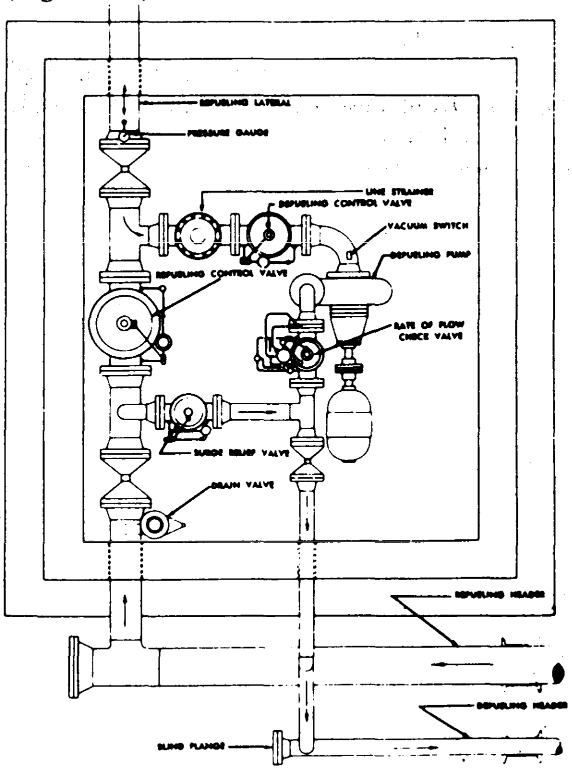


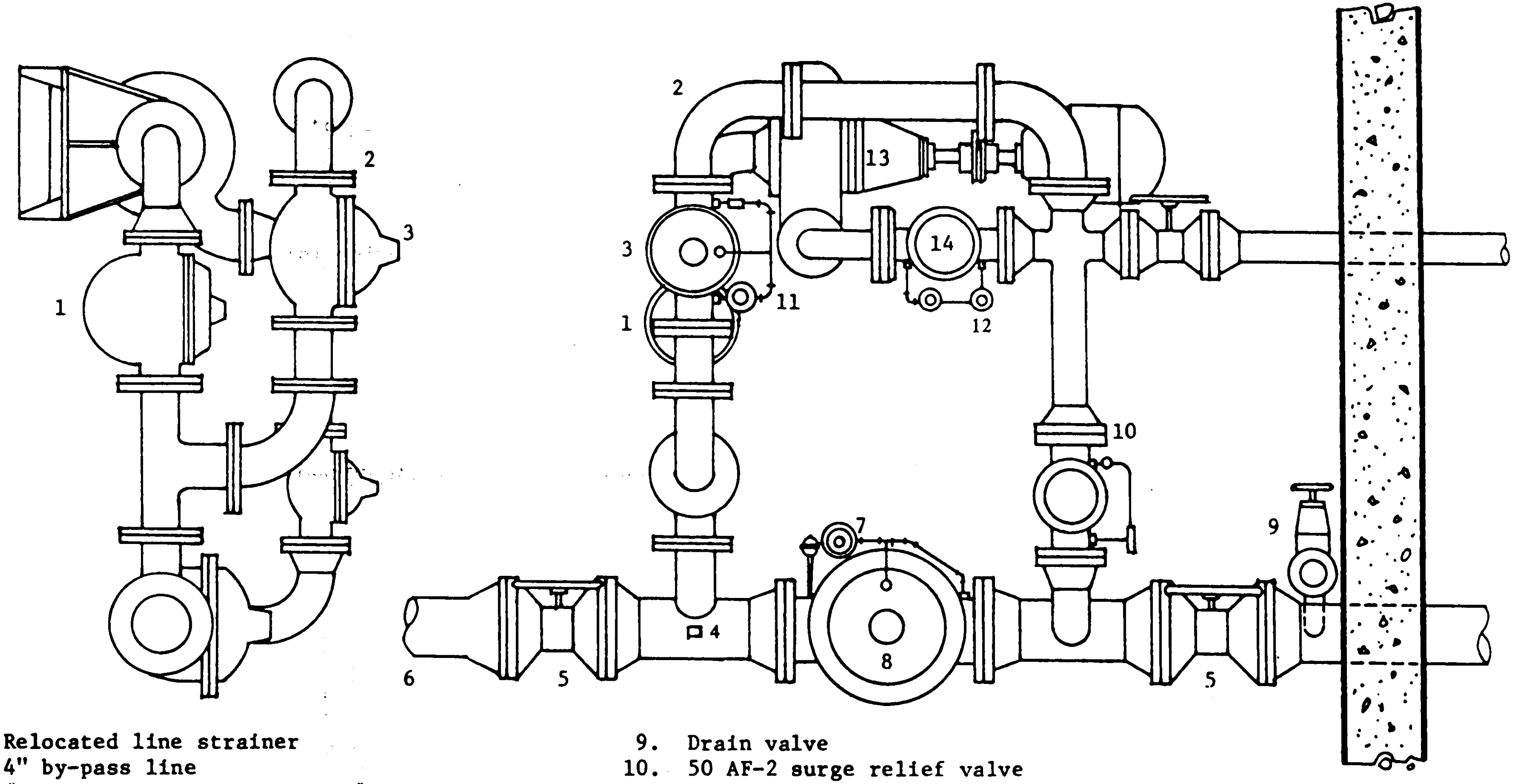
Figure 4-1. Original Hydrant Lateral Control Pit, System II.

c. Operations. The refueling control valve is installed in the lateral control pits of the hydrant lateral pipeline. It maintains a constant downstream pressure when the solenoid is energized. When this solenoid is deenergized, the valve closes tight. The valve is controlled by a pressure reducing (CRD) control and a solenoid-operated pilot control. The main valve is hydraulically operated. There is provision for manually actuating the valve by inserting a pull rod into the valve stem. A CV flow control provides opening rate adjustment. The valve fails "safe" because it closes tight if diaphragm becomes ruptured. Pilot valves are connected to the main valve to provide the following operation:

(1) Fueling Operation. When the solenoid is energized, the pressure reducing (CRD) control takes control of the main valve and causes it to maintain a constant downstream pressure. The pressure is adjustable from 50 to 150 psi.

(2) Emergency Shutoff-Remote Control. When the solenoid pilot control is deenergized, the main valve closes tight.

(3) Controlled Opening Rate. The CV flow control installed in the valve cover limits the flow out of the cover,



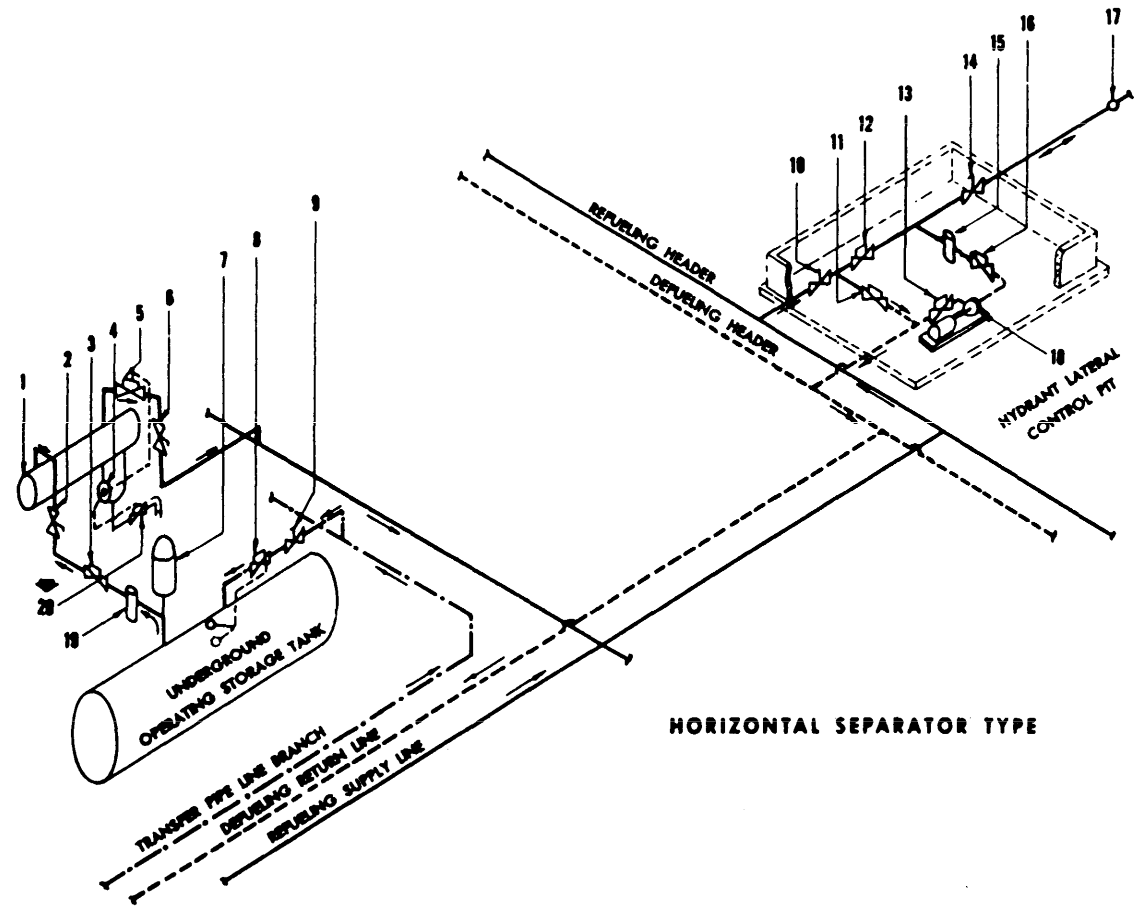
1. Relocated line strainer
2. 4" by-pass line
3. #134 AF valve - Convert to #51 AF-4 Valve
4. Vacuum switch
5. N.L. plug valve
6. Lateral
7. Existing solenoid
8. 90 AF-8 refueling control valve
9. Drain valve
10. 50 AF-2 surge relief valve
11. Connect in parallel electrically with 7
12. Add #C52EXM solenoid from 3 and connect in parallel with defuel pump motor
13. Defuel pump
14. 41 AF valve - Convert to 41 AF-10 valve

★Figure 4-2. Modified Lateral Control Pit, System II (Rapid Defuel).

thereby permitting a controlled opening rate. This rate is adjustable from 5 to 60 seconds.

(4) Fast Closing. If downstream conditions cause a rapid rise in downstream pressure, the pressure relief (CRL) control opens quickly, thereby dumping high upstream pressure into main valve cover chamber. This causes the main valve to close quickly in one second or less. This control must be set 2 to 3 psi higher than the set downstream pressure.

(5) Excess Flow Control. This component of the refueling control valve is identified as the Clayton CDHS-3 Pressure Differential Control (this control is also installed on refueling control valves located in the type I system). It is a compact, snap-action pilot valve, operated by the pressure differential impressed across a special diaphragm.The pressure setting is adjustable, and a rising differential actuates the control. A manual reset is used to return the control to the "cocked" position after being tripped. The valve action is usually a four-way action, but a variety of flow patterns is also possible. The new adjusting screw is a nonrising type, and is covered with a protective cap. All moving parts are sealed with O-ring packings, and extra long life bearings are used throughout. Two new methods of testing the operation of the excess flow control on the refueling control valve (also use these procedures for Panero system refueling valves) has been adopted and is contained in attachment 4 of this manual. The old method of testing the excess flow control by simulating excess flow conditions



1. Filter/separator
2. Plug valve
3. Nonsurge check valve
4. Flanged float control
5. Fuel discharge valve
6. Plug valve
7. Fueling pump
8. High level shutoff valve
9. Plug valve
10. Plug valve
11. Pressure relief valve
12. Fueling control valve
13. Rate of flow control valve
14. Plug valve
15. Line strainer
16. Defueling control valve
17. Fueling hydrant valve
18. Defueling pump
19. Line strainer
20. Water drain valve

Figure 4–3. Isometric View of Typical Hydrant Fueling System II (Since 1955)—With Horizontal Filter Separator.

several times cannot now be performed without violating the new criteria in TO 36A12-13-1-131 CL-1 paragraph 5 through 6.

d. **Adjustment Procedures (see figure 4-5):**

(1) Pressure Setting Instructions. It is very important that the pressure relief (CRL) control be set 2 to 3 psi higher than the pressure reducing (CRD) control. To accomplish this setting, proceed as follows:

(a) Install pressure gage if not already available to indicate downstream pressure.

(b) Establish flow rate of 50 to 100 gpm through valve.

(c) Remove pressure relief (CRL) control adjusting screw housing, and turn adjusting screw clockwise, until it bottoms.

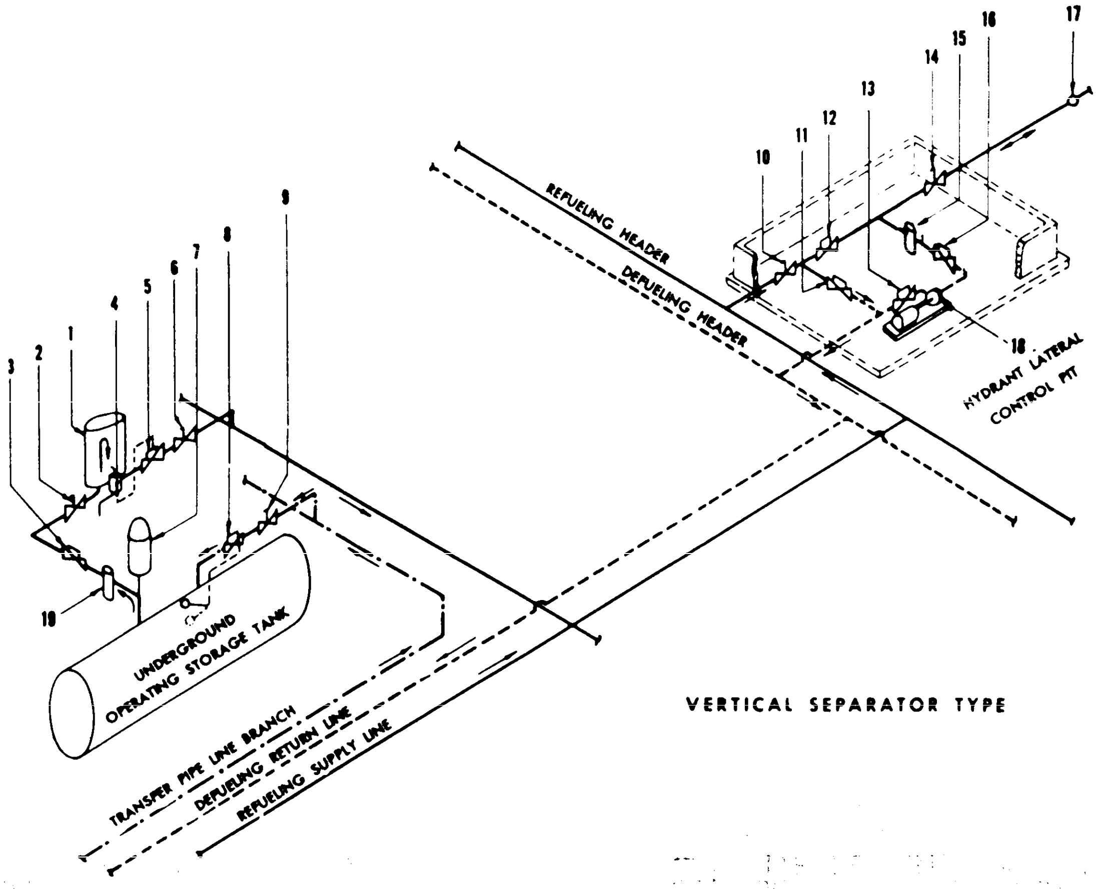
(d) Remove pressure reducing (CRD) control adjusting screw housing, and turn adjusting screw until pressure is 5 psi above desired set pressure. Turn adjusting screw clockwise to raise pressure, turn counterclockwise to lower pressure.

(e) Turn pressure relief (CRL) control adjusting screw slowly counterclockwise until pressure is 2 to 3 psi above desired set pressure. Lock screw in this position.

(f) Turn pressure reducing (CRD) control adjusting screw slowly counterclockwise, until desired set pressure is reached. Lock screw in this position.

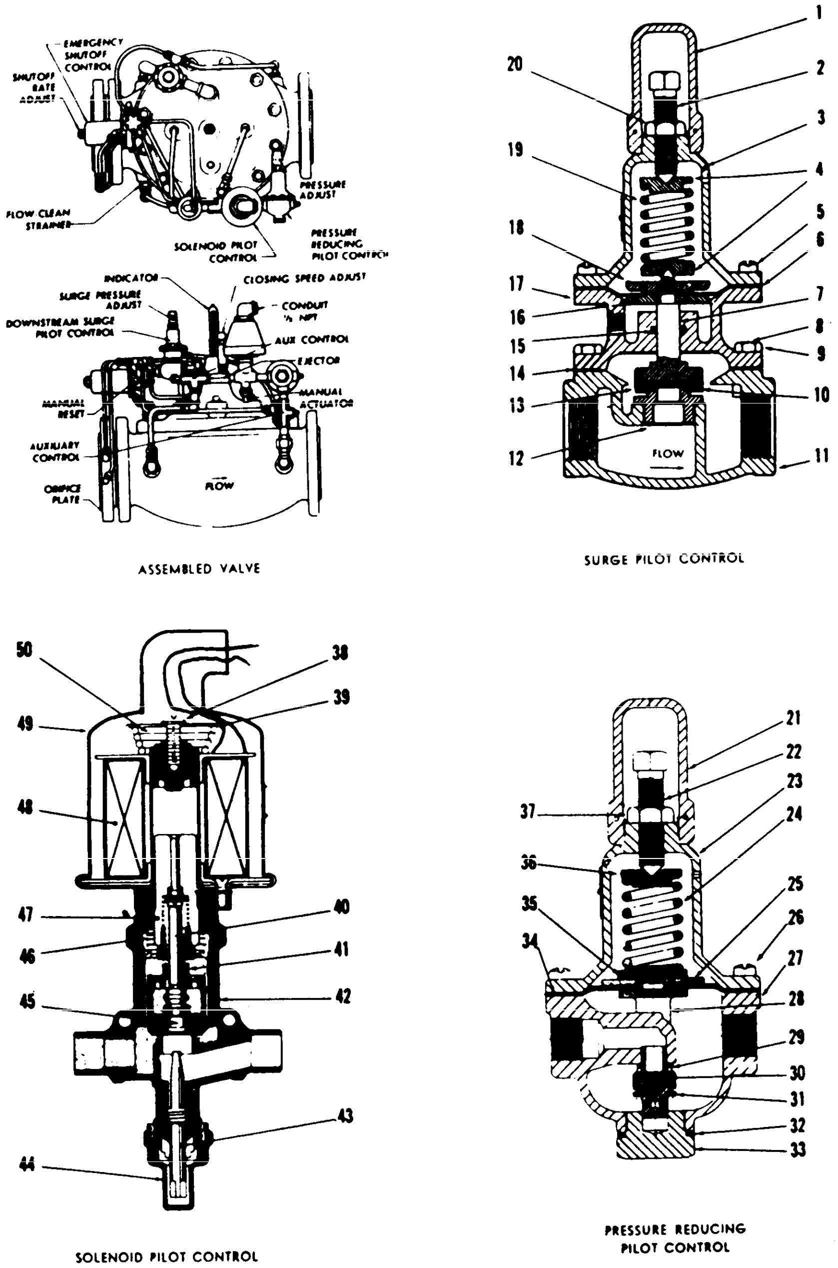
(g) Replace adjusting screw housings.

(h) Reseal housing.



1. Filter/separator
2. Plug valve
3. Nonsurge check valve
4. Automatic water drain valve
5. Fuel discharge valve
6. Plug valve
7. Fueling pump
8. High level shutoff valve
9. Plug valve
10. Plug valve
11. Pressure relief valve
12. Fueling control valve
13. Rate of flow control valve
14. Plug valve
15. Line strainer
16. Defueling control valve
17. Fueling hydrant valve
18. Defueling pump
19. Line strainer

Figure 4-4. Isometric View of Hydrant Fueling System II (Since 1955)—With Vertical Filter Separator.



1. Adjusting screw housing
2. Adjusting screw
3. Cover
4. Spring guide
5. Machine screw
6. Diaphragm
7. Stem
8. Stud
9. Nut
10. Disk retainer
11. Body
12. Seat
13. Disk
14. Gasket
15. "O"-ring
16. Lower diaphragm washer
17. Upper body
18. Upper diaphragm washer
19. Spring
20. Jam nut
21. Adjustment cap
22. Adjustment screw
23. Cover
24. Spring
25. Diaphragm washer
26. Machine screw
27. Body
28. Yoke
29. Seat
30. Disk
31. Disk retainer
32. Gasket
33. Plug
34. Diaphragm
35. Diaphragm nut
36. Spring guide
37. Jam nut
38. Machine screw
39. Spring retainer
40. Plunger
41. Plunger stop
42. Body
43. Manual opening stem
44. Manual opening cap
45. Seat
46. Impact spring
47. Plunger assembly
48. Coil assembly
49. Solenoid case
50. Coil retaining spring

Figure 4-5. Fueling Control Valve.

(2) Opening Rate Adjustment. Adjustment for opening rate should be made individually, at each installation. Proceed as follows:

(a) Remove CV flow control adjusting screw cap, and turn screw clockwise, until it bottoms. This is the slowest possible rate setting.

(b) If necessary to increase opening rate turn screw counterclockwise.

(3) Excess Flow Shutoff Point. To adjust the point at which the valve shuts off because of excess flow, follow procedures outlined in attachment 4.

4-8. Defueling Control Valve:

a. **General.** The defueling control valve (figure 4-6) is a diaphragm actuated shutoff valve.

b. **Description.** The main valve is of the same construction as the valve shown in (figure 4-6). The valve is controlled by sensing lines with an ejector strainer and a solenoid pilot control.

NOTE: Valves not having self-cleaning strainers in sensing lines should be modifed to incorporate such strainers.

c. **Operation.** The defueling control valve is installed in the hydrant lateral control pit on the defueling pump suction line. Operation of the valve and the defueling pump occurs simultaneously. When the pump starts, the valve opens wide; when it stops, the valve shuts off tight. The valve is controlled by a solenoid and is operated hydraulically by line pressure. There is a provision for manually actuating the valve by inserting a pull rod into the valve stem.

NOTE: This valve is removed from the lateral control pit when pits are modified for rapid defuel (see figure 4-2).

d. Test Procedure (see figure 4-6):

(1) Open isolation shutoff valves on each side of the hytrol main valve. Energize solenoid pilot control, and note valve position indicator on top of main valve; main valve should open wide.

(2) Deenergize solenoid pilot control, and note valve position indicator. Main valve should close tight, stopping flow through the valve.

(3) Repeat this procedure at least 5 times. Defueling control valve must function smoothly, without evidence of sticking or binding.

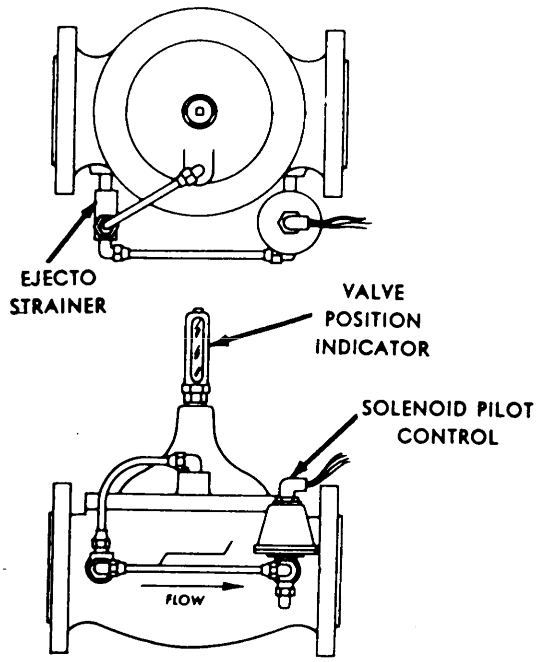


Figure 4-6. Defueling Valve.

4-9. Rate of Flow Control Valve:

a. General. The rate of flow control valve (figure 4-7) is a combination two-stage rate of flow control valve and a fast-closing, hydraulically operated check valve that closes the main valve against reverse flow.

b. Description. The main valve is a diaphragm type modified globe valve containing a single seat, a resilient disk, and a stem position indicator. No external packing glands are used. The diaphragm must not be used as a seating surface. If the diaphragm becomes ruptured, the valve will close tight. The valve is self-contained and operates satisfactorily on a minimum line pressure of 4.5 psi.

c. Operation. The rate of flow control valve is installed in the hydrant lateral control pit on the discharge of the defueling pump. It performs two distinct functions: it maintains either of two preset flow rates; it acts as a check valve to prevent reverse flow. This valve is hydraulically operated. There is provision for actuating the valve manually by inserting a pull rod into the valve stem. The valve is controlled by two differentia (CDHS-2) controls actuated by differential pressure across a specially designed orifice plate. A solenoid-operated control is energized to select the low flow rate. The check portion of the flow control valve will cause this valve to close against reverse flow. The valve fails "safe," because it closes tight if the diaphragm becomes ruptured. CDHS-2 control are connected to the main valve to give the following operations:

(1) Full Flow Rate. When the solenoid control is deenergized, the "high flow" control causes the valve to maintain a preset "high flow." This flow rate is adjustable from one-fourth its full rated capacity.

(2) Reduced Flow Rate. When the solenoid pilot control is energized, the "low flow" control causes the valve to maintain a preset "low flow".

NOTE: The low flow rate is no longer used on systems that have been modified with the magnetic control switches. (See paragraph 4-14b).

(3) Check Valve. The valve acts as a fast-closing check valve whenever a pressure reversal occurs.

d. Pressure Setting Instructions (see figure 4-7). Both differential controls must be set in the field. Proceed as follows:

(1) When installation of manual isolation valves and rate of flow control valve is complete, do not pressurize system.

(2) Back off adjusting screws on both controls until they are loose. Do not back off adjustment screws on differential controls when system is under pressure.

(3) Turn adjustment screws on both controls in, two full turns. This sets both differential controls at a mini-

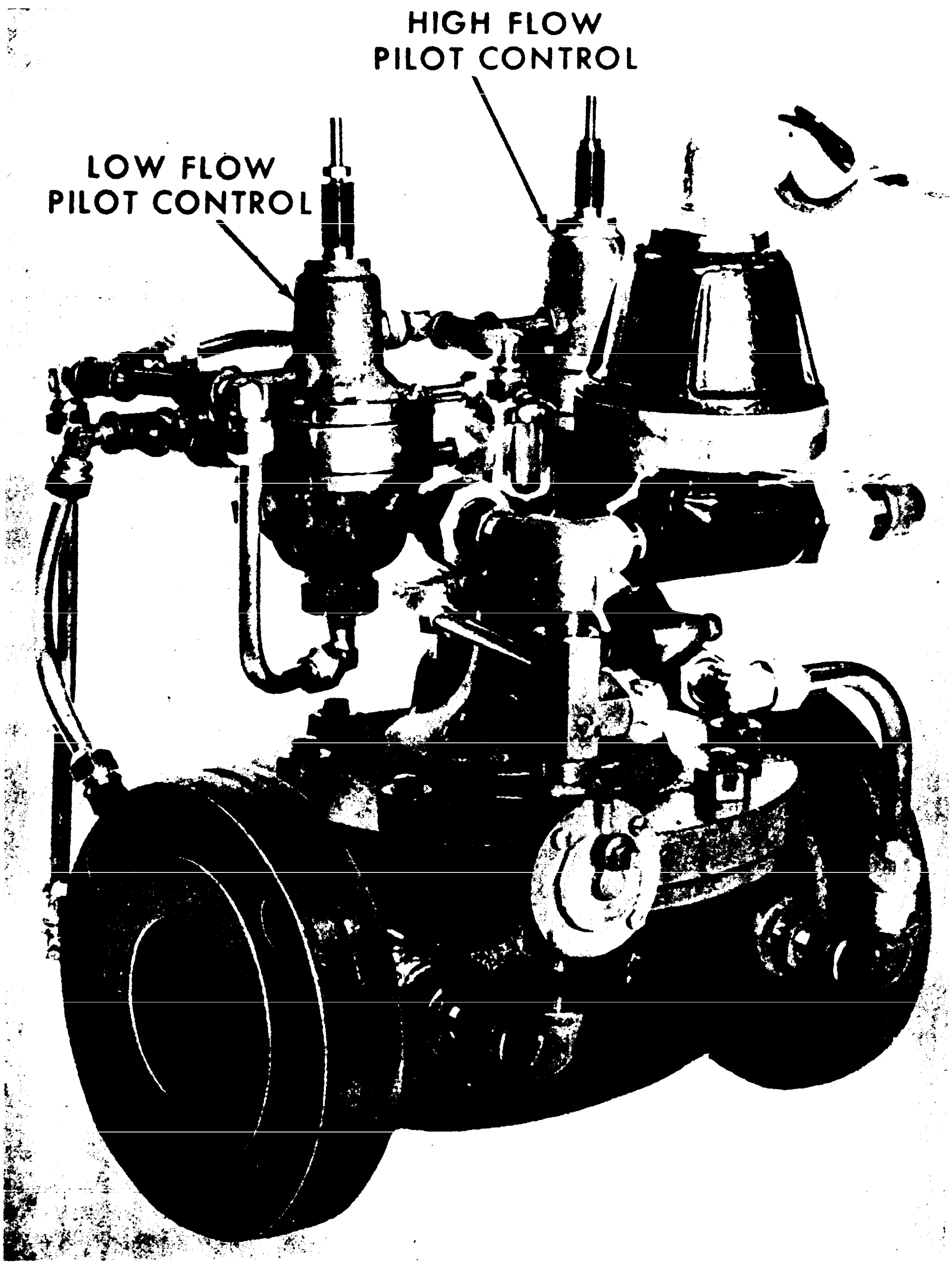


Figure 4–7. Rate of Flow Control Valve.

mum setting. Under no circumstances should pressure be applied to either differential control with a setting less than this "two-turn" minimum.

(4) The low rate control must be set first for proper operation of the rate of flow control valve.

(5) Close isolation valves on each side of the main valve.

(6) Pressurize system.

(7) Open upstream isolation valve; main valve must remain closed.

(8) Bleed air from valve at high points.

(9) Open downstream isolation valve. Establish flow through valve.

(10) Energize solenoid control.

(11) Turn low rate adjusting screw slowly clockwise until desired flow rate is established. Lock jam nut on adjusting screw. The rate of flow control valve is not equipped to indicate flow rate. If there are no meters or other flow indicating devices in the line, consult the factory for recommendations for a differential gage or manometer.

(12) After setting the low rate control deenergize the solenoid control.

(13) Turn adjusting screw on high rate control clockwise until desired rate is established. Lock jam nut on adjusting screw.

4-10. Combination Dual Rate of Flow Control, Solenoid Shutoff and Check Valve:

a. **General.** The combination dual rate of flow control, solenoid shutoff and check valve is used in the modified lateral control pit as shown in figure 4-2. This valve is located at the same location and is essentially the same as the rate of flow control valve mentioned in paragraph 4-9. The only difference between the two valves is that a solenoid is installed in the control tubing after the high rate of flow (differential) control. This modified valve operates the same as the rate of flow control valve but also acts as a defuel control valve. (The original defuel control valves have been removed from defuel pump suction pipelines of the modified lateral control pit.)

b. **Pressure Setting.** Follow the same procedures outlined in paragraph 4-9d.

NOTE: If existing fueling systems have been modified with the new magnetic control switches, the slow flow rate will no longer be required (see paragraph 4-14b).

4-11. Combination Dual Pressure Relief, Solenoid Shutoff and Check Valve:

a. **General.** The dual pressure relief valve (figure 4-9) is installed in the modified hydrant lateral control pit downstream of the refueling control valve between the hydrant lateral pipe line and the defueling line (bypass piping around defuel pump.) (See figure 4-2). This relief valve performs two functions, (1) relieves excess pres-

Figure 4-8. Combination Dual Rate of Flow Control, Solenoid Shutoff and Check Valve.

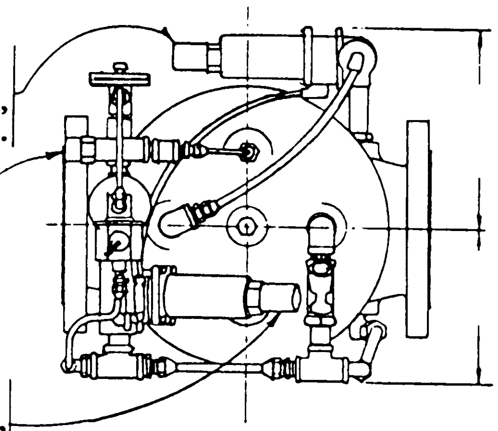
H.P. CONTROL

To increase the setting, turn adjusting screw clockwise. To decrease the setting, turn the adjusting screw counterclockwise.

Closing speed control - turn clockwise to reduce closing speed. Do not close completely. Valve will not close if this is done.

L.P. CONTROL

To increase the setting, turn adjusting screw clockwise. To decrease the setting, turn the adjusting screw counterclockwise.



1. 100 hytrol (main valve)
2. X101 valve
3. X474 ejector
4. B1 check valve
5. CV control (closing speed control)
6. CRL-16A back pressure control
7. CS3X solenoid control
8. 100 KR hytrol
9. CSC swing check
10. CRL-16A surge relief control

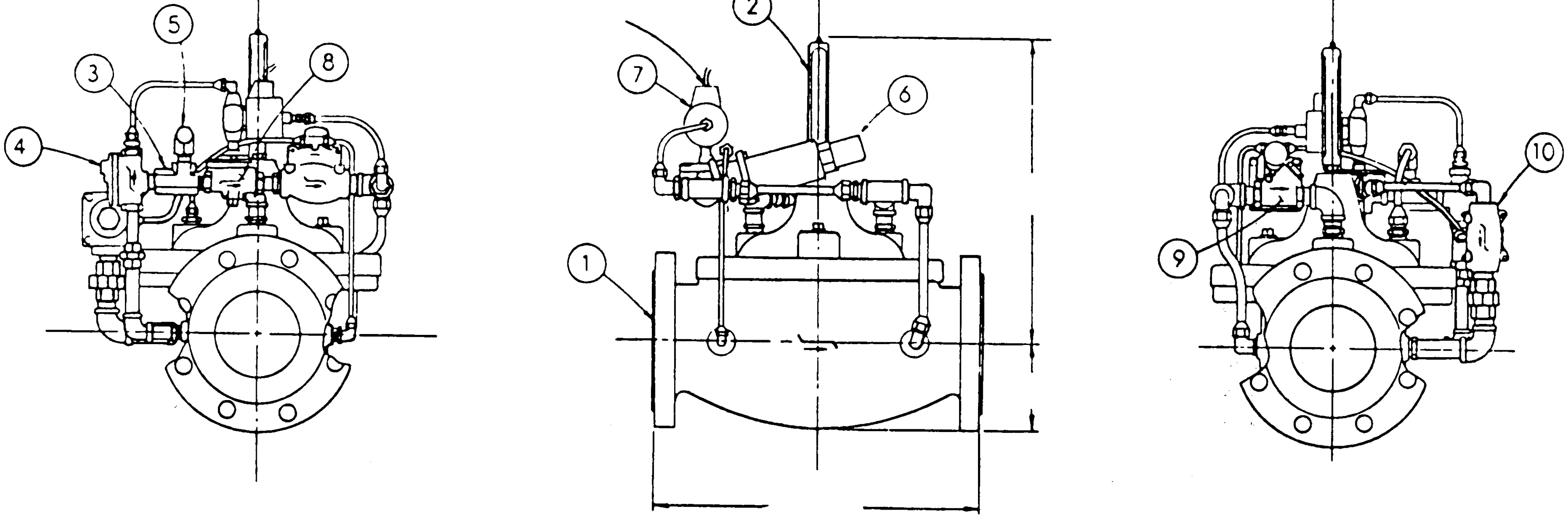


Figure 4-9. Combination Dual Pressure Relief Solenoid Shut off and Check Valve.

sures in the hydrant lateral piping caused by quick closing valves during the refueling operation and (2) maintains a minimum pressure of 5 psi on the hydrant lateral piping when the refueling pumps are not in operation.

b. **Operation.** During rapid defueling operations, pressure supplied by the aircraft pumps will open the dual pressure relief valve to allow the normal defueling operation. It also provides a thermal relief for the hydrant lateral piping when all valves are closed. When the refueling pumps are started the solenoid is energized, locking out the low pressure relief control which then puts the valve under control of the high pressure relief control. For additional operating details refer to the manufacturers manuals.

c. **Pressure Setting.** The dual pressure relief valve should be set to relieve at 3 to 5 psi above the normal refueling pressure when the refueling pumps are in operation and 5 psi when the refueling pumps are stopped. To adjust the pressure relief control, proceed as follows:

(1) Remove adjustment covers from both pressure relief controls and turn the adjustment screws clockwise until they bottom.

(2) With no hydrants open start the refueling pump and turn the adjusting screw on the high pressure relief control counterclockwise slowly until the relief valve starts to open. Observe valve position indicator to determine this point. Then turn adjusting screw in clockwise until the valve just closes.

(3) Lock the adjusting screw in position and replace the adjustment cover.

(4) Stop the refueling pump and turn the adjusting screw on the low pressure relief control counterclockwise slowly until the pressure in the hydrant lateral drops to 5 psi.

(5) Lock adjusting screw in position and replace adjusting screw cover.

(6) Remove adjusting screw cover on the CV flow control and adjust the *closing speed* to give smooth pulsation free operation.

(7) Lock adjusting screw in position and replace adjustment cover.

4-12. Pressure Relief Valve:

a. **General.** The pressure relief valve (figure 4-10) is installed in the hydrant lateral control pit between the refueling pipeline and the defueling line. Pressure relief valves are provided to relieve excessive pressures that might occur from a too rapid closing of a downstream valve, thermal expansion of fuel in a closed section of pipeline, and pumping against a closed valve.

b. **Testing.** All pressure relief valves should be tested for workability and accuracy at intervals prescribed in chapter 10, for testing the pressure relief valve (figure 4-10) use the following procedures:

(1) Block the section of piping protected by the pressure relief valve so that the upstream pressure can be relieved only by passing through the pressure relief valve. This is done by gradually closing the manual valve downstream from the refueling control valve with the system pressurized.

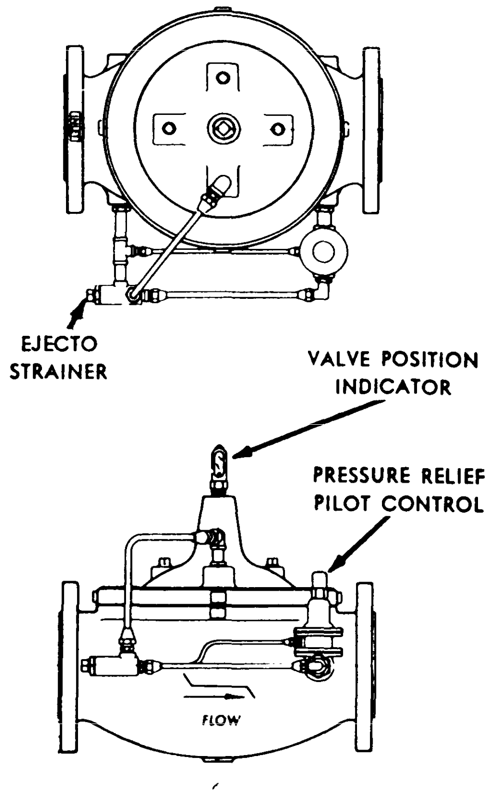


Figure 4-10. Pressure Relief Valve.

(2) Observe valve position indicator on top of the relief valve cover. The valve should open slowly and modulate to restore set pressure.

(3) Increase pressure in the upstream line suddenly to beyond the relief valve control setting by rapidly closing the manual valves downstream from the fueling valve. Relief valve should open wide immediately.

(4) Repeat above tests a minimum of five times. The relief valve must function smoothly, without evidence of binding or sticking.

c. **Pressure Setting.** Relief valves in hydrant systems should be set at 100 to 125 psi or 10 psi above hydrant head pressure. To adjust the pressure relief valve, proceed as follows:

(1) Remove adjustment cover on the pressure relief control and turn adjustment screw clockwise until it bottoms.

(2) Block off the section of piping protected by the relief valve and establish desired opening pressure on the valve.

(3) Turn adjusting screw counterclockwise slowly until relief valve begins to open. Observe valve position indicator to determine this point.

(4) Lock adjusting screw in position and replace adjustment cover.

d. **Maintenance:**

(1) Relief Valve Fails to Open. Failure of the relief valve to open can be caused by clogged control tubing, pressure relief control stuck closed, or main valve failure. Remove and check all tubing for obstructions. Consult manufacturer's manual for pressure relief control and main valve overhaul.

(2) Relief Valve Fails to Close. Failure of the relief valve to close can be caused by broken or leaking tubing, clogged strainer-orifice, clogged cover chamber tubing, pressure relief control stuck open, or mechanical obstruction in main valves. Inspect tubing for looseness or breaks. Clean strainers and cover chamber tubing. Consult manufacturer's manuals for pressure relief control and main valve overhaul.

(3) Pulsations. Pulsation is caused by air in the cover chamber. Loosen plugs on top of cover or plug on top of VPI to bleed air.

(4) Relief Valve Fails to Open Fully. Failure to open fully is usually caused by defective "O" ring packing in the strainer orifice assembly as shown in figure 4-11. Replace "O" ring packing according to the manufacturer's instructions and ensure proper seating of strainer and "O" ring packing.

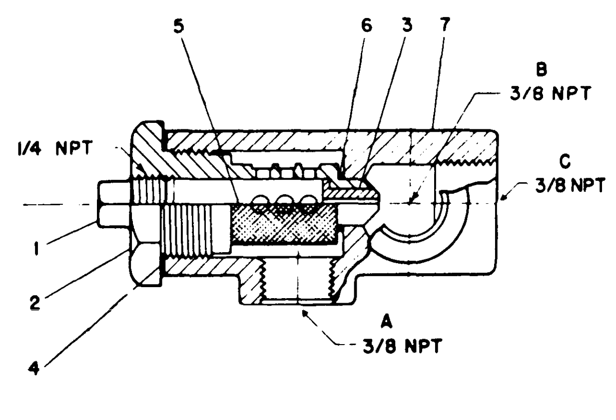


Figure 4-11. Strainer Orifice.

4-13. Defueling Pump:

a. Use. The defueling pump is installed in the hydrant lateral control pit and is used to pump fuel from the aircraft into the operating storage tanks installed at the pumphouse or separate defueling tank. This pump is controlled by the defueling switch at the hydrant outlet.

b. Description:

(1) Self-Priming Centrifugal Defueling Pump (figure 4-12). The pump differs from a standard centrifugal pump in that a vane type pump is mounted on the pump shaft. When the main pump discharge pressure is below 10 psi, the priming pump is in the priming position as shown in figure 4-12. The priming pump then draws from the section side of the pump and discharges at a point downstream from the check valve, thus priming the centrifugal pump. When the main pump discharge pressure reaches 10 psi, the priming pump moves into the neutral position.

(2) Vane Type Positive Dispalcement Defueling Pump. This pump is constructed essentially as shown in figure 2-2. The rotor contains six nonmetallic sliding vanes actuated by push rods. The pump shaft is connected through a helical reduction gear to the electric motor.

c. **Maintenance:**

(1) Self-Priming Centrifugal Pump. Maintenance procedures given in paragraph 2-4 apply to this pump. The priming pump, not covered in paragraph 2-4 will require little maintenance; however, if pump fails to prime, proceed as follows:

(a) Check to be certain that priming pump is not sticking in the neutral position.

(b) Replace any vanes that are broken or chipped.

(c) Check the built-in check valve on the discharge side of the centrifugal pump to be certain it is not sticking in the open position.

(2) Vane Type Positive Displacement Pump. Maintenance procedures given in paragraph 2-4 apply to this pump.

4-14. Remote Controls (Electrical and Magnetic):

a. Electrical. (Right side of figure 4-13.) Portable remote control stations (Hydrant System II), with cable attached, for fueling operations has two push-button switches with an overall integrally molded neoprene (polychloroprene) jacketed housing, and a three- or four-pole plug on the other end of the cable for plugging into the fueling receptable on the watertight combination electrical pull and receptacle box at each fueling point. A similar type cable with three push button switches and a four- or five-pole plug is used for defueling operations. This cable is plugged into the defueling receptacle of the combination electrical pull and receptacle box at each fueling point. When not in use, both fueling and defueling control stations (and cables) usually are placed and kept in the pumphouse. Inspection and replacement of the fueling and defueling switch cable assemblies are the responsibility of the civil engineer.

b. Magnetic. (Left side of figure 4-13.) The electrical portable remote control stations (Hydrant System II) with cable attached, are being replaced with magnetic controls. Installation instructions have already been issued to the field. This modification replaces refuel and defuel control cables and the female sockets in the electrical apron receptacle cover with sealed weatherproof magnetic switch assemblies, and a portable magnet with a lanyard cord attached. The emergency stop switch is also replaced with a magnetic switch. The cover for the emergency stop switch is replaced with a new cover with a built-in magnet.

(1) To operate refuel or defuel pumps, it is only necessary to place the magnet on the two reference

points (rivet heads) after the pumphouse has been properly set up for operations.

(a) The horseshoe magnet may have a small hole through which a cord or lanyard is attached. (A small nylon parachute cord is recommended.)

(b) This provides a method for quick removal of the magnet that results in immediate stopping of pump operation.

★ (c) A small piece of wood can be used to prop open the spring loaded covers when using the magnet for refueling or defueling. The emergency stop switch is usually closed.

NOTE: The spring loaded covers over the refueling and defueling switches may be removed with no adverse effect.

(2) To activate the emergency stop switch, lift the emergency stop cover and release.

(a) After the emergency stop circuit is broken, manual reset is required at the pump house.

(b) Standard operating procedures (SOP) should be established to deactivate the pumps at the pump house when the system is not in use. This will prevent any unauthorized personnel with a magnet from starting the refuel or defuel pumps when system is not in use.

(3) The maintenance of these magnetic controls consists primarily of keeping the magnetic switch plates free of debris, water and ice. If at any time, the magnetic switches fail, they may be removed by prying the switchplate loose with a suitable tool.

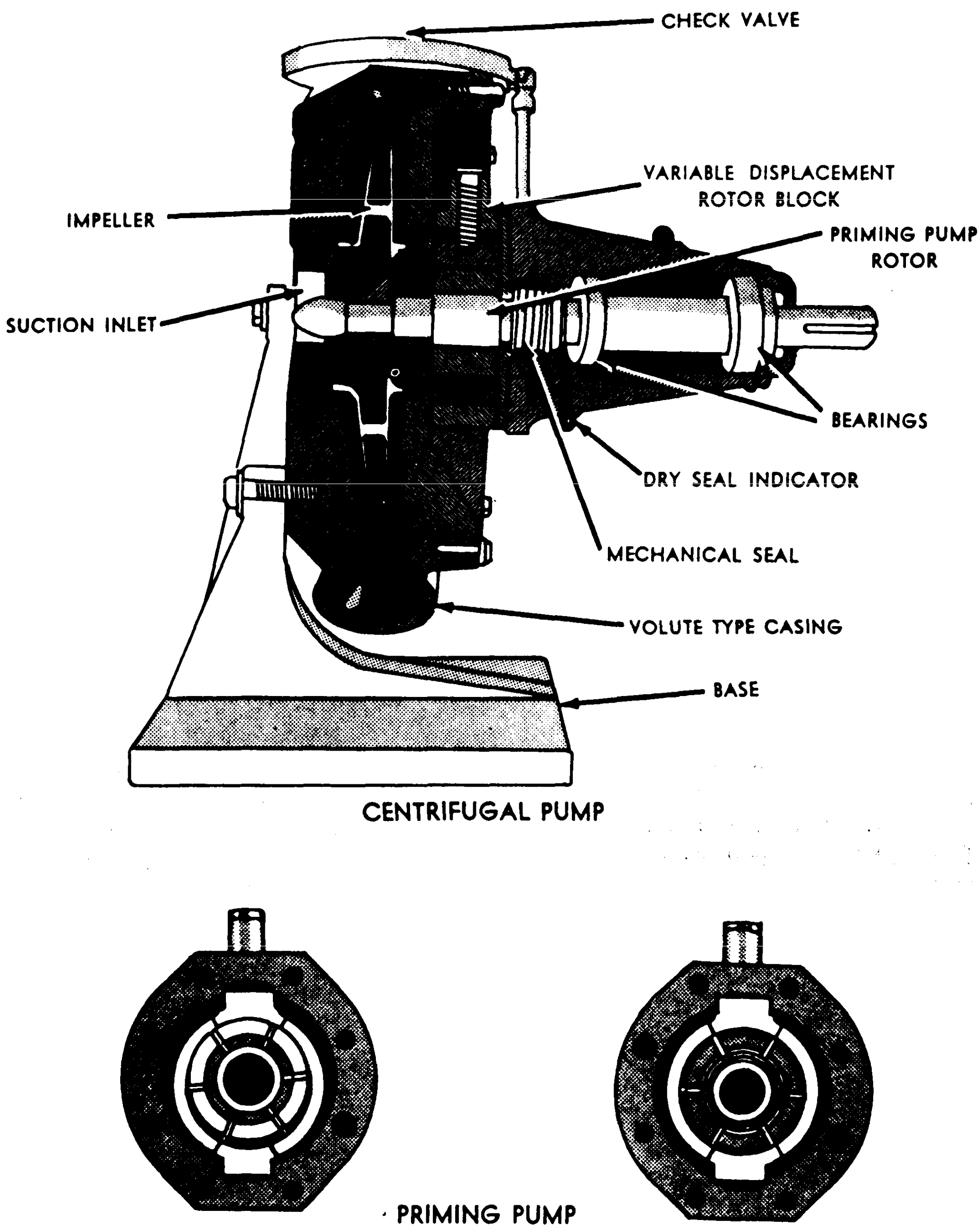


Figure 4-12. Self-Priming Centrifugal Pump.

(4) The magnetic switch wires are pulled up through the threaded hole until the butt-connections can be cut off and the insulation stripped.

(5) The new switch plate assembly should be tested with an ohmmeter and magnet before it is installed. If operative, connect the wires with a crimped on butt-connector and clean the sealing surface on the receptacle with sand paper or scrapers to remove all the old sealer.

(6) Apply new sealer as when originally installed, firmly place the switch unit on the outside surface of the receptacle opening and retain in this position until adhesive seal has cured.

NOTE: The reduced rate (50 GPM) for defueling is no longer connected and will not operate after the magnetic control switches are installed.

4-15. Fueling Hydrant Quick Coupler Valve:

a. General. The fueling hydrant quick coupler valve (see top view figure 4-14) is placed on the adapter permanently installed on the hydrant riser pipe. The quick coupler locks into position and is held securely by a self-locking device. This design affords fast attachment of the coupler and hose (components of the MH-2 series hose cart). Flow of fuel is possible only when the lever of the coupler is placed in the "open" position. When in this position, the coupler cannot be removed from the adapter. The lever must be in the "closed" position when attaching the coupler to the adapter.

b. Maintenance. Maintenance of the hydrant quick coupler valve (which, with its hose, is a component of the MH-2 series hose cart) is the responsibility of the Motor Vehicle Maintenance Shop. When existing inactive (blind flanged) laterals are activated on Type II systems, the BCE will procure both adapter and liquid level control valve and proper hydrant quick coupler valve. This ensures that mating valves are furnished for activation of the system. When new or replacement quick couplers are required (after initial installation) these quick couplers will be procured by the Motor Vehicle Maintenance Shop.

4-16. Adapter and Liquid Level Control Valve:

a. General. The adapter and liquid control are combined as a single unit. The adapter (lower view figure 4-14) provides a quick, pressure-tight connection between portable hose equipment and the permanently installed underground piping. The liquid level control valve controls the level at which fuel is maintained in the piping at the end of defueling operations to prevent entrance of air into the piping system.

NOTE: Hydrant fueling systems (Type II Systems) at some bases with KC-135 jet tankers assigned have been modified by Project "Rapid Flo." Such modifications affecting the adapter and liquid level control, where accomplished, negate some of the following information in this paragraph because the float assembly is removed from the control.

b. Operation. During fueling operations, the float assembly is lifted from its seat by operations, the float chamber fills with fuel and the float rises to

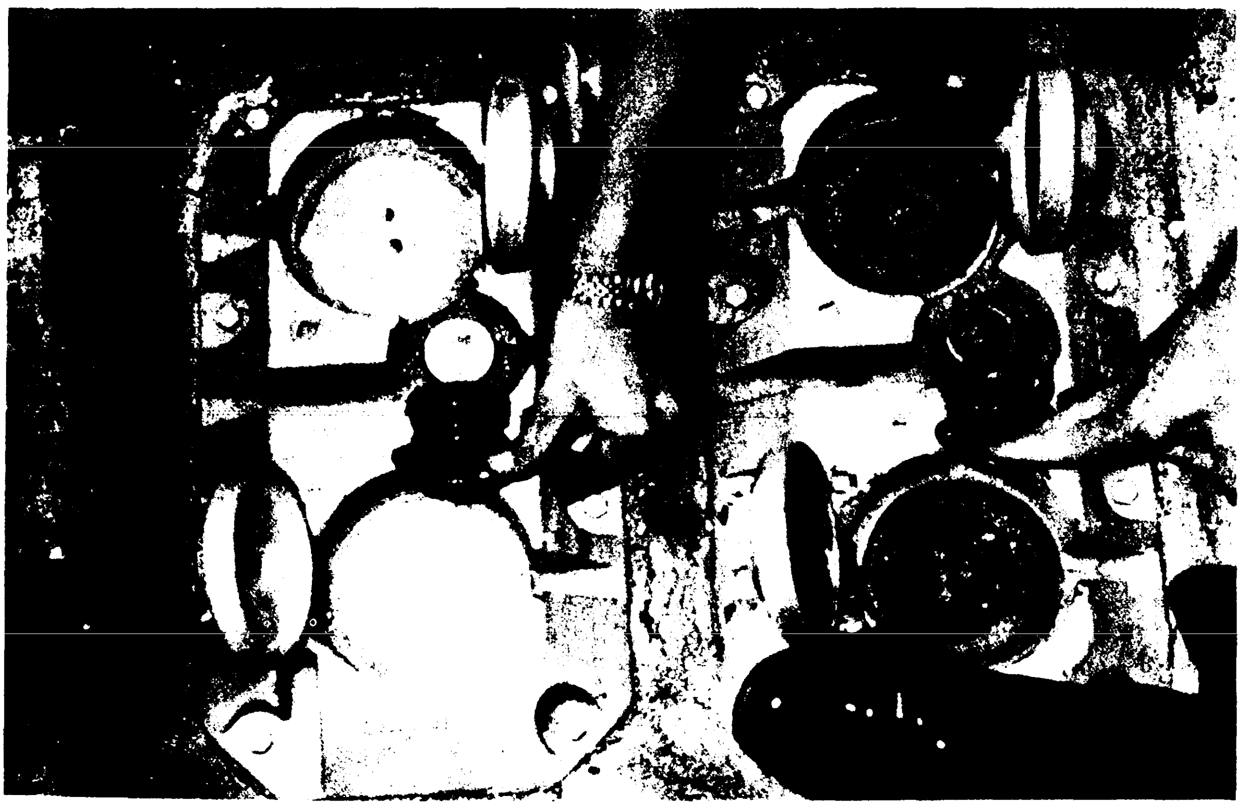


Figure 4-13. Magnetic Remote Pump Control Station.

1. Handle
2. Groove pin
3. Lever
4. Gasket
5. Lock spring
6. Sleeve
7. Ball (½-in. dia.)
8. Bumper
9. Ground cable
10. "O"-ring
11. Push rod
12. Disk retaining ring
13. Disk
14. Seat
15. Dust plug
16. Stop ring
17. Seal
18. Poppet spring
19. Poppet
20. "O"-ring
21. "O"-ring
22. Outer cam
23. Cam spacer
24. Bearing
25. Shaft
26. Groove pin
27. Center cam
28. Bushing
29. Roll pin
30. Locking plunger
31. Locking spring
32. Cover
33. Seal
34. Gasket
35. Seat
36. Disk retainer ring
37. Poppet
38. Dust cover
39. Lower body
40. Stem
41. Disk
42. Gasket
43. Disk retainer
44. Seat
45. Spring
46. Gasket
47. Upper body
48. Lockwire
49. Outboard stop
50. Coupling ring
51. Bumper
52. Ball (½-in. dia.)
53. Poppet disk
54. Spring
55. Sleeve
56. Plunger
57. "O"-ring
58. Snap ring
59. Bushing
60. Washer
61. Seat
62. Retainer
63. Adapter
64. Plate
65. Float ball

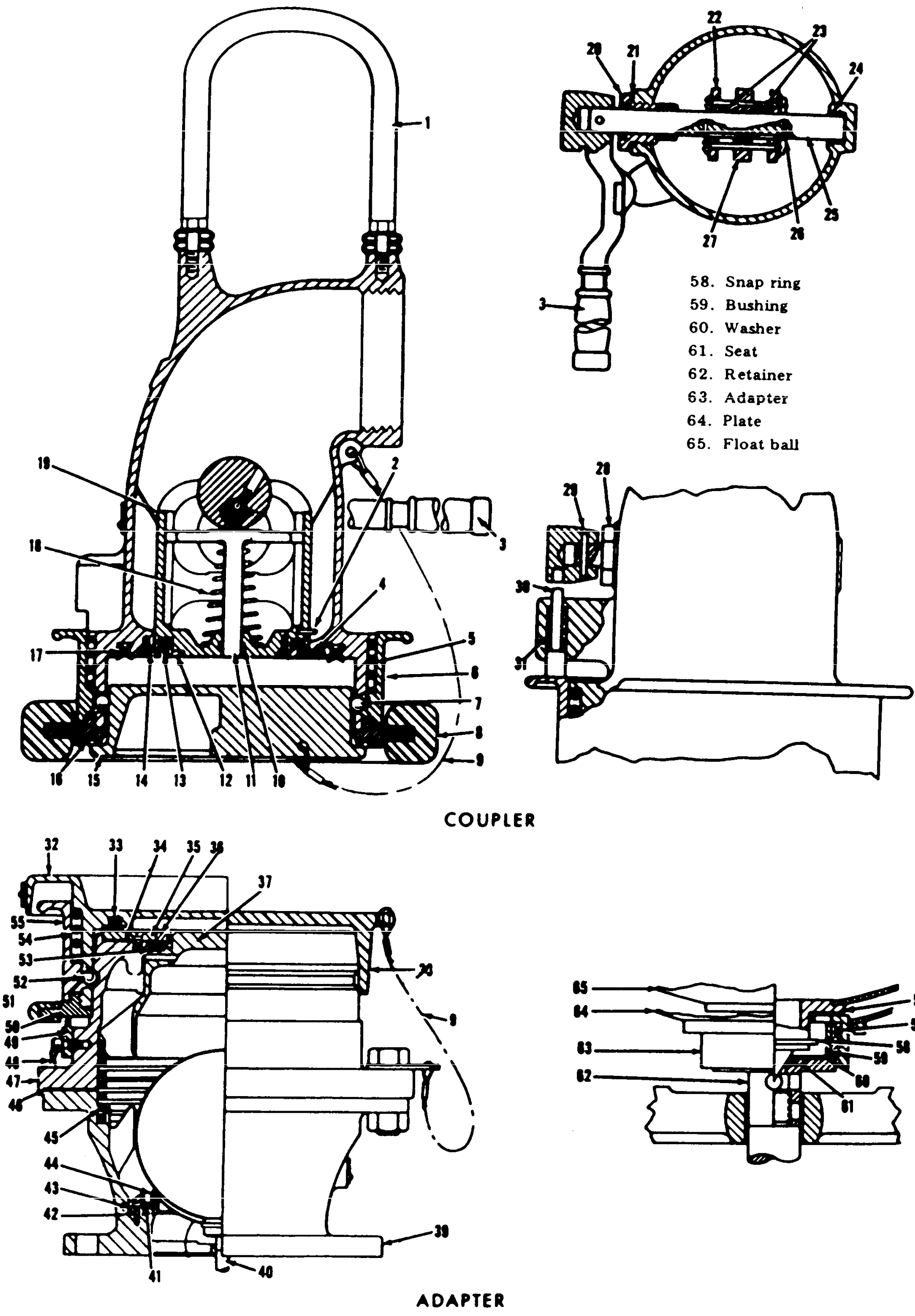


Figure 4–14. Hydrant Quick Coupler Valve and Adapter With Liquid Level Control.

open the valve. At the end of the defueling operation, the float chamber drains and the float drops to close the valve and prevent air from entering the system.

c. **Maintenance.** The primary cause of trouble will be entrance of dirt and foreign matter fouling the disks, seats, and seals. Whenever the quick coupler valve is uncoupled from the adapter, be sure dust covers are replaced. Consult manufacturer's manuals for disassembly and replacement of parts.

(1) Valve Fails to Permit Fueling When Poppets are Open. This condition is caused by the float valve assembly being in closed position. Be sure float chamber is full of fuel and under pressure. If problems continue relieve pressure and then disassemble float assembly to locate cause of sticking.

(2) Float Valve Fails to Shut Off. Failure of the float valve to close can be caused by defective float seat, leakage through defective gaskets around the float seat, and obstruction in the lines and orifices leading to the float chamber. Remove valve and attach a coupler equipped with fitting to permit loading the valve with 20 to 25 psi air pressure. Apply soap suds around all sealing points around the valve and apply air pressure to determine source of leak.

(3) Bypass Valve Fails to Open. Failure of the bypass valve (located on the side of the adapter and level control valve) to open is evidenced by failing of the float valve to open during defueling operations. Be sure float valve is filled with fuel and wait 20 seconds to make sure pressures above and below the float valve are equalized. If the bypass still fails to open, disassemble the bypass valve.

NOTE: A replacement poppet kit is available for the Cla Val 352AF hydrant adapter. This kit should be installed on all these adapters to preclude a sticking problem encountered with the orignal poppet. It will be stamped as MOD-1 on the poppet face.

Chapter 5

PRESSURIZED HYDRANT FUELING SYSTEM, TYPE III (PHILLIPS)

Section A—General

5-1. General Information. This is the latest hydrant fueling sytem to be added to the Air Force inventory. It uses many new components that are similar to the ones covered in the preceding chapters under Type I and Type II systems. The Type III system is designed for a minimum flow rate of 1,200 gpm to a maximum of 6,000 gpm. This system continually monitors the fuel passing through it and will shutdown automatically in case of contamination due to water or solids. See figure 5-1 for a typical pressurized system that also identifies the various components of this system. Maintenace of those components in this sytem not common to those in systems I and II is done according to the manufacturer's guidance until standards can be developed.

Section B—System Components

5-2. Storage Tanks. (See figure 5-1, item 1.) The storage tanks constructed for the Type III hydrant system are the cone roof, with floating pan type tank. Bulk storage tanks are used directly as operating tanks when the distance from the fueling apron to the tanks is less than 1 mile. In this case, the bulk tanks must be modified as required to conform to the latest standards for operating tanks. Operating storage tanks are used when the distance from the fueling apron to the bulk storage area exceeds 1 mile. Two tanks are required for each hydrant fueling system. They are sized according to the system capacity:

a. 1,200 through 2,400 gpm—Two 2,500 bbl tanks.

b. 3,000 through 4,200 gpm—Two 5,000 bbl tanks.

c. 4,800 through 6,000 gpm—Two 10,000 bbl tanks.

5-3. Low Level Shutoff. (Not shown in figure 5-1.) The operating storage tank is equipped with a low level shutoff switch, and when the fuel level reaches a predetermined point (approximately 1 foot 6 inches) a controller shuts down all fueling pumps.

5-4. High Level Shutoff. (See figure 5-1, items 3 and 4.) The operating storage tank is equipped with a high level control valve (4) and float assembly (3). When the fuel level in the tank reaches a predetermined point, the valve closes and stops the flow of fuel through the inlet line. The valve used is a remote control valve.

5-5. High Level Alarm. (See figure 5-1, item 2.) The high level alarm is installed on the tank to give warning in case the remote control valve fails to cut off the flow of fuel into the tank. This alarm is a float-actuated mercury switch that sets off the alarm when fuel reaches a predetermined level.

5-6. Fueling Pumps. (See figure 5-1, item 5.) Refueling pumps for systems 1,200 gpm each and for systems over 2,400 gpm, have capacities of 1,200 gpm each. For aboveground operating tanks, they are centrifugal, horizontal split case, double suction volute type (similar to the Peerless centrifugal pump). For underground operating tanks they are vertical turbine pumps. A minimum of two pumps must be provided for every hydrant fueling system.

5-7. Filter Separators. (See figure 5-1, item 8.) Filter separators are provided on both the inlet and outlet side of all storage tanks, except that the inlet filter separator may be omitted in noncorrosive systems when the fuel is filtered before entering the bulk storage tanks. The capacity of the entering filter separator should be 1,200 gpm, while the fueling filter separators should have the same capacity as the fueling pumps. The rate of flow and check control valve (9) is installed on the discharge piping of the filter separator. Notice that the fuel discharge rate of flow, check and shutoff valve (10) installed on the entering line has an additional component that is a solenoid. This solenoid closes the main valve when the contamination monitor in the system senses contamination leaving the filter separator.

5-8. Nonsurge Check Valve. (See figure 5-1, item 6.) This valve is very similar to the nonsurge check valve covered under Type I and II systems. The only difference between the two valves is the use of hytrol check valves in place of the two swing check valves. This check valve is used throughout the system.

5-9. Manual (Block) Valves. (See figure 5-1, item 7.) The main type manual (block) valve used on this system is the ball valve. It will be noticed that there are block valves located throughout the system. You may find a butterfly valve used as a block valve in this sytem.

5-10. Emergency Shutoff Valves. (See figure 5-1, items 11, 18, and 21.) There are three automatic valves located in the system that are classed as emergency shutoff valves. They may have other functions that are covered later in this chapter. These valves are the solenoid control valve (with differential control feature), (11); solenoid control valve, (18); and the rate of flow, check, and solenoid valve (21).

5-11. Refueling Loop. (See figure 5-1.) The refueling loop located on the flight line is a continuous pipeline that makes a full loop from the storage tank around through the hydrant outlets and back to the storage tank. The refueling points are installed in pairs. By this we mean there are two hydrant outlets very close to each other. Each hydrant point has a refueling hydrant control valve (16) and a fuseable link butterfly valve (15) that closes in case of fire.

5-12. Back Pressure (Defueling) Valve. (See figure 5-1, item 12.) The back pressure control valve is held closed during refueling and requires no electrical cords for defueling. This valve is the combination back pressure and solenoid shutoff valve.

5-13. Back Pressure and Check Valve. (See figure 5-1, item 14.) The back pressure and check valve relieves pressure in the system at a predetermined pressure.

5-14. Pressure Pump. (See figure 5-1, item 13). The pressure pump is a small 70 gpm, inline, centrifugal pump that maintains pressure on the fuel system at all times. (Not required on all systems).

5-15. Pressure and Flow Switches. (See figure 5-1, items 20, 23, and 19). The pressure switches (20 and 23) start the selected fueling pump or the pressure pump at a predetermined pressure. The flow switch (19) will lock on the lead pump at a predetermined rate of flow.

5-16. Strainers. (See figure 5-1, item 17). The strainer in the inlet line is a basket strainer of 100 mesh.

5-17. Product Recovery System. (See figure 5-1, item 24). Product recovery systems are provided at each operating tank. Each system is connected to the operating tank water drawoff line and includes a tank, product recovery pump, and all necessary pipe, valves, and fittings. (Also see paragraph 2-6).

5-18. Operation of the Type III Hydrant System. See figure 5-1 for referenced items. The Type III hydrant system is a pressurized system. When there are no refueling or defueling operations in progress, the system pressure is maintained by the pressure pump. When the pressure drops below a preset pressure, the pressure switch (23) energizes the pressure pump (13), and the pump maintains system pressure between 67 and 75 psi. If there should be excess pressure (above 75 psi) while the system is idle, the pressure and check valve (14) opens and relieves pressure back to the suction of the fueling pump. This valve is set to open at 76 psi and above.

a. **Refueling.** When the special refueling vehicle is connected to one or two of the hydrants and the refueling control valve (16) is opened, the pressure within the system drops. The pressure switch (23) closes the contacts in the selected refueling pump circuit and starts the refueling pump (5). The lead pump (first refueling pump to come on) should be rotated among the pumps because the lead pump usually operates more than the others. The lead pump starts the flow of fuel through the system and when it reaches its maximum flow rate, the second pump is started by one of the flow switches (19). When the second pump reaches its maximum flow rate, the third pump is started by one of the other flow switches (19). During operation, the solenoid control valve (with differential control feature) (11) is energized and the valve opens. The solenoids of the combination back pressure and solenoid shutoff valve (12) and the solenoid control valve (18) are also energized. The combination back pressure and solenoid shutoff valve is held closed while the solenoid control valve is opened. When refueling has been completed and the demand for fuel is lower, the flow switches open the circuits to the pumps they are controlling. The lead pump will not cut off until the fuel flow drops to 25 gpm or below. Any flow of 25 gpm or below is handled by the pressure pump.

b. **Defueling.** When the refueling vehicle is connected to the hydrant and its pumps are started, fuel will pass through the combination back pressure and solenoid shutoff valve (12) when the pressure in line reaches 80 psi. You will notice that fuel will enter the tank through the normal discharge line. This is why the tank high level alarm (2) is important and must be in good operating condition. Fuel will not pass through the high level shutoff valve (4) during defueling.

c. **Circulating.** When the system is to be circulated, all other operations cease. First select the pump to be used for this operation. There will only be one pump required because the rate of flow, check and solenoid valve (21) restricts the flow to 600 gpm. The manual valve (22) is opened. (This valve is usually closed and the manual valve on the loop will be closed.) The size of the lines determines the time it takes to completely circulate the fuel in the system.

Chapter 6

PRESSURIZED HYDRANT (HOT) FUELING SYSTEM, TYPE IV

Section A—General

6-1. General Information. This system is just a modified version of the Type III Pressurized Hydrant Fueling system. It uses many of the same components used in the Type III system. The most noticeable difference between the systems is the method used to dispense the fuel at the outlet. The Type IV system uses the pantograph method (see figures 6-1 and 6-2) instead of the special refueling vehicle mentioned in paragraph 5-18a. Other differences may also exist between the Type III and IV systems, such as the type and size of storage tanks used and the following design, inspection, and maintenance requirements.

a. Positive mechanical exhaust type ventilation for pits more than 6 feet in depth is not required when pits are provided with rolling pit covers and can be fully opened. If repair work inside the pits is required, the LFM personnel perform a vapor test to ensure that the LEL content is at a safe level. Personnel will also have the oxygen level checked to ensure that it is greater than 19.5 percent. Entry will not be made without air supplied respirators if the vapor concentration is greater than 4 percent of the LEL.

b. Recalibration of differential pressure gages on filter separators of piston type is done once a year by LFM personnel. The only adjustment necessary is to realign the inch and metric scale with the zero mark.

c. The draining of sediment or water from system meters is not required.

d. Recalibration of Smith type meters is done every 2 years by LFM personnel according to the manufacturer's service handbook, or at any time their performance is doubtful.

e. Requirement for emergency shower or eyebath (as specified in AFM 161-30) is changed to a portable eyebath kit available through local base supply channels. The eyebath kit should be mounted on the stairway wall inside the electric control room to avoid freezing of the water in the winter time. Frequent inspections to make sure that the bottle contains enough water is made by the operator personnel.

f. Inspection of the electric emergency cut-off switches for proper functioning is made by LFM personnel once a month.

g. Inspection and maintenance of the AIR-hydraulic operated dead-man controls in the refueling pits, also pumps and controls inside the electric room are performed by LFM personnel once a month according to the manufacturer's instructions.

h. Line strainers equipped with differential pressure gages will only be opened and cleaned by operator personnel when the differential pressure has reached the maximum of one bar (14.2 psi). Approximately every 6 months, operator personnel notify LFM personnel before the next opening of the strainer housing to make sure that LFM inspects the interior of strainer housing and the strainer basket when unit is opened.

Section B—System Components

6-2. Inspection and Maintenance Requirements for Pantograph Refueling Arm:

a. Inspection by operator. Before the first hot refueling operation of each day, do the following:

(1) Turn control circuit switch to automatic position.

(2) Connect the refueling nozzle to the nozzle tester and put the locking arm in the fueling position ("ON").

(3) Actuate air-controlled dead-man switch to pressurize pantograph (including the refueling nozzle) in the "ON" position, and make sure that nozzle pressure does not exceed 55 psi. If this pressure is exceeded one or both bypass valves in the pit may be "open". Both must be closed during all refueling operations.

(4) Check entire pantograph unit, starting from the flange where the loading arm connects with the vertical aluminum pipe stub, the metal swivel joints, pipes, hoses, adaptor and refueling nozzle. If there is any leakage, this refueling arm cannot be used for hot refueling until the problems are corrected.

b. Inspection and Maintenance by DE or LFM Personnel. The following must be done twice a month:

(1) Turn control circuit switch to automatic position.

(2) Connect the refueling nozzle to the nozzle tester and put the locking arm in the fueling position ("ON").

(3) Open both bypass valves located in the refueling pit (in the flow diagram these bypass valves are numbered with I 16 and I 17 for pit No. 1) to pressurize the entire refueling arm. If the pressure gage on the nozzle tester remains below the 7-bar (99 psi), operate the deadman switch to turn on one pump to pressurize for a few seconds until the 7-8 bar (99-113 psi) is reached. REPEAT THIS PRESSURIZING THREE TIMES.

(4) Carefully inspect nozzle, adaptor, hose, swivel joints, and flanges and repair or replace all wornout parts (for the refueling nozzle, a TO with assigned number 37 A6-7-1 is under preparation). The area adjacent to the nozzle and adaptor could be a source of hose failures; therefore, the hose in

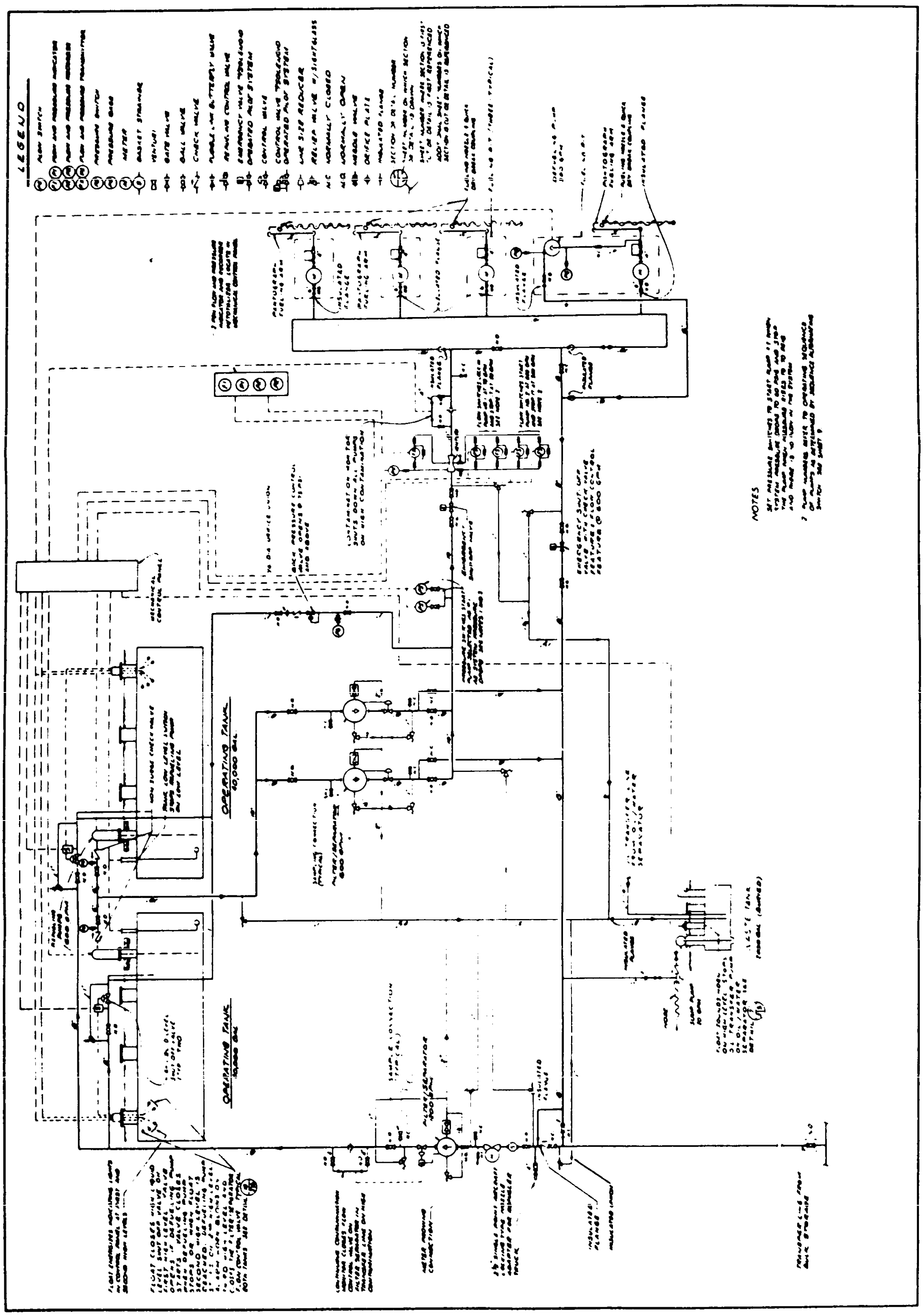


Figure 6-1. Type IV Pressurized Hot Fueling System.

back of the adaptor will be carefully examined with the thumb to detect any soft spots. Soft spots are cause for replacement.

(5) Swivel joints are not lubricated. In case of leakage take swivel joints apart, clean, and then put back together. Leakage or seepage can usually be eliminated by this method.

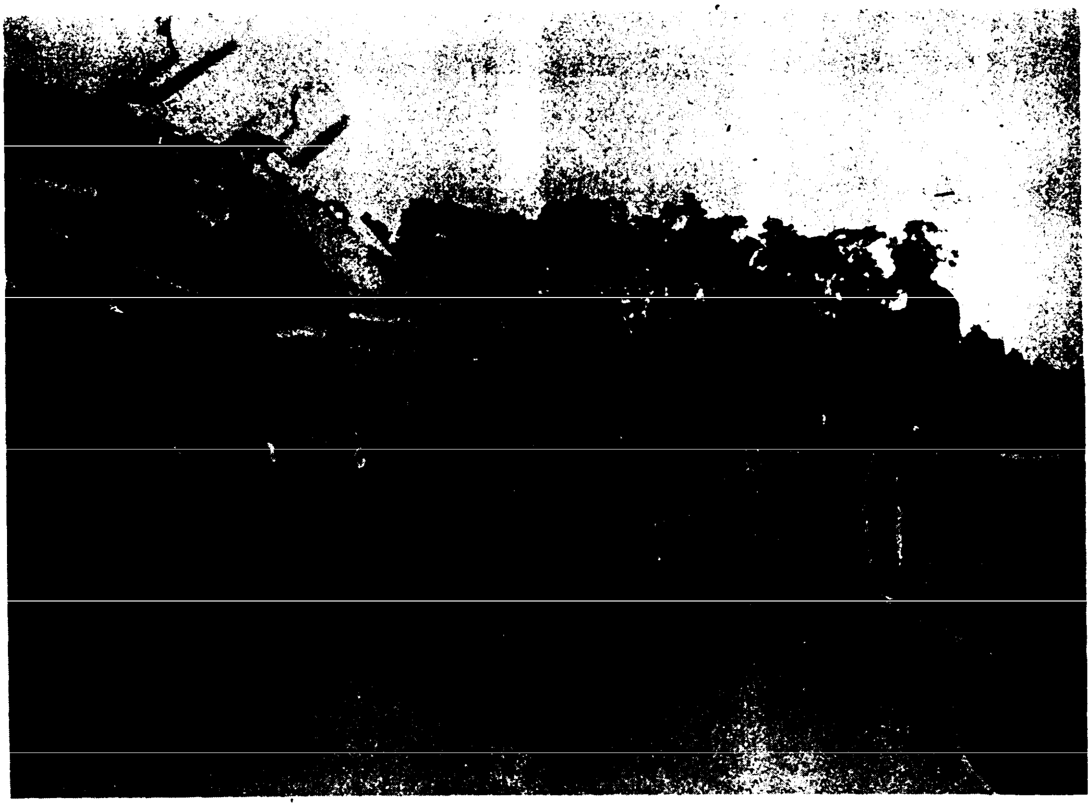


Figure 6-2. Type IV Pressurized Hot Fueling System, Pantographs.

Chapter 7

MECHANICAL SYSTEMS (CONVENTIONAL TYPE)

Section A—General

7-1. General Information. Mechanical petroleum storage and dispensing systems consist primarily of tanks located either on the surface or underground; and an electrically operated pumping system and piping installations for the receipt of fuel from tank cars or tank trucks and the issue of fuel to tank trucks. Receipt of petroleum will ordinarily be by force of gravity to underground tanks, and by pump for surface tanks. Issue of product is made by an electrically operated pumping system, remotely controlled from a central control system. The electrical system has adequate safety features as an integral part of design and construction. If properly maintained and operated, the system will present no hazardous problems. The piping sytem is simple in design and requires only a reasonable amount of attention and maintenance to prevent dangerous operating conditions. For specific description and maintenance details of mechanical system components, refer to other paragraphs as noted below:

a. Tank cleaning preparations (chapter 11).

b. Tank truck and transport unloading (chapter 2, section A).

c. Pumps (paragraph 2-4).

d. Vapor lock (paragraph 2-4).

e. Belowground and aboveground storage (paragraph 2-7).

f. Plug valves (paragraph 2-29).

g. Line strainer (paragraph 2-33).

h. Air eliminator (paragraph 2-34).

i. Pressure relief valve (paragraphs 4-12 and 10-16i).

NOTE: Aqua systems are not permitted for dispensing aviation fuels. Aviation fuels must be dispensed by a mechanical system.

Section B—Motor Vehicle Fueling systems

7-2. Motor Vehicle Fueling System. Motor vehicle fueling systems (figure 7-1) are usually designed to dispense one grade of fuel from an underground storage tank through a service station type dispenser to a vehicle, or to a multiple outlet system serving several dispensing outlets. Separate systems are used for each grade of fuel dispensed. The dispensing units are purchased separately for each base. Therefore, your base could possiblyhave several different name brands of dispensing units installed. Some dispensing units are plain in appearance, and they record only the number of gallons delivered. Other units of more modern design show the price as well as the number of gallons. The dispensing rate is usually based on 10-15 gpm per outlet for passenger cars and up to 25 gpm per outlet for trucks and buses. The only source of detailed information that is available on the various dispensers are the manufacturer's instructions. Due to the numerous models and types of dispensers that are available, only general information on them is covered in this section.

7-3. System Components:

a. Pumps. The pump assembly used can be either located in the dispenser unit itself or it can be of the submergable type that is located in the tank. The actual working pressure varies depending on the model and type of dispenser used.

b. Meters:

(1) Description. The meter is generally a four cylinder positive displacement type designed especially for use in gaoline dispensing pumps. Under normal use it requires very little attention.

(2) Maintenance and Repair. The meters are kept according to the manufacturer's instructions. Repair or replacement of parts is usually handled by the manufacturer.

(3) Test and Adjustment Meter:

(a) To ensure efficient operation on newly installed pumps, all air must be completely expelled by circulating 20 or more gallons of liquid through them. After this has been done, the built-in air release ensures efficient and accurate operation.

(b) Generally, there is no adjustment provided in the computer for correcting measurement; if any adjustment is necessary, it is normally made in the meter. The meter is tested with liquid in measures approved by the Department of Weights and Measures before being shipped and is then sealed as correct. After installing, no adjustment should be necessary. Meters should be calibrated at intervals described in chapter 10 using a 5-gallon measurer certified by the local Department of Weights and Measures.

(c) To adjust, follow the manufacturer's instructions.

(d) Meters are considered satisfactory for further operation when the error of the meter does not exceed 0.2 percent of the total quality delivered. This will amount to 2 to 3 cubic inches on a 5-gallon test run. (0.2 percent of 5 gallons equals 2.31 cubic inches.)

(4) Check and Relief Valve Assembly. The check and relief valve functions in two ways. It holds liquid in the discharge portion of the unit and also relieves any excess pressure from expansion of liquid above check valve.

Section C—Truck Fillstands

7-4. General Information. Air Force bases handling

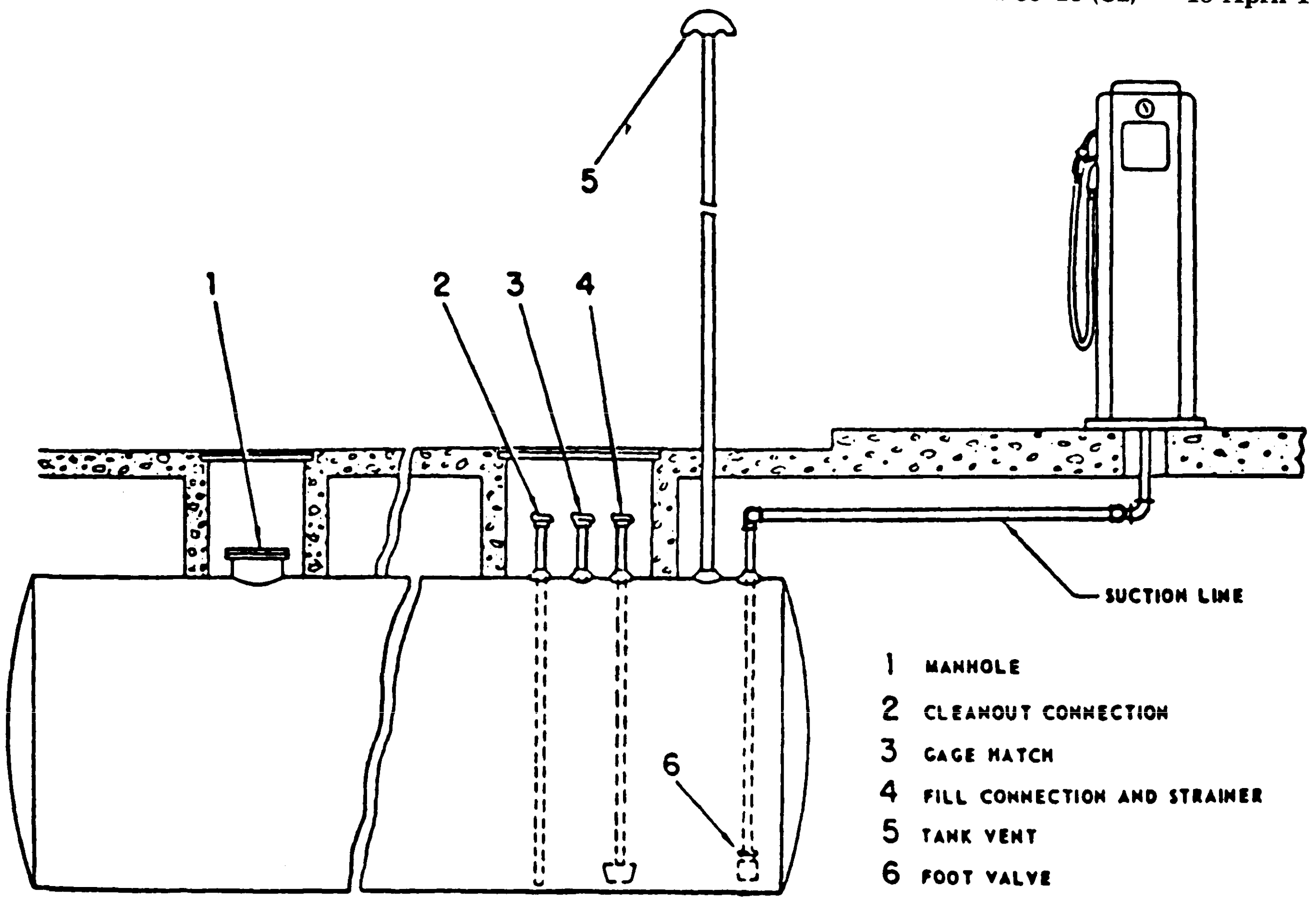


Figure 7-1. Diagram of Service Station Tank and Pump Installation.

bulk petroleum products will require facilities for issuing fuel to refueler trucks or tank trucks. The fuel products to be dispensed are usually JP-4, avgas, mogas, and diesel fuel. The number of simultaneous loadings required is determined by the command having jurisdiction from a study of the mission and operation requirements. A minimum of one and a maximum of four outlets will be provided for each grade of fuel.

7-5. Types of Stands. Bottom loading stands, top loading stands and combination top and bottom loading stands will be provided as follows:

a. Bottom Loading Stands. Bottom loading will be provided for all aviation fuel products (JP-4, JP-5, JP-7, JP-8, and avgas). This is essential to reduce turbulence and splashing and thereby decrease dangers from static electricity. Any existing top loading stands for aviation fuel must be modified immediately to permit bottom loading only.
NOTE: Those bases having a requirement to load out commercial vehicles not equipped with bottom loading in support of emergency war plans must request a waiver for their retention through command channels. Detailed instructions for such modifications are available from HQ USAF/LEEE. The loading arm is either a metal counterbalanced swivel type of aluminum or a stainless steel construction, or an approved rubber hose connected to the stand with a horizontal swing joint. For jet fuel, a drybreak coupler should be installed between the loading hose and single point nozzle. For avgas, a 3-inch, drybreak coupling nozzle with a quick disconnect swivel coupling is connected to the arm or hose. The single point nozzle for jet fuel must differ from the drybreak coupling nozzle for avgas to prevent accidental intermixing of products. The design flow rate for aviation fuel will be 600 gpm for each loading arm.

b. Top Loading Stands. Top loading stands will continue to be provided for all ground fuel products (mogas, diesel, and heading oils) with elevated platforms, metal counter-balanced loading arms and lever-operated loading valves. Arms will be of the stationary type. Do not use slide sleeves. The drop tube will be of sufficient length to reach the bottom of the tank and the discharge end will be cut at a 45-degree angle. The design flow rate for ground fuels will be 300 gpm for each loading arm. Fill rates for empty units will not exceed 3 fps until the downspout is submerged. All top loading fill stands should be modified as rapidly as possible for bottom loading capability. Before decision is made to install top loading fillstands, local air pollution standard must be considered.

c. Combination. Top and Bottom Loading Stands.

Combination type truck fillstands will be provided for ground fuels whenever completely new facilities are constructed. These stands include the features described above for both bottom and top loading. This permits the flexibility of loading from ground level if trucks are equipped for bottom loading or from the top if they are not. This applies to ground fuels only and in no case will top loading or combination top and bottom loading stands be provided for aviation fuel.

7-6. Meters. See chapter 2, section E, for description and procedures covering the maintenance of meters.

7-7. Strainers. See paragraph 2-33 for description and procedures covering the maintenance of strainers.

7-8. Swing Joints. Swing joints of a number of types and different manufacture are used on truck fillstands.

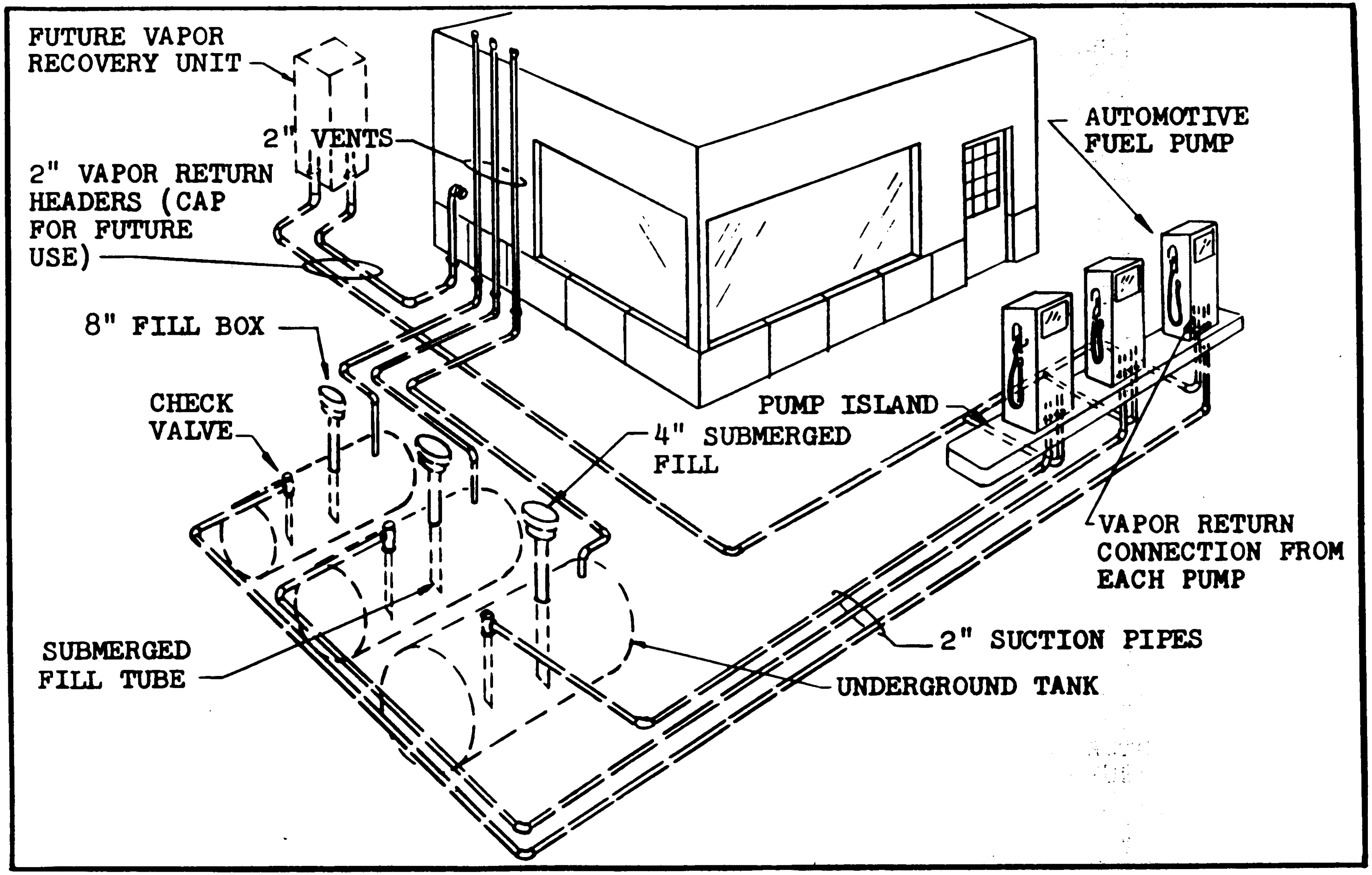


Figure 7-2. Motor Vehicle Fueling Station.

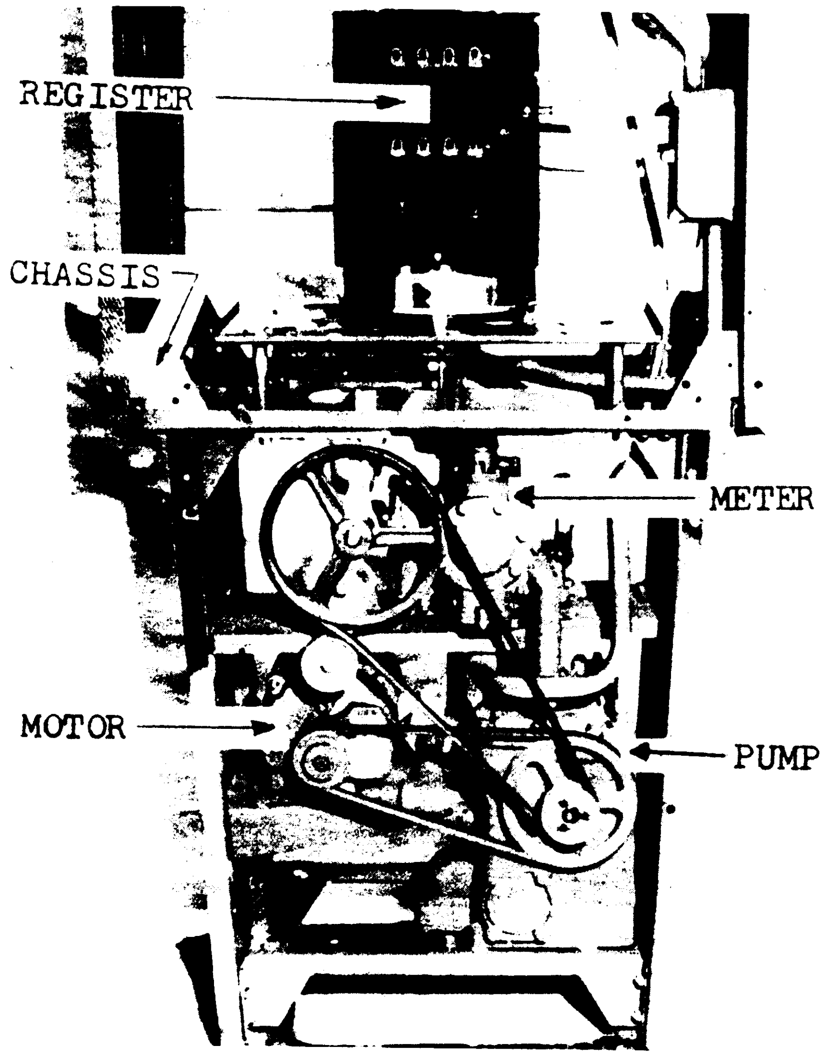


Figure 7-3. Components of a Commercial Type Automotive Pump.

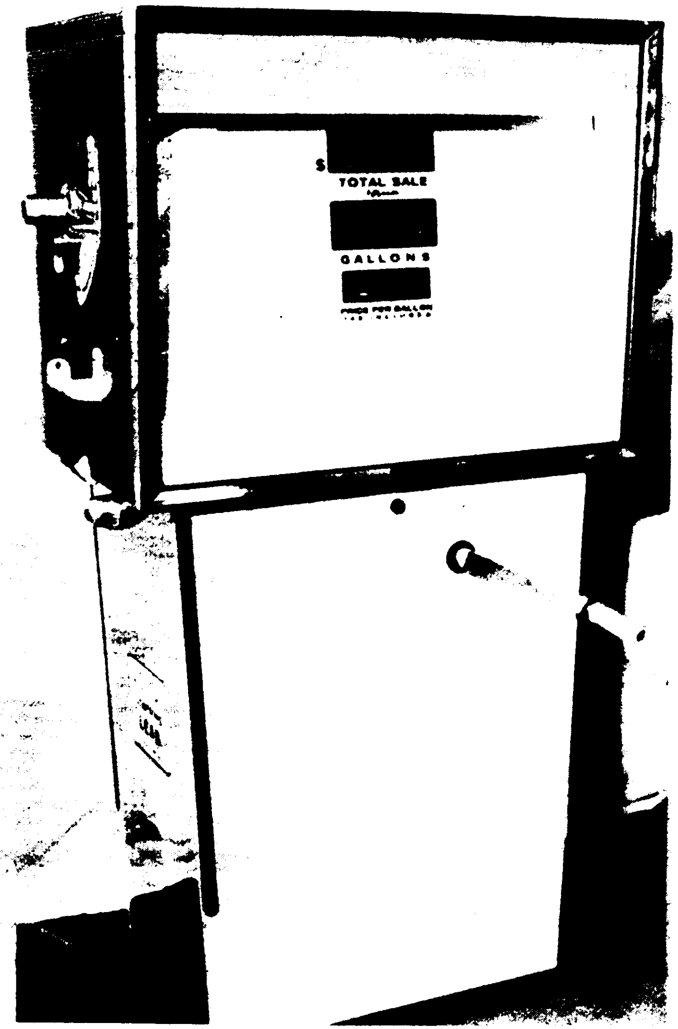


Figure 7-4. Service Station Type Computing Pump.

The following paragraphs contain information on replacement of packings in several types. Little if any maintenance will be required on swing joints other than lubrication and replacement of packings when leakage occurs.

a. **Ball Bearing Type With Plug Retainer (Grease Type):**

(1) Remove swing joint from fillstand riser pipe.

(2) Remove cotter pin and ball retainer. If grease is thick and heavy, pour lubricant solvent (recommended by lubricant manufacturer) into plug hole and rotate to grease. Turn joint so the plug opening will face downward; rotate male end of joint. Bearings can easily be removed. On removal of the ball bearings, the swivel members are released and the packing may be readily removed.

CAUTION: Extreme care should be taken when removing old packings, to prevent damage to the face of the packing chamber.

(3) The face of the chamber must be smooth and free of any roughness or cuts that will prevent lips of the packing unit from completely forming the necessary seal. All parts should be thoroughly cleaned and a thin coat of light grease or oil placed on the packing unit and the ball races. Insert packing in proper position.

(4) Place swiveling members in position and press together sufficiently to place one ball in each race. Balls may be started into their races by slowly rotating the male end of the joint and forcing the ball into position through the plug opening. The first two balls take up the squeeze against the packing. Continue rotating and feeding balls into races until they are filled. If difficulty is encountered when inserting the last few balls into the races, a soft punch may be used to tap them into position.

(5) Replace ball retainer plug, screw down on the balls and back plug off a quarter turn, replace cotter pin, and lubricate. Replace in position in pipeline.

b. **Ball Bearing Type With Cap Retainer (Packing Type):**

(1) Remove swing joint from fillstand riser pipe.

(2) Lossen and remove cap; remove nipple. Use care in removing nipple from joint housing to prevent loss of bearings in outer race. Remove bearings from inner race.

(3) Remove old packing and thoroughly clean bearings, retainer cap, nipples and joint housing. Check packing chamber for cuts and abrasions. Check retainer cap grease seal for condition and replace if required.

(4) Install new packing in packing chamber; place bearings in inner race. Install nipple. Place bearings in outer race. Install and tighten retainer cap. Lubricate joint with grease gun.

c. **Threaded Gland Type Swing Joints:**

(1) Remove packing gland setscrew. Back gland out of joint body. Remove nipple and gland.

(2) Remove old packing and thoroughly clean all parts of swing joint. Check packing chamber for scoring, cuts, or damage that would prevent sealing of the joint.

(3) Install new packing in chamber. Insert nipple and gland. Tighten gland down snugly against the packing and install set-screw.

d. **Bolted Type Swing Joints.** To obtain even pressure on the packing, spring-loaded bolts are used between gland and body of the swing joint.

(1) Remove swing joint from fillstand riser pipe.

(2) Loosen and remove nuts, bolts, and tension springs from gland and body. Remove nipple and gland.

7-9. Static Grounding. Fillstand grounding assembly, see figure 1-10 for details.

Chapter 8

PIPELINE SYSTEMS

Section A—Off-Base Pipeline Systems

3-1. General Information. Off-base supply pipelines are used to transfer petroleum products from oil field to refineries, and from refineries to air bases, terminals, and points of distribution. Usually these pipelines are owned, operated, and maintained by civilian concerns (except for government owned or leased pipeline systems) and will vary in size, construction, and operation. Additional factors influencing the operation and type of system are terrain features (underwater, above or below ground, road and railway crossing, expansion joints) and year of installation. This section will give a general decription of these type pipelines and operation and maintenance procedures that apply to most systems.

8-2. System Description. These systems consist primarily of the pipeline and a series of pumping stations. Pumping stations are made up of storage tanks, strainers, pressure regulators, scraper traps, valves, pumps, and power generated equipment.

a. Pipelines. Pipelines are constructed normally of 40-foot lengths of pipe welded together and either surface laid or buried. The diameter of pipe varies from 4 to 14 inches, depending on the designed capacity of the sytem. For a more complete understanding of the pipeline, a brief description of each step in the construction of pipelines follows:

(1) Planning. During initial planning, the most desirable route is determined from preliminary surveys and aerial photographs. Populated areas and rough terrain are avoided when possible. Existing rights of way (railroads, gas, electric, etc.) are used where practicable. A detailed survey is made for engineering data, and necessary rights of way are secured. Rights of way are usually 50 feet wide. The engineers determine exact route, elevation of pipeline, and location of the pumping stations.

(2) Site Preparation. After a complete survey has been made, the entire right of way is cleared. The necessary pipe is strung out along the right of way, followed by a ditching crew that excavates the trench for the pipe. The depth of the trench is not consistent, but, in general, the pipe is laid below the frost level (usually 3 feet).

(3) Pipe Laying. The pipe is aligned next to the trench and welded to form one continuous run of pipe. It is then cleaned of all rust, mill scale, dirt, and foreign matter; coated with enamel (A); coated with tar (B); and covered with spiral wrappings of asbestos felt, spun glass fabric, kraft paper, or similar material (C, D, E, F, G) as shown in figure 8-1. The protected pipe is lowered into the trench and covered.

(4) Special Terrain:

(a) Underwater. Normal pipelines are usually buoyant and require additional weight when laid under water. To prevent the pipeline from floating, a heavy gage pipe may be used, or additional weight may be added by encasing the pipe in concrete or installing heavy cast iron weighting devices.

(b) Aboveground. Sections of pipeline may be laid above ground when terrain condition dictates. Such conditions would include rivers with high currents and soft bottoms, rocky mountainous areas, and marsh or swamp lands. Supports for aboveground pipelines range from simple wooden supports to complex suspension devices spanning rivers and valleys.

(c) Road and Railroad Crossing. Pipelines laid under roads and railroads are usually in a steel casing to provide ease of removal and installing for repairs without disturbing the roadbed above the pipeline. The casing is 4 inches greater in diameter than the pipe and is usually sealed and vented at both ends. Saddles are installed in the casing to support the pipeline.

(5) Expansion Joints. Aboveground pipelines may be laid with a slack line or expansion loops to prevent damage from temperature changes. Aboveground piping in a tank farm or dispensing area is usually provided with sufficient changes in direction of the piping to absorb expan-

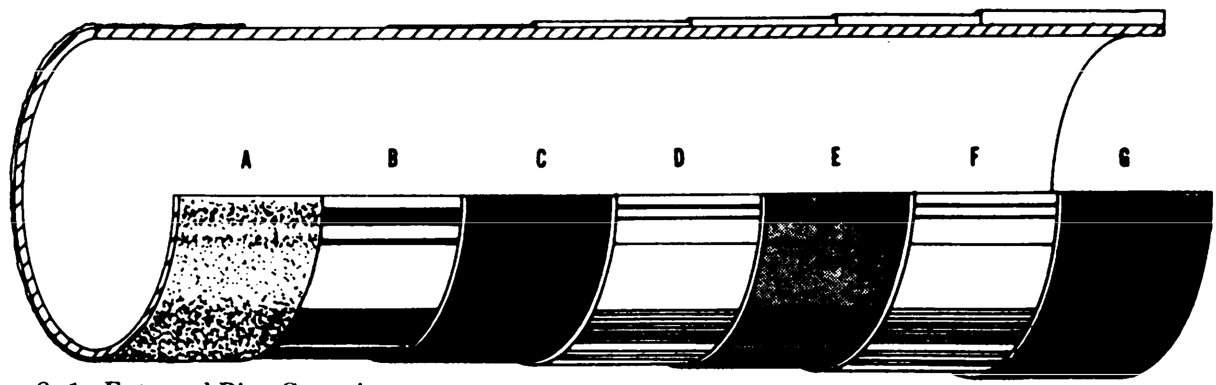


Figure 8-1. External Pipe Coverings.

sion or contraction of the piping due to temperature change. For short runs of piping, commercial type expansion joints are sometimes used to absorb expansion or contraction of the piping. Piping to these joints must be guided on both sides of the joint for proper alignment. The slip sleeve or bellows type expansion joints should be checked during routine maintenance inspection of pipeline for breaks or leakage through the packing. They should also be checked for misalignment and adequate flexibility to make sure they are properly protecting the equipment intended. Repairs must be made immediately.

b. **Pumping Station:**

(1) Storage Tanks. (Also see paragraph 8-3c). Three types of pumping stations are used to transfer petroleum products. The put-and-take operation incorporates floating roof, spheroidal, spherical, and lifter roof tanks. The float tank operation is similar to the put-and-take operation except that it incorporates a smaller tank called a float tank. The tight line operation is a closed system and pumps directly between pumping stations without the use of storage tanks. Storage tank description and maintenance are covered in chapter 2, sections C and D.

(2) Sand Traps. Sand traps are installed in the incoming stream of each cross country pipeline pump station to collect dirt, sludge, scale and floating debris pumped through the pipeline. The traps are fabricated from larger diameter pipe than the main pipeline and are installed in parallel to reduce the velocity of flow to permit debris to settle to the bottom. Sand traps are usually installed with a bypass valving arrangement, so the traps may be cleaned without stopping flow in the main pipeline. Sand traps should be cleaned after each scraper operation. Before cleaning, the sand trap should be isolated from the main pipeline, drained of product, then disassembled at the flanged or grooved connections. Screen installed in the downstream end of the trap should be thoroughly cleaned before reassembly.

(3) Strainers and Water Solids Separators. Strainers and water solids separators are placed in lines leading to pumps and meters. Strainers or solids separators are usually of the basket or self-clean type. Filter separators incorporate filter coalescer cartridges to remove water and solids from petroleum products.

(4) Valves:

(a) Plug and gate valves are used either fully open or fully closed and offer a completely open port with low resistance. These valves are used primarily in the main pipeline as shutoff valves and may be manually operated by hand-wheels, or electrically operated by motors controlled from the pump house. Gate valves are the only type valves that permit passage of the scraper during cleaning operations.

(b) Check valves are used in tank suction lines and pump manifolds to prevent reverse flow. Check valves used in pipeline operations are usually of the horizontal swing type instead of the diaphragm actuated type.

(c) Relief valves are used in higher pressure oil, compressed air, steam, and fuel lines to prevent rupture of the line in the event of excessive pressure. Relief valves are used on the pumping station equipment rather than in the main pipeline and are of the spring-loaded type.

(d) Globe and needle valves are used as throttling devices on the pumping station equipment. Their high flow resistance and obstructed port opening make them impractical for main pipeline use.

(5) Pumps:

(a) Centrifugal Pumps. The majority of pumps used in pumping stations are centrifugal pumps ranging from one to six stages per pump. Centrifugal pumps are often preferred because of their light weight, space saving, high flow rate, lack of vibration and line surge, and ease of maintenance.

(b) Reciprocating Pumps. Multicylinder double-acting pumps offer long service, high efficiency, and slight vibration. Because of their high initial cost, heavy construction, and increased space requirements, reciprocating pumps are used only where permanence is required.

(c) Rotary Positive Displacement Pumps. Rotary positive displacement pumps incorporate a pair of gears or cams revolving in opposite direction to force the liquid out through the discharge. There are no valves in these pumps; therefore, they are better adapted to handle viscous liquids (such as heavy oils). These pumps are limited to 500 gpm and 230 feet head.

(6) Surge Arresters. If the flow of liquid in a pipeline is suddenly stopped, an excessively high pressure is created instantaneously because the kinetic energy of flow is converted to pressure energy. The resulting shock often causes leaks and damage to connected equipment. A common device designed to decrease shock in pipelines is the air chamber. This type of surge arrester is quite effective but has the serious disadvantage that air and liquid are in constant contact under pressure. The air gradually becomes absorbed by the liquid; the effectiveness of the air chamber is destroyed. A more efficient type of surge arrester separates air from liquid by use of compressed air in an oil-resistant inner tube. Another type of arrester is divided into two parts separated by stainless steel bellows. The space between the bellows and the upper portion of the chamber is filled with oil and nitrogen gas under pressure.

(7) Power Generated Equipment:

(a) Steam. Steam is the oldest method of powering transfer pumps; however, most steam plants have been replaced by reciprocating engines and electric motors. Some steam plants are still in existence and incorporate reciprocating type pumps. Newer installations, located near refineries or handling viscous crude where high pressure steam may be obtained or used to heat and lower the viscosity of crude oil, may be equipped with steam turbines and centrifugal pumps.

(b) Reciprocating Engines. Older installations use a slow speed oil or diesel engine that burns the crude oil in the pipeline for fuel. Newer installations are using high speed gas engines, oil-diesel, and gas-diesel engines to power transfer pumps. The newer engines cannot use crude oil for fuel and therefore require storage tanks or taps to product pipelines (such as gasoline, diesel, fuel, and butane). A few pumping stations have installed small processing plants to refine crude oil into usable engine fuel.

(c) Electric Power. Newer installations are usually more economical to construct and maintain by using electrically powered equipment for pumping operations. Three types of electric motors are generally used. Induction motors equipped with speed reduction are used on small reciprocating pumps. Synchronous motors are preferred for larger reciprocating pumps because of their high efficiency at lower speeds. High speed squirrel cage induction motors are used on virtually all centrifugal pumps. Electric power can be supplied from nearby transmission lines on electric plants. In many locations, hydroelectric and natural gas electrical power plants are being installed as part of the pumping station.

(8) Pressure Controls. Pressure controllers serve two functions. The primary function is to prevent line ruptures and leaks caused by excessive pressure. The secondary function is to maintain a constant flow rate between pumping stations in a tight line system to eliminate the need for float tanks. If the pumping rate of one station in a tight line system falls below the pumping rate of the next station, the downstream station pumps will run partially empty and may vapor lock. Vapor lock causes pounding and surging in the pipeline. It can cause the pump seals to run dry, destroying the seals and seizing the shafts. Two types of automatic diaphragm actuated pressure controllers are used: the parabolic-plug control valve (figure 8-2) and the V-port control valve. Both valves are similar in construction and operation. Liquid flowing into the valve is divided into two passages to create a balanced pressure on top and bottom of the control plug. A spring-loaded diaphragm is controlled by compressed air admitted to the top of the diaphragm. The compressed air opposes the spring and positions the plug control to the desired line pressure.

(9) Communications. Rapid communications are essential for efficient pipeline operation. Since public communications are seldom within range of the out-of-way pumping stations, most pipelines install their own communication systems.

(a) Telegraph or Teletype Systems. Telegraph systems were the earliest used by pipelines. In recent years, the telegraph key has been replaced by teletype systems operating on the same circuits as the telegraph. The teletype is the most common communication system used by pipelines today.

(b) Telephones. Magneto type telephones are installed in some of the smaller pipeline systems. In larger systems, where several circuits are necessary, an elaborate carrier type telephone system is used.

(c) Radio. The Federal Communications Commission has granted petroleum industries specific frequency bands in VHF, UHF, and Microwave. Radio is necessary in extensive pipeline systems for constant communications between bases, maintenance crews, dispatchers, and remote control points.

(10) Miscellaneous. Miscellaneous equipment found in pumping stations include building facilities, control panels, gages, fire fighting equipment, water detectors, sump pumps, compressed air systems, and electronic measuring devices. These components vary with the type of system and are considered as accessory equipment for the major components of the system.

8-3. Operations:

a. **General.** In emergency situations and oversea commands, Air Force personnel may be required to take over, operate, and maintain a cross-country pipeline system. The liquid fuels engineer will be responsible for all maintenance of pipelines acquired by the Air Force. Before operating a pipeline, the liquid fuels engineer or his delegated representative should consider the following:

(1) Secure all plans, system diagrams, and information possible to determine location and function of all components (especially valves) in the system. Some installations may require a complete engineering study to secure sufficient information for operation and maintenance.

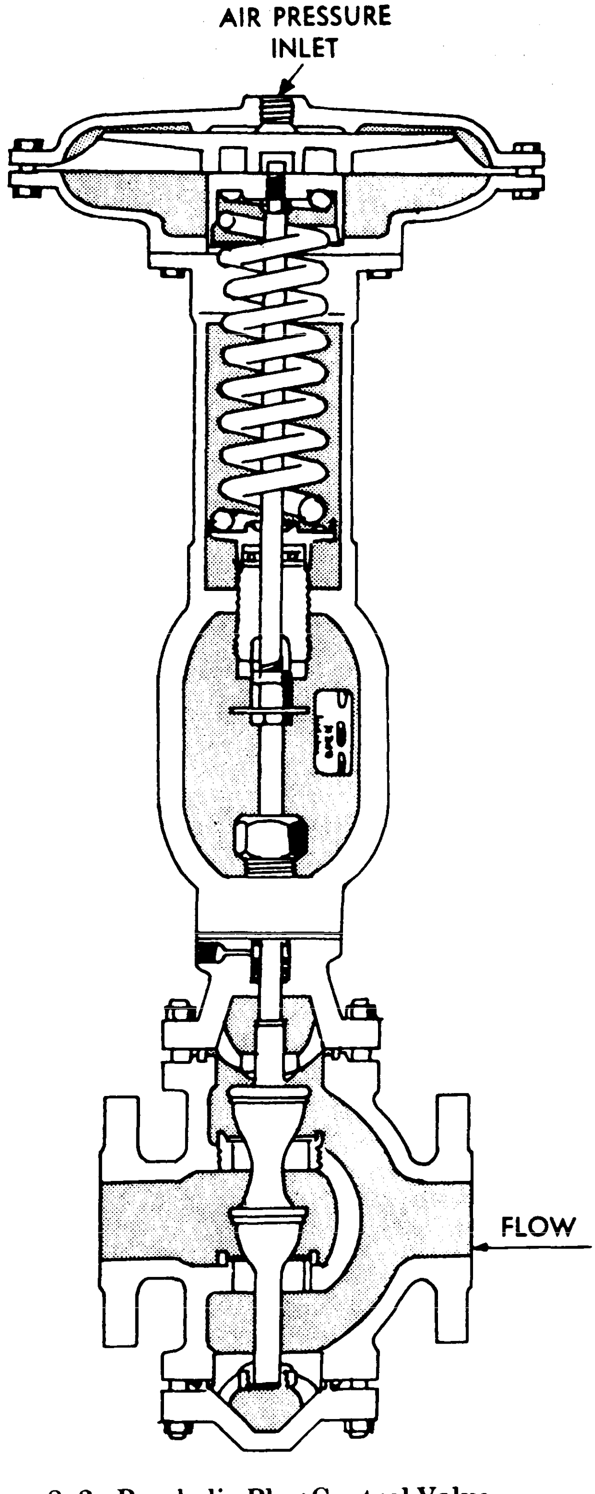


Figure 8-2. Parabolic-Plug Control Valve.

(2) Reports should be made to determine the manpower necessary for each installation. Personnel selected should have previous experience in the type of equipment they are to operate. Skilled engineers, electricians, mechanics, and pump operators are usually required at each pumping station.

(3) Complete and thorough inspections should be made of all equipment in the pipeline system to ensure proper working condition. Failure at one pumping station can cause a complete shutdown of the entire pipeline.

b. **Organization.** Good organization is essential to coordinate the operation of the pumping station and the distribution of fuel. The following organization is recommended:

(1) Dispatcher. The dispatcher has complete charge of the operation of the pipeline, dispatching orders to govern starting and stopping of units, raising or lowering of pressure, opening or closing of important valves, utilization of tankage, and sampling of product. The dispatcher must be kept informed of abnormal pumping conditions that may affect the pumping schedule. In extensive pipeline systems, dispatchers may be located at the origin, at bases receiving fuel, and at key control points along the pipeline. However, one dispatcher will be responsible for mantaining a complete picture of the overall operation and the coordination of all scheduling within the system.

(2) Pumping Station Operator. The pumping station operator is responsible for receiving and carrying out the dispatching orders, notifying the dispatcher of abnormal operations, and complete supervision within the pumping station. The personnel required to operate a pumping station will vary from one man who assumes all duties in a small pump house, to a large complex personnel system in extensive multi-pipeline systems.

(3) Maintenance Personnel. Maintenance personnel are governed by the size of the system. Equipment used in pipeline systems will differ from standard Air Force equipment. This requires spare parts to be improvised or purchased from manufacturers. The operators should be capable of conducting a thorough technical inspection of the equipment. Base maintenance shops and personnel should be used when possible for repairs. A crew should be available to patrol the pipelines at least once a year or more frequently if required.

c. **Types of Operation (See figure 8–3):**

(1) Put-and-Take. With put-and-take operation, each station draws from its own tankage and pumps into the tankage of the next station; thus each station works with a tank head on its suction side and pumps independently of the other stations. This method is preferred for slow moving heavy oils or in systems where all stations cannot maintain the same flow rate.

(2) Float Tank. Float tank operation is similar to put-and-take except small float tanks are used instead of large storage tanks. All pumping stations must maintain approximately the same flow rate. The float tanks are installed in the main pipeline to compensate for any variance in flow rates.

(3) Tight Line. With tight line operations, one station pumps directly into the suction manifold on the next station. In this operation all stations must maintain the same flow rate. Advantages of this operation are:

(a) Highly volatile products are conserved by being under pressure at all times.

(b) Evaporation losses in tankage are eliminated.

(c) Schedules are easy to set up and maintain because of the constant flow rate.

(d) Maintenance is reduced through the elimination of tankage.

(e) Combining products is reduced by keeping the product in line under pressure until it reaches its destination.

d. **Advance Operating Procedures.** Advance notice of all pumping operations is given by the dispatcher to pumping station operators. Before placing the station into service, the following checks are made:

(1) All fans and blowers are operating properly to ensure adequate ventilation.

(2) All protective devices are in service. (For example, valves in line to pressure switches should be fully open.)

(3) Flow of water is started in cooling lines to bearing jackets, stuffing boxes and water quench lines.

(4) Lubricating oil levels are checked.

(5) Air pressure for pneumatic controls are checked. Drip wells and filter are blown down to remove moisture and foreign particles.

(6) Pressure controls and instruments are set to pressure on the dispatch order.

(7) Power supply is checked. Steam plants have a full head of steam. Reciprocating engines have an adequate reserve of fuel. Electric plants are checked for proper line voltage.

(8) All reciprocating engines are warmed up before applying load.

(9) Opening and closing of valves before pumping varies with different systems and pumps. Operators should be familiar with their system and the position of valves located on the equipment.

e. **Starting and Operating.** The pumps are started at the order of the dispatcher. Any difficulty in starting or maintaining normal operational conditions must be reported to the dispatcher. Sampling or testing equipment is often installed in pipelines handling a variety of products. Constant temperature and gravitometer readings are necessary for the dispatcher to verify progress through the line and to make accurate cuts between batches. At the completion of the pumping operation, the dispatcher will give the order to shut down the pumping stations. Shutdown procedures vary with the types of pumps and equipment and should be set up by personnel familiar with the equipment.

8–4. Maintenance of Pumping Stations. Maintenance inspections of pumping stations should be made by the operating personnel at hourly intervals during operation. Inspections should include bearings, packing glands, mechanical seals, lubrication and cooling systems, electrical controls, and gages. A stock of spare parts is usually maintained at most pumping stations; however, older in-

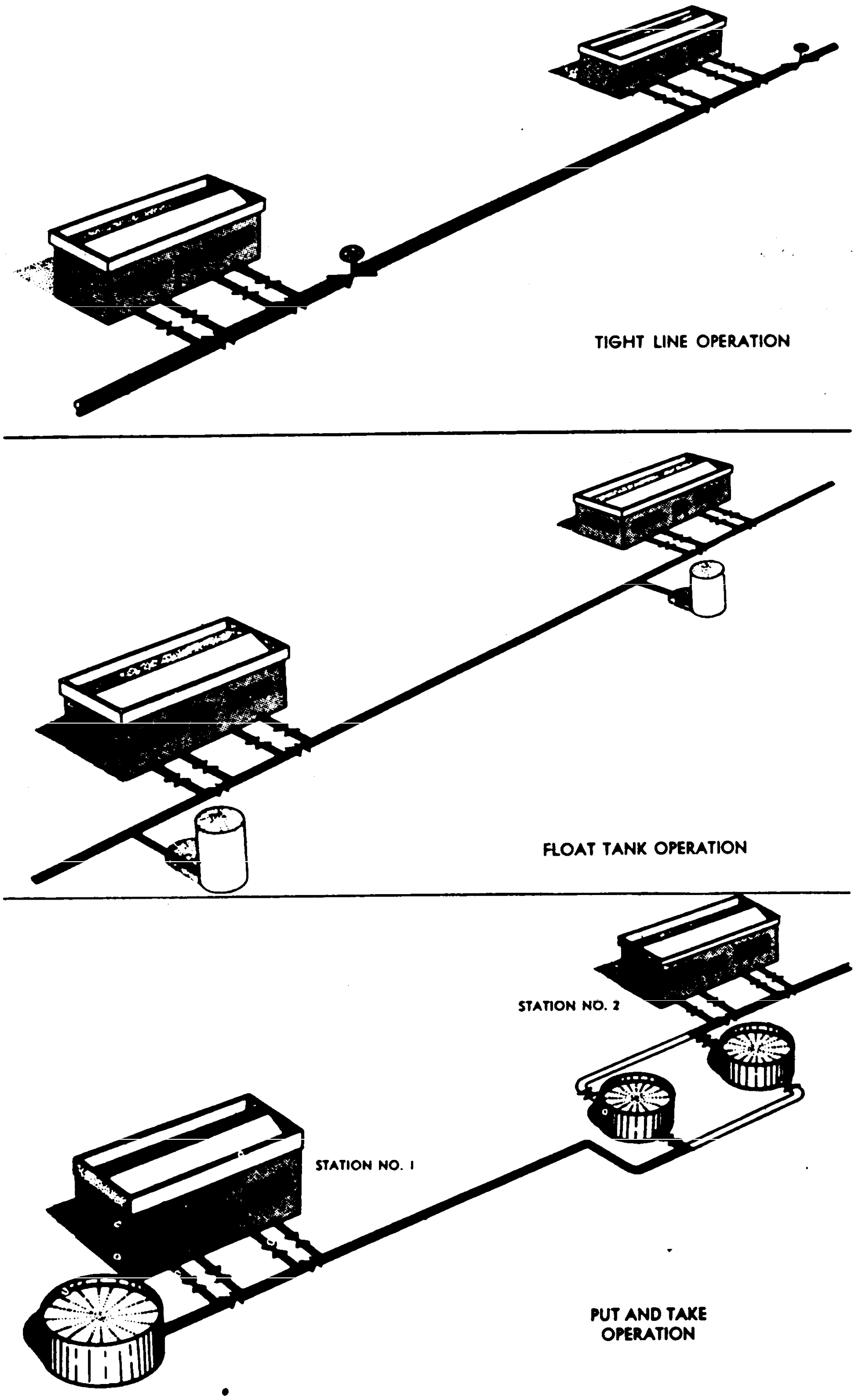


Figure 8-3. Pumping Station Operation.

stallations using obsolete equipment may have depleted their stock of spare parts, requiring the use of improvised or "shop made" parts. Minor repairs can usually be done by operators with the aid of base maintenance personnel. Major repair work will require the coordination of manufacturer representatives, local contractors, and base maintenance personnel.

8-5. Maintenance of Off-Base Pipelines:

a. **Inspections.** Off-base pipeline inspections are made by line walkers, vehicles, and light aircraft. Air patrols should be flown once a week at an elevation of less than 500 feet from the ground and at speeds from 65 to 80 miles per hour. The pipeline should be marked with posts or signs at 1-mile intervals and at bends. The pilot acts as observer and checks for surrounding construction work (roads, sewers, etc.) that may eventually cross the pipeline; change in color of vegetation that may indicate a leak; oil slicks on lakes and streams near the pipeline; and the overall condition of the right of way. Line walkers or vehicle patrols make detailed inspections once a year of the entire pipeline, checking the general condition of the right of way, valves located in remote areas, supports on aboveground pipelines, and any condition that may indicate a leak. Quite often, defects in the pipeline are reported by nearby land owners.

b. **Leak Detection.** Leaks may be detected by pressure checks, volume checks, line patrols, and leak detector apparatus.

(1) Pressure Checks. Pressure check off-base piping systems annually in the same way prescribed in paragraph 8-11c for on-base piping systems.

(2) Volume Checks. Continuous records are kept on volume and temperature of liquid passed through each pumping station. A difference in meter reading that cannot be accounted for by temperature corrections between two stations usually indicates a leak.

(3) Locating Leaks. The above method can locate only a leaking section of pipeline. The following methods are used to pinpoint a leak:

(a) Continue the pressure test until the pressure drops to a minimum and holds. By multiplying the line pressure (in psi) by 2.31 and dividing the total by the actual specific gravity of the fluid in the line, the total head in feet of fluid in the line may be obtained. By adding this total to the elevation of the pressure gage, the elevation of the leak may be located on a contour map of the pipeline. In sections containing peaks and valleys, pressure readings are necessary at several low spots to determine the location of the leak.

(b) Line walkers equipped with lead detecting apparatus (if line contains a leaded fuel) are usually necessary to find the exact location of the leak. For other products various types of detectors are used, ranging from mechanical devices that make contact with the pipe to electronic sounding devices. The manufacturer's instructions should be followed for the operation and testing of leak detectors. NOTE: Hydrostatic testing of off-base pipelines is made as directed in paragraph 8-11d.

c. **Repairs (figure 8-4).** Pipeline leaks are usually caused by corrosion both inside and outside of the pipe. Less frequent causes of leaks include cracked welds, split seams and joints, and separation at collars. Initial repairs can be made with clamps placed over the damaged area, using caulking components or gaskets to seal the leak. These repairs are usually temporary and modern practice is to arc weld all leaks. LFM should make sure that schematics are annotated to show where major breaks and leaks have occurred in the pipeline.

(1) Pits and Small Leaks. Pits on the exterior of a pipeline are caused by corrosion. If discovered before a leak develops, they may be repaired by filling the pit by arc welding. Small leaks may be repaired by welding a circular patch over the hole.

(2) Large Punctures and Holes. Large holes in pipelines usually create a safety hazard for welding because of the large spillage that has saturated the ground. Temporary line repairs are made by clamping a steel plate of the same curvature as the pipe over the damaged area, using a petroleum resistant rubber for a seal. The area may then be cleared of all hazards. The steel plate clamped over the leak can be permanently welded to the pipe. For most welding operations, the pipeline can remain in service during repairs. However, if there is danger of the arc penetrating the pipe (thin wall or badly corroded pipe), the system should be shut down during repairs.

(3) Major Repairs. In the absence of modern equipment, major repairs involving several sections of pipe can be made by two methods.

(a) If the pipeline can be taken out of service, the

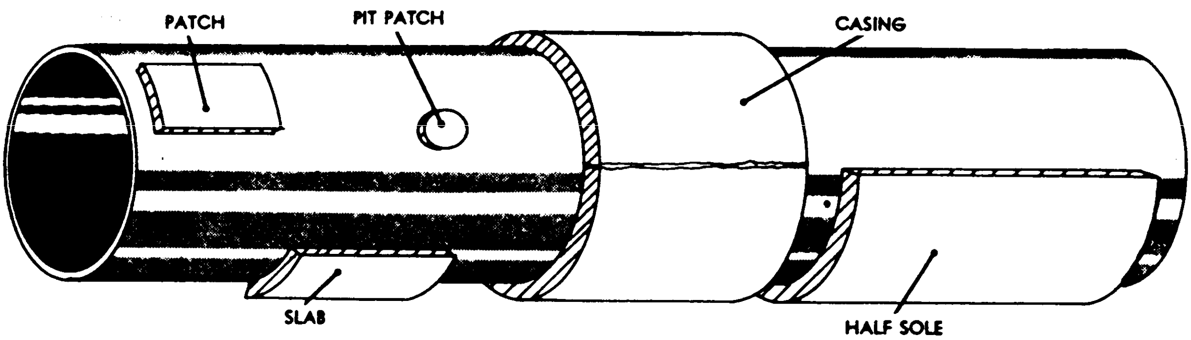


Figure 8-4. Pipeline Repairs.

preferred method is to replace the damaged section with new pipe. (If modern equipment is available, almost any type of repair or modification can be made without taking the line out of service.)

(b) If the pipeline cannot be taken out of service, a casing can be welded over the damaged sections. Casings are made by splitting a larger pipe in half, fitting the halves around the damaged section of pipe, and welding the longitudinal seams. The casing is swagered at the ends to the circumference of the pipe and welded. Casings are considered temporary and should be used only under extreme conditions.

8-6. Pipeline Cleaning:

a. **General.** Pipelines are cleaned with line scrapers forced through the line by the liquid being pumped. Intervals between cleanings vary with the size of the pipe and liquid being pumped (see paragraph 8-6b(3) note). A drop in the flow rate, or the need for a pressure increase, indicates a loss of efficiency and the need for cleaning. Batching pigs (figure 8-5) are used to separate fuels, prevent contamination, and mixing between batches. Treatment of batching pigs is the same as for line scrapers. Water slugs are not permitted to separate batches.

b. **Types of Scrapers.** Scrapers vary in design with the size of the pipe and intended purpose. The following are general classifications:

(1) Gaging scrapers are used for the initial cleaning of a new line. A gaging scraper has a stellite-edged sizing plate at the front, one synthetic rubber cup behind the plate, and another cup at the rear of the scraper. It is propelled through the line with compressed gas or water to remove foreign matter left by construction of the line.

(2) Product line scrapers are generally 4 to 14 inches in diameter and have brushes mounted on steel springs integrated with rubber or leather cups. (See figure 8-5 for a typical scraper.) The springs ensure brush contact of worn brushes and flexibility to pass obstructions. A bypass through the scraper agitates and propels the loose scale forward, to prevent it from accumulating and clogging the line. This scraper may be used in continuous runs up to 200 miles.

(3) A solid plastic "pig" (or scraper) is ideal for cleaning short runs of pipe, such as on-base transfer pipeline. The scraper is made of a resilient synthetic foam with an abrasive coating; because of its resiliency, the plastic scraper will pass through plug valves, short radius, and even square turns, so that pipeline cleaning is simplified. Sending and receiving traps is not required. The scraper cost is also materially lower. Current experience indicates that pipeline cleaning with the plastic scraper is well within base in-house capabilities. Typical solid plastic pigs are shown in figure 8-6.

NOTE: The use of compressed air as a propelling medium is specifically prohibited for safety reasons. (Compressed gaseous nitrogen or a liquid fuel is recommended in place of compressed air.) Pipeline cleaning may be required:

(a) Following a prolonged period of pipeline inactivity.

(b) Along with conversion of fuels handling.

(c) After several years of service.

c. **Scraper Traps.** A typical piping arrangement for easy insertion and withdrawal of scrapers without shutting down or reducing normal pumping rate in a pipeline is shown in figure 8-7. Each sending and receiving trap has a scraper barrel (figure 8-8) made of pipe that is 2 inches larger in diameter than the line, and of such length that the sending trap will contain a single scraper (and the receiving trap, three scrapers) and the anticipated accumulation of solid scrapings. Most receiving stations are equipped with receiving tanks to catch the oil and sediment in front of the scraper. The contaminated product can be settled and the clean oil drawn off the top and returned to the system.

d. **Scraper Operation.** Determine the scraper best suited for the operation. Check specifications to be sure it will pass through all valves and bends. Keep accurate records of the time the scraper is started and quantity of oil pumped, to trace the progress of the scraper and determine time of its arrival at the receiving station. It is good practice to bypass meters while scraper sediment is in the line. The scraper should be run at the minimum velocity (2 miles per hour) with no shutdowns while the scraper is in the line. Shutdowns will permit the scrapings to settle in front of the scraper, causing it to become stuck (that usually requires cutting of the line to retrieve it).

(1) Scraper Insertion (figure 8-7):

(a) Close valves D and F; open vent and drain valves.

(b) After barrel has drained, open end flange and insert scraper past kick-off line (valve F).

(c) Close drain valve and secure barrel fitting. Open valve F slowly, allowing barrel to fill while venting through vent valve and forcing scraper into reduced section of barrel.

(d) After barrel is full, close vent valve.

(e) Open valve D while throttling down valve E. This will launch scraper into the main line.

(f) When scraper has left station, open valve E fully and close valve F and D and drain sender. Report time of departure to dispatcher.

(g) Watch discharge pressure gage for sudden increase in pressure until scraper reaches destination. Record time of any changes that would indicate a stuck scraper.

(2) Removing Scraper:

(a) One hour before scraper is due, open valves A and C. Sample stream at frequent regular intervals (1 to 3 minutes). When first indications of foreign substances appear, open drain valve and close valve C.

(b) When scraper moves through valve A, throttle valve B slightly to force scraper into receiving barrel.

(c) After scraper has moved into barrel, open valve B fully.

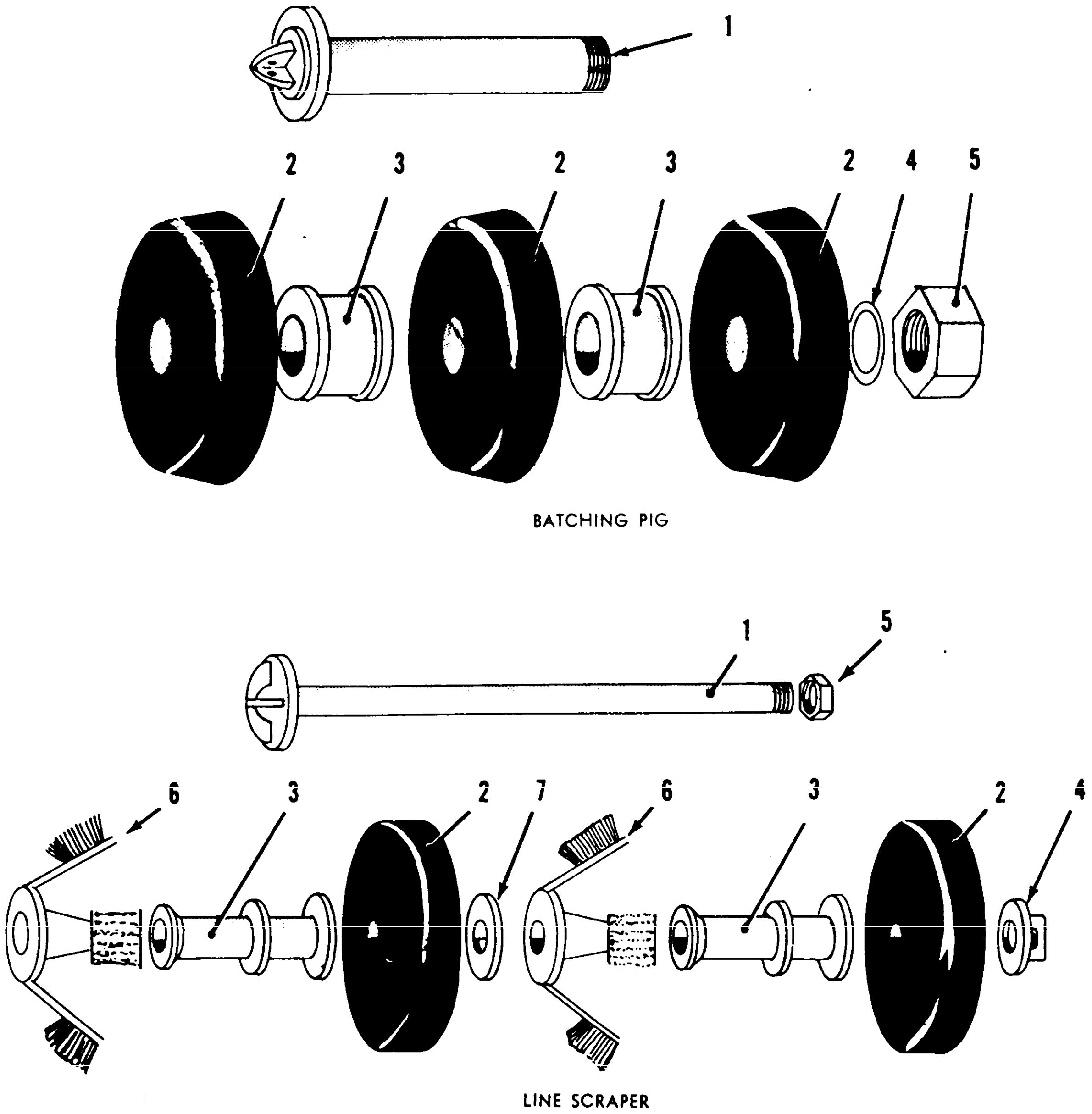
(d) Close valves A and C.

(e) Drain scraper barrel by opening drain and vent valves.

(f) Open barrel fitting and retrieve scraper.

(g) Remove any foreign matter from inside barrel and secure barrel fitting.

(h) Notify dispatcher of time of arrival, amount of



1. Body assembly
2. Rubber cup
3. Body spacer
4. Rear bumper
5. Body nut
6. Spring-mounted wire brushes
7. Cup flange

Figure 8–5. Typical Scraper and Batching Pigs.

Figure 8-6. Typical Solid Plastic Pigs.

sediment or other foreign matter, and general condition of scraper.

(3) Scraper Tracing. Several methods are used to locate scrapers stuck in lines. The knife type scrapers make sufficient noise to be followed by line walkers. Brush type scrapers are relatively silent and require a transmitting device to reveal their exact location. Their general location can be found from the time and quantity of fuel pumped befor the stoppage occurred. Special devices include:

(a) Noisemakers fastened to the scraper.

(b) Small battery-operated radio transmitters located by radio receivers equipped with directional antennas.

(c) Radioactive material that can be located with a geiger counter.

(d) Magnetized cores in scrapers that can be detected with a magnetometer.

SECTION B—ON-BASE PIPELINE SYSTEMS

8-7. General Information. On-base pipelines are used for the following general purposes:

a. Fill bulk storage tanks.

b. Withdraw fuel from bulk storage tanks.

c. Fill trucks.

d. Transfer fuel between bulk and operating storage tanks.

e. Fill aircraft from hydrant operating storage tanks and dispensing systems.

8-8. Description of On-base Pipelines. On-base pipelines for transfer of petroleum products are identified as follows:

a. Commercial pipelines to deliver fuel to the bulk storage tanks. These pipelines are usually underground except at tie-in connections to the base pipelines. These pipelines are constructed on government property by issuance of real estate easements. On-base portions are owned, operated, and maintained by the commercial pipeline company involved. The base civil engineer is authorized to perform emergency maintenance on on-base commercial pipelines if necessary to protect against environment pollution damage to public property or meet emergency wartime mission requirements. The real estate easement agreement with the pipeline owner takes note of this and provides for suitable contractor reimbursement to the Government.

b. Unloading pipelines between truck or rail unloading outlets, unloading pumphouse and bulk storage tanks. Usually these pipelines are partially aboveground and partially underground and are used to transfer fuel from tank trucks and rail cars to bulk storage tanks.

c. Transfer pipelines between bulk storage, transfer pumphouse and truck fill stands or hydrant dispensing systems. Normally, these pipelines are underground except in the immediate area of the facility involved and are used to transfer fuel from bulk storage tanks to truck loading and hydrant operational storage tanks. Most facilities have separate unloading (fill) lines and transfer (withdrawal) lines; however, some facilities use a single line for both filling and withdrawal from bulk storage tanks.

d. Refueling header pipelines between hydrant pumphouse and lateral control pits. These pipelines are underground except in the pumphouse and are used to transfer fuel from hydrant operating tanks to control pits and hence to apron outlets and aircraft or trucks.

e. Defueling header pipelines between lateral control pits and hydrant pumphouse. These pipelines are underground except in the pumphouse and are used to transfer fuel from the lateral control pit back to the hydrant operational tank(s). Most facilities designate a single tank for defueling. Some of the Type I hydrant systems (Panero design) use an intermediate defuel tank for gravity flow from control pits. Fuel is then pumped from this defuel tank through an underground pressurized pipeline back to the hydrant operational storage tank.

f. Lateral pipelines between lateral control pits and

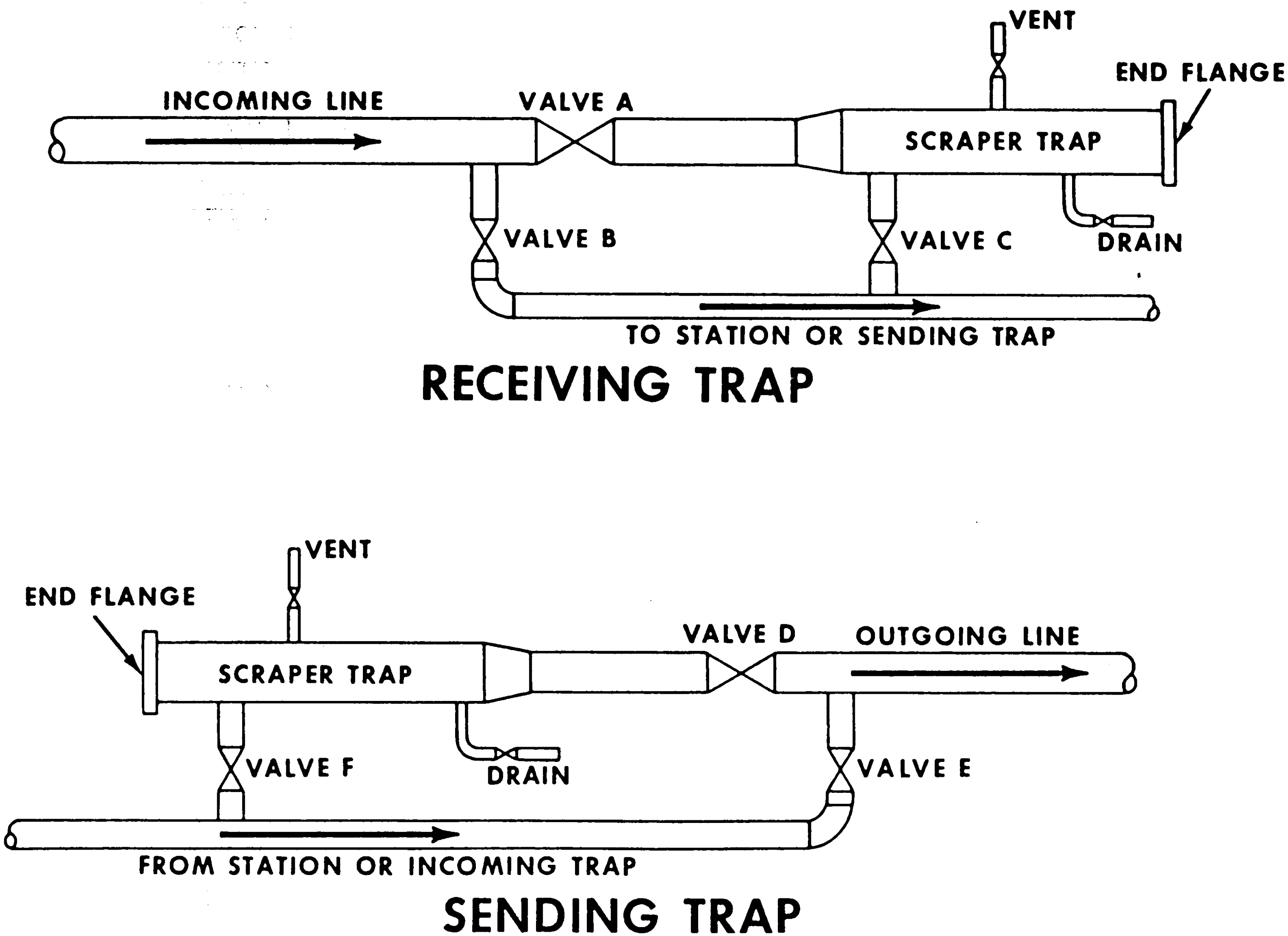


Figure 8–7. Scraper Trap Systems—Sending and Receiving.

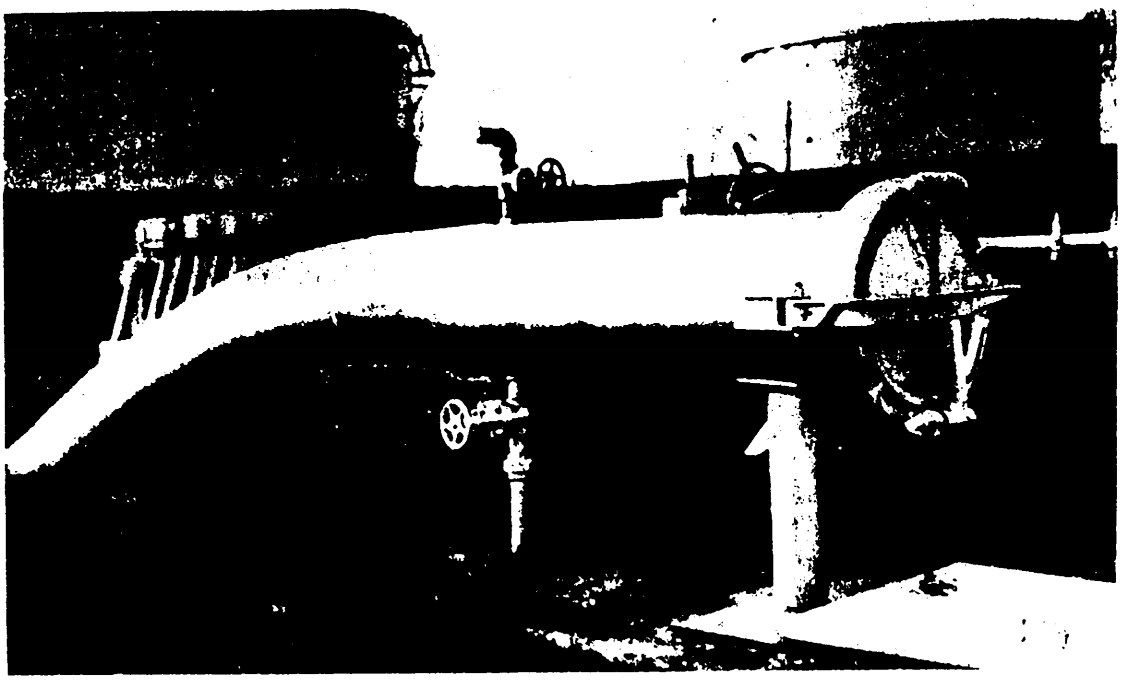


Figure 8-8. Scraper Trap.

apron outlets. These pipelines are underground and under the apron pavement and are used to transfer fuel under pressure regulated conditions to aircraft (refueling) and to remove fuel from the aircraft (defueling).

NOTES: 1. Stripping connections (for drainage of water from low points in the piping) are drained by operator personnel at intervals prescribed in TO 37-1-1. However, when additional or improved stripping connections are required, BCE provides installation.

2. If existing low point drains have not been modified to allow for easy draining of liquid into glass containers, they should be modified as soon as possible. Local configuration will determine method or type of modifcation necessary.

8-9. Pipeline Materials:

a. Black Steel Pipe. The majority of on-base petroleum pipelines are constructed of welded black steel pipe (Grade A). Above ground portions of these pipelines are protected with white paint. Most of the underground portions of these pipelines are protected with a wrapping and coating. Many bases have cathodic protection systems installed as additional protection for the underground portions of these pipelines. Galvanized steel, copper piping and control lines are not permitted on petroleum systems. Petroleum systems containing galvanized steel pipe in contact with fuel must be replaced with black steel or black iron pipe. Existing galvanized ground fuels piping may remain in use.

b. Wrought Iron Pipe. A few bases may have welded wrought iron pipe in place of black iron or black steel pipe. Wrought iron pipe has improved corrosion resistance qualities but is higher in cost. Above ground portions are protected with white paint.

c. Stainless Steel Pipe. Very few systems have used stainless steel pipe. Stainless steel has excellent corrosion resistant qualities when installed above ground and should not be painted except for banding and directional arrows according to MIL-STD-161. When installed underground, stainless steel corrodes unless it is protected. Stainless steel pipe installed underground must be wrapped, coated, and cathodically protected to prevent corrosion.

d. Aluminum Pipe. Some of the newer systems and special fuel systems have used welded aluminum pipe. Aboveground portions of aluminum pipeline are unprotected (not painted) except for product banding and directional arrows according to MIL-STD-161. Underground portions are wrapped, coated, and protected with a cathodic protection system. When a system is cathodically protected, it should not be overprotected.

e. Fiberglass Reinforced Plastic (FRP) Pipe. Some of the newer systems, and repair by replacement of corroded piping systems, have used FRP pipe. This pipe is satisfactory for underground systems only and is corrosion resistant without additional wrapping. Cathodic protection is not required. This pipe is not guaranteed when installed in the ground frost area.

f. No copper or copper alloy material is used for petroleum systems.

8-10. Operating On-Base Petroleum Systems. The operation of on-base petroleum systems, that includes all Air Force on-base pipelines, is the responsibility of the base fuels management officer (FMO). These responsibilities are delineated in AFR 144–1. The base civil engineer is responsible to provide the fuels management officer with a current certified on-base pipeline inventory (in US gallons).

8–11. Maintenance of Pipelines (On-Base):

★**a. Inspections—Aboveground Piping.** Aboveground portions of on-base pipelines are visually inspected for leaks or drips at the same time that other maintenance tasks are being performed in these areas. Fuel leaks constitute an emergency condition for which immediate repair is justified. The type of repair is determined by the nature of the leak. Corrosion leak in an aboveground pipeline requires welding for permanent repair. Approval from the MAJCOM liquid fuels engineer is required before commencement of welding or any hot work in connection with repair of on-base petroleum pipelines.

b. Inspections—Underground Piping. All LFM personnel should be aware of the various underground pipeline routes and make a general visual surveillance whenever they are driving by or working in these areas. The pipeline should be walked at least twice a year. Leaks in underground pipelines can sometimes be detected by fuel surfacing on the ground, by fuel run-off in the storm drainage system, detection of fuel in underground pits or manholes, or the continuous odor of fuel in a particular area. Any suspicious circumstances are justification for immediate investigation to include pressure testing of the line in question and excavation if soil conditions permit.

c. Pressure Test (Annual). Pressure test of all on-base (above and belowground) fuel piping systems is done once a year by using existing installed pumps in the various fueling systems. Unloading, transfer, truck loading, and hydrant dispensing piping systems are pressurized by running the appropriate centrifugal or vertical turbine pumps against a closed system for approximately 30 seconds. Appropriate valves will be closed to trap this pressure in the system. Pressure gage reading will be taken at this time. Also, all aboveground portions and portions located in concrete pits are visually checked for leaks and closed valves are audibly checked for sound for indication of an internal leak through the valve. If no visible or audible leaks occur, then pressure gage readings are taken every 15 minutes for the first hour and once every half hour for the next hour. Total time of pressure test will be two hours. All pressure tests are recorded and include the following:

(1) Name of system test (that is, refuel header, defuel header, lateral pipelines). Provide facility number.

(2) Date of test and weather conditions (sunny and 80°F, cloudy and 65°F).

NOTE: Record any weather change during test period.

(3) Pressure Readings.

(a) Start (approximate local time) pressure ____

(b) 15 minutes (approximate local time) pressure

(c) 30 minutes (approximate local time) pressure ____

(d) 45 minutes (approximate local time) pressure

(e) 1 hour (approximate local time) pressure ____

(f) 1.5 hours (approximate local time) pressure ____

(g) 2 hours (approximate local time) pressure ____

NOTE: These records will be maintained and kept on file in the Liquid Fuels Maintenance (LFM) shop for 5 years. Copies of these records will be sent to the MAJCOM Liquid Fuels Engineer when requested.

★**d. Hydrostatic Pressure Test.** (Do not use water). Hydrostatic pressure test is done on all underground aviation fuel transfer pipelines on a 5-year recurring basis. The actual year that this testing will be performed is determined by the MAJCOM Liquid Fuels Engineer. Hydrostatic pressure is supplied by use of a hand operated hydraulic pump with a built-in reservoir tank.

(1) Isolate section to be tested with blind or spectacle flange.

NOTE: If block valves will hold pressure, flanging is not required.

(2) Using a hand operated hydrostatic pump, perform static pressure test at 150 percent of the normal operating pressure for a minimum of 4 hours.

★(3) Record pressure every 15 minutes for the first hour, then every hour thereafter (use chart similar to chart in paragraph 8–11c(3)). If at the end of steps 1, 2, and 3, no leak is indicated, further testing is not required. If a leak or excessive pressure drop is indicated, then perform a flow test. This is done by repressurizing the line to 150 percent of the normal operating pressure, by using the hand operated hydrostatic pump with a separate reservoir. Measure and record the amount of fluid required to maintain this pressure for a 4 hour period. Forward copies of all test results to appropriate MAJCOM Liquid Fuels Engineer.

NOTE: The date of the next hydrostatic pressure will be placed in the "Remarks" section of the schematics, system status charts, or stenciled in an appropriate location on the facility.

Chapter 9

CORROSION CONTROL

Section A—General

9-1. General Information. A program of corrosion control is necessary to prevent deterioration of metal components of a fuel system (such as storage tanks and pipelines) and avoid increased maintenance and replacement problems, operating hazards, contamination of product, and possible outages. Department of Transportation (DOT) requires all coated underground piping systems that transport hazardous fuels to be provided with cathodic protection. A general discussion of corrosion theory and principles is covered in AFM 85-5 for cathodic protection and AFM 85-3 for protective coatings. A word of caution; when a system is cathodically protected, it should not be overprotected.

9-2. Controlling Corrosion. Corrosion control can be divided into three major categories: cathodic protection, protective coatings, and chemical treatment of the fluid. Chemical treatment is not commonly used in POL fluids. Basically, corrosion is an electrochemical reaction, much like that in a dry cell battery. The following four conditions must be present for corrosion to exist:

a. Anode.

b. Cathode.

c. Electrical connection between anode and cathode.

d. Anode and cathode must be submerged in an electrolyte. The absence of any one of these four conditions prevents corrosion. Applying cathodic protection causes the metal pipe or structure to become entirely a cathode. Applying a protective coating to an aboveground facility prevents the structure from touching an electrolyte (water, moisture, etc.). An electric current flows through a conducting electrolyte between the anode and the cathode. Corrosion, that takes place where the current leaves the metal to enter the electrolyte, (the anode) must be avoided.

9-3. Corrosion of Fuel Systems. Corrosion attack on fuel systems, excluding fiberglass reinforced plastic systems, is not confined to any particular component, type of system or specific metal. It may take place internally, externally, or both may exist simultaneously depending on local conditions. Aluminum pipe, when installed underground, will corrode rapidly when connected to almost any other metal, and when in contact with concrete. Special consideration must be given to aluminum piping installed underground. Aluminum piping is more stable when exposed to the atmosphere. One of the reasons that aluminum piping was used on the Panero laterals is that the inside of the pipe is dry when not being used in the fueling process. Similar reasoning was used in developing the operating procedure for the Pritchard system. The lateral piping is steel; steel corrodes in the atmosphere, thus the steel piping must be full of fuel at all times to prevent corrosion. This is even more critical in areas where the atmosphere contains salt-laden air.

a. **Internal Corrosion.** Water is a better electrolyte than refined petroleum products. For this reason, the use of salt water to maintain water bottoms in storage tanks, and as moving agents to transmit petroleum products through pipelines, is prohibited. Fresh water bottoms in storage tanks are permitted only as a temporary measure when the tank bottom is known to be leaking and repairs cannot be made until all products have been removed. Approval from the command liquid fuels engineer must be obtained before introducing any water into a fuels system.

b. **External Corrosion.** The first requirement for corrosion control of buried or submerged metals is a good protective coating. This coating serves two main purposes:

(1) It isolates the metal structure electrically from its environment.

(2) It reduces the amount of current required when cathodic protection is applied. All underground metallic POL piping or tanks must be coated and have cathodic protection.

Section B—Insulation

9-4. General Information. The quality of a coating is judged by its ability to resist moisture absorption, resist POL product attack, and maintain mechanical stability. Some of the more commonly used coatings are extruded polyethylene and hot-applied coal-tar enamel. Piping joints should be covered with a material that is compatible with the pipe coating and should be recommended by the pipe coating manufacturer. Insulating joints are frequently used to isolate fuel systems from other utilities, or piping of dissimilar metals. (The structure-to-soil potential of aluminum pipe should not be more negative than -1.2 DC volts.)

9-5. Methods of Application:

a. **Coatings and Wrappings.** Where additions or repairs to fuel piping systems are made, the latest techniques and methods of applying protective coatings should be used to ensure maximum effectiveness and long life. For new extensions or for repair jobs, the factory-applied polyethylene coatings should be used. Coated piping can be purchased; however, if coated pipe cannot be located at the time you need it, the following inhouse procedure should be performed. First, thoroughly clean the pipe and apply a coat of coal-tar primer. After the primer has dried, two coats of hot coal-tar enamel are applied, either by turning the pipe, or by applying with a rag, allowing enough drying time between coats. Application is made according to the manufacturer's recommendations. At the time of the second coating, the pipe should be covered with one wrapping of kraft paper. At connection welds, couplings, fittings, and other exposed areas, a coating equal to that applied in the shop should be provided in the field to ensure uniform protection of all areas of the pipe. For field repairs, particular attention should be given to restoring the coating to its original condition after repairs have been completed. When the soil is saturated with petroleum products, that is usually the case after a leak has been discovered, two layers of plastic pressure-sensitive tape should be used instead of tar or asphaltic compounds. Before the tape is applied, the pipe should be wire brushed, thoroughly cleaned, and a special plastic primer coat applied. Plastics (such as polyethylene and polyvinyl chloride (PVC)) are not readily attacked by hydrocarbons and can be used to great advantage for this type of repair.

b. Insulating Joints. Insulating joints are widely used along with cathodic protection systems to isolate protected structures electrically from unprotected structures, and, especially, to prevent galvanic action between dissimilar metals (such as steel and aluminum) when connected together. It is important that insulating joints be properly maintained and not rendered ineffective by improper application of paints and electrical bonds. (Detail explanation of insulating joints is in AFM 88-9, chapter 4).

Section C—Cathodic Protection

9-6. General Information. For coatings and wrappings to be completely effective, they must be free of pinholes, breaks, and other discontinuities. In actual practice this degree of perfection is never attained. As a result, there are small areas throughout the fuel system that are completely unprotected. It is in this area where cathodic protection can be more effectively and economically applied as a supplement to the coating to give added protection against corrosion. The Department of Transportation (DOT) requires all coated underground piping systems that transport hazardous fuels to be provided with cathodic protection. The design of cathodic protection systems is covered in AFM 88-45. The maintenance of cathodic protection systems is covered in AFM 85-5. All new construction of underground metallic piping or structures must include coating and cathodic protection as a part of the construction project. Fiberglass pipe is nonmetallic and requires no cathodic protection.

9-7. Cathodic Protection. Cathodic protection is obtained by applying an impressed or natural DC current through a ground bed into the ground, in such a manner and magnitude as to have a flow of current to every square inch of the underground structure. The act of the current flowing onto the structure changes the anodic areas to cathodes, thus preventing a discharge of current from the structure to the ground and the resulting corrosion. The direct current is generally obtained from one of two sources, sacrificial anodes or impressed current. Sacrificial anodes provide their own voltage to drive the current as a result of the natural difference in potential of the structure to be protected and the metal of the anode. Magnesium is most commonly used since the driving voltage is greater than other metals. Zinc is often used when the structure to be protected is located in salt water or very low resistant soils. Impressed current systems have rectifiers, ground-beds, and the connecting cables. The rectifier changes the AC to DC and uses a multitap transformer to allow voltage adjustment to change current output. It also contains meters that reveal the voltage and current output. The correct design and installation of a cathodic protection system requires special study and field testing by competent and experienced personnel. Where an impressed current type of cathodic protection system is installed, careful consideration should be given to other nearby underground metal structures to prevent damage by cathodic interference. It is, therefore, recommended because of the complexity involved in applying an impressed current type of cathodic protection system, that a corrosion engineer be employed to make the necessary field investigation, make necessary adjustments, and set the rectifier for optimum performance.

9-8. Maintenance of Cathodic Protection Systems. Where a cathodic protection system has been installed, it must be maintained in good order to remain effective. Usually the system has no moving parts and is composed of such components as rectifiers, connecting cables, ground-beds, sacrificial anodes, insulating connections, test stations, and current drainage bonds. The sacrificial anode system does not require the same degree of maintenance as the impressed current system mainly because the anodes are self-contained and require no outside power supply. AFM 88-5 should be consulted to determine if the system is being maintained properly. The base assigned corrosion engineer and cathodic protection technician should be contacted at any time the cathodic protection system is not operating properly.

Section D—Protective Coatings

9-9. General Information. The purpose of this section is to discuss the surface preparation and protective coatings (paint) of above-ground POL structures including storage tanks and pipe lines. Exterior coatings are of particular interest since they are attacked by the normal weathering elements, that is, sun, rain, and wind. Interior coatings generally last longer since they are protected from these elements by roofs of submersion in POL products. The success of protective coatings is directly dependent on the surface preparation of the substrate; or, in the case of maintenance painting, the preparation of the existing protective coating film. Neglect of proper surface preparation is false economy regardless of type of coating to be used.

★9-10. Surface Preparation and Protective Coatings. Surface preparation and coating systems specified in AFM 85-3 for steel structures shall be used.

9-11. Inspection. The most perfectly prepared specifications can be voided or completely destroyed by poor inspection practices. A highly qualified coatings inspector should be assigned to projects of this type. Since vast funds are expended on coatings for POL facilities, we must ensure the best possible job is obtained for the funds expended. Every phase of the operation must be observed and items recorded for future reference. Storage of material, surface preparation, mixing of coating materials, and actual application are all equally important. Particular attention should be given to pinholes, holidays, and dry mil thickness application.

Chapter 10

PREVENTIVE MAINTENANCE

Section A—General

10-1. General Information. Definite procedures for preventive maintenance of petroleum storage and dispensing systems are necessary for efficient, safe operation. The objectives of preventive maintenance are to:

a. Prevent breakdowns.

b. Ensure proper maintenance.

c. Provide immediate and adequate minor repair to avoid major repair.

d. Control maintenance costs.

e. Establish specific personnel assignments for maintenance functions.

f. Develop minimum adequate maintenance data through the records and procedures of AFR 85-1. The instructions given in this part serve as uniform guide procedures for servicing and inspecting all assembled components and systems involved in handling, storing and dispensing aviation fuels and lubricants. It will be necessary to supplement this manual with the manufacturers' instructions because many older fuel systems were not standardized in design, and components (even of standard systems) may be of different manufacture.

10-2. Policy Procedure for Liquid Fuels Maintenance (LFM) Personnel. To decrease the possibilities of fuel spills, the following Liquid Fuels Maintenance prcedures are mandatory:

a. Base civil engineering LFM personnel must notify base fuels management personnel on duty at the fuels control center (FCC) before removal of any system component or when the system is opened in a manner that would permit a fuel spill.

b. Base civil engineering LFM personnel must install blind flanges when a component of a fueling system is removed or altered and left unattended. A closed valve upstream that is tagged or locked is not considered a positive shutoff and will not eliminate the requirement for the installation of blind flanges. Open end pipe flanges or loosened flanges (unbolted except for one or two bolts to hold valve or equipment in position) will not be permitted to be left unattended at any time.

c. The individual who physically removes a component or alters the system is responsible to install blind flanges and thus ensure the integrity of the fueling system. The base civil engineer must repeatedly stress this philosophy to engrain integrity and responsibility in each individual engaged in this work.

d. The LFM supervisor will obtain blind flanges and gaskets in sizes to meet equipment requirements. These materials will be obtained and held as a minimum reserve authorization on bench stock according to AFR 85-1 and AFM 67-1, volume II, part two, chapter 19.

10-3. Civil Engineer Responsibility. Preventive maintenance is the responsibility of civil engineer personnel. AF Form 1841, Maintenance Action Sheet, will be prepared by civil engineer personnel using this section and the manufacturer's literature as guides. The maintenance services outlined in AFR 144-1 and TO 37-1-1 that are performed by the operator personnel on the installed systems will be spot checked by the LFM supervisor (or a designated representative) confirming that this work has been done. In addition, designated representatives from both the liquid fuels maintenance (LFM) and base fuels management office (BFMO) perform systems inspections on a weekly basis according to TO 37-1-1, paragraph 4-9h. One of these weekly inspections should be conducted at least once a month by a team consisting of the LFM supervisor and the FMO or superintendent. This joint monthly inspection, providing detailed review of AFTO Forms 39, replaces one of the weekly inspections and must not be delegated. Close attention must be given during this inspection to the following:

a. Adequate discrepancy description.

b. Date discovered.

c. Work order control number.

d. Transfer of work order control numbers, for routine maintenance, from AF Form 1135, BCE Real Property Maintenance Request, Fuel System Discrepancy to AFTO Form 39, and Inspection Record. Services designated in AFR 144-1 and TO 37-1-1 are generally periodic checks during operation to discover malfunctions occurring between routine inspections and service performed by civil engineer personnel. NOTE: To ensure against mission degradation and to allow preplanning of work, the liquid fuels maintenance function will coordinate with the base fuels management officer on all scheduled maintenance tasks which could affect the fueling operation at least 5 days before maintenance occurs.

10-4. AF Form 1841, Maintenance Action Sheets (MAS). A full discussion of forms used in the preventive maintenance program is provided in AFR 85-1.

a. AF Forms 1841 need only be prepared when new items are being added to the Recurring Maintenance Plan (RWP), or when new tasks need to be added to existing MASs in sufficient detail to cover all of the required maintenance actions for like items or systems, and provide standard work hours required to perform the maintenance actions identified for each frequency. AF Forms 1841 may be reproduced and placed into craftsmen's book so that more than one craftsman can do equipment maintenance on separate items of equipment covered by the same MAS at the same time. These books will be updated at the same time the MAS file is updated.

b. The mechanical superintendent and engineer make sure that periodic review of the recurring maintenance file (RWP) and recurring maintenance schedule are made to determine that new RWP items are added to the file, removed items are deleted, and the maintenance actions listed on the maintenance action sheets meet the latest maintenance criteria.

Section B—Preventive Maintenance Services and Inspections

★10–5. General Information. The following paragraphs describe preventive maintenance services to be performed by BCE personnel as part of regular maintenance. System areas, to which instructions apply, are indicated in parentheses after the component as equipment identification. AF Form 1841, Maintenance Action Sheet, should be completed for all maintenance actions. The maintenance frequencies are shown in bold type at the end of each paragraph or subparagraph. The BCE can alter the maintenance frequencies if documented evidence suggests no degradation in equipment or service will result.

10–6. System Area:

a. Large grass areas within the bulk storage complex will be mowed by the BCE grounds section as required by AFR 91–26. FREQUENCY: MONTHLY OR AS REQUIRED.

b. Use fireproof chemicals for sterilization of dikes to prevent growth of vegetation inside the diked area. Repeat only as required. This work will be performed by BCE grounds section. FREQUENCY: MONTHLY OR AS REQUIRED.

NOTE: BCE craftsmen must make sure that the job site is returned to its original configuration after maintenance tasks are complete.

★10–7. Hose. (Unloading area, piers, truck fill stands, aircraft refueling area). Hydrostatically test hose at 1½ times dead head (shutoff head) pressure of system. Nicks, cuts, and scuffs noted at time of testing will be marked with red paint or tape. Hose assemblies with working pressures less than 20 pounds per square inch gage (psig) need not be pressure tested. Even though hydrostatic hose testing for RPIE is a joint operator/ and LFM responsibility, primary responsibility lies with LFM. Operator personnel make sure that hoses are made available when testing is necessary; LFM maintains hydrostatic test records and performs hydrostatic tests. Mutual arrangements for doing hydrostatic hose testing by vehicle maintenance shop is satisfactory and encouraged where possible. Paint a 2-inch band on each hose end to indicate coupling slippage. FREQUENCY: Prior to initial installation and as determined by the LFM supervisor.

10–8. Gaskets. Use care to prevent damage to gaskets when removing couplers, strainers, covers, fill caps, gage covers, and valves. FREQUENCY: AS REQUIRED.

NOTE: Operators replace gaskets on strainers only; all other gasket replacements (such as on valves and flanges) are the responsibility of the LFM. To avoid delay in replacing damaged gaskets, the LFM keeps gaskets in stock (including strainer gaskets required to be replaced by the operators).

10–9. Storage Tanks:

★a. Aboveground Tanks: Visually check the exterior of each tank for leaks or signs of corrosion. Give special attention to rivets and seams. Scrape clean and repaint any rust or corrosion spots.

NOTE: Tank bottom water drain lines will be 3/4-inch. If the tank has a larger diameter water drain line installed and it has deteriorated to the point that replacement is necessary, installation of a separate 3/4-inch drain should be accomplished at the next tank entry. This work requires welding of a 2-inch threaded nozzle through the shell plate according to API Standard 650. FREQUENCY: MONTHLY.

b. Floating Roof or Pan:

(1) On open top floating roof tanks the center primary roof drain system is emptied of any water, the driptight plug placed in the roof drain opening, and the drain valve near the bottom of the tank shell closed when product or ambient temperature drops to freezing or below. The drain valve is kept in the closed position except after each rain or snowfall, at which time it will only be opened for the exact period of time required to drain the roof and drain line. (See paragraph 10–9b(4)). FREQUENCY: DAILY OR WHEN REQUIRED.

(2) Check centering of roof or pan. FREQUENCY: MONTHLY.

★(3) The perimeter tank seal will be cleaned and checked by LFM personnel. Covered roof tanks may be visually inspected from the gaging platform. Rust scale accumulations in this are from the tank wall (in the case of aviation gasoline fuels, it will contain tetraethylead). This scale will be handled as sludge from tank cleaning operations (reference paragraph 11–13). Since the fumes at the edge of the roof are very hazardous, special clothing and breathing apparatus must be worn during this operation (reference paragraph 11–6c). FREQUENCY: MONTHLY.

(4) The base civil engineer (BCE) is responsible for draining floating roofs and interior dike basins in bulk storage tank farms. Certain responsibilities may be delegated to system operators whenever it is considered an advantage to the Air Force. Informal delegation of responsibility for draining floating roofs and dike basins to fuels management person-

nel is not satisfactory. Due to the serious consequences of improper accomplishment of these tasks, delegation must be made by a signed Memorandum of Agreement between the FMO and the BCE. This memorandum must clearly define responsibilities of each organization. A proposed format is shown in attachment 5. Unless a signed Memorandum of Agreement is in effect between the BCE and the FMO, the responsibility for checking and draining roof drains or interior dike basins is not considered significantly delegated and will remain with the BCE. This BCE responsibility involves the following:

(a) During or immediately after a rain, BCE's liquid fuel maintenance (LFM) personnel will drain all water from floating roof and interior dike basins. LFM personnel will continue on-site surveillance. The roof and the dike drain valves must never be opened at the same time. On completing draining, LFM personnel close and secure floating roof and dike drain valves that will remain closed except for the exact period of time required for future drainage. Keys for locks used to secure both the roof drain and dike drain valves will be maintained by LFM personnel. When the temperature of the product or the ambient air temperature drops to freezing or below, LFM personnel will secure the drip tight plug in top center of the floating roof(s). FREQUENCY: AS REQUIRED.

(b) During freezing winter conditions, antifreeze (isopropyl alcohol) solution or deicing fluid will be used in all roof drain lines. LFM responsibilities for winterization areas follows:

1. Fill the floating roof drain lines with antifreeze solution or deicing fluid after 48 hours of 20 degree or lower ambient air temperatures or as designated by the MAJCOM fuels engineer. The roof drain valve is secured and has a metal sign displayed on the valve stating: "CAUTION. WINTERIZED. DO NOT DRAIN." FREQUENCY: AS REQUIRED.

2. Perform tests of antifreeze or deicing fluid solution for proper composition and record results. FREQUENCY: MONTHLY.

(c) The following procedures will be implemented at bases that have problems removing snow from floating roof tanks. These procedures are to be done by LFM personnel to facilitate removal of snow from floating roof fuel tanks when other methods of snow removal are impractical (For example, resupply to maintain floating roof in high position may not always be possible.) FREQUENCY: AS REQUIRED:

1. Drain antifreeze or deicing fluid by gravity flow from roof drain by piping it into partially buried 55 gallon drum(s). The actual number of empty drums needed to hold drained solution will have to be determined locally. FREQUENCY: AS REQUIRED.

2. Shovel snow from the outer periphery of the roof toward center roof drain. A solution of isopropyl alcohol and water should then be applied to melt the snow. Then drain the melted snow through the roof drain piping into the dike. When necessary, a small quantity of urea is applied in the dike area to melt any ice accumulation. This may be needed until the solution evaporates. FREQUENCY: AS REQUIRED.

NOTE: The solution of isopropyl alcohol and water should be prepared in the proportions recommended in AFM 91-14. Solution can then be pumped to the roof using either the 500 gallon M12A-1 decontamination apparatus assigned to BCE or any approved explosion-proof electric or a gasoline drive pump approved by ground safety. If any electrical operated pump is used, and explosion proof receptacle will be required for safety purposes. Under no circumstances will any pumping apparatus be operated within 50 feet of any fuel storage tank. Pumps should be located on the upwind side of the tank and outside the perimeter fencing when possible. Fire department standby operations will not be required when the above criteria are met.

(d) To ensure effective removal of snow when the need arises, each LFM supervisor must make sure that the following items of equipment or materials are available and on hand: FREQUENCY: AS REQUIRED:

1. The pump adequate for pumping solution to roof cover. (Pump to be stored in BCE storage area).

2. Adequate number of empty 55 gallon drums for preparation of alcohol solution and draining of antifreeze from roof drain. (Drums to be stored at fuel bulk storage area. Adequate empty drum(s) will be partially buried at each floating roof drain valve to permit gravity draining and containment of antifreeze or deicing fluid solution.)

3. Lengths of hose necessary to reach roof cover.

4. Street brooms and aluminum shovels as required.

5. A minimum of 100 gallons of isopropyl alcohol for each storage tank having a floating roof.

(e) The BCE must provide the manpower and the equipment necessary to do the following tasks: FREQUENCY: AS REQUIRED:

1. Assemble required equipment and supplies and transport them to the fuel bulk storage area.

2. Setup and operate the pumping devices to be used.

3. Drain or refill the roof drain piping with antifreeze or deicing fluid.

4. Mix solution of isopropyl alcohol (solution will vary depending on outside temperature.)

5. Sweep and shovel snow to center of the roof (repeat as necessary).

6. Apply alcohol solution to the snow around the tank drain (repeat as necessary).

7. Disassemble equipment and return to the BCE storage area.

c. Tank Inspection and Cleaning. (See table 10-2.) These inspections must be done by qualified civil engineering personnel. Tank cleaning and repair work may be scheduled in advance, but the need to clean and repair is based on the result of these inspections. More frequent inspections are allowed only when serious tank, coating, or fuel problems are suspected or known to exist (see chapter 11).

(1) Tank cleaning and inspection criteria are shown in table 10-2 for all aviation fuels. Ground fuel tanks will be inspected when results of discharge line samples exceed solids limits per T.O. 42B-1-1.

(2) Minor deviations in frequency of tank inspections because of nonavailability of tank-cleaning personnel or a bioenvironmental engineer, receipt problems, etc., are permitted for up to 45 days. Periods in excess of 45 days must be approved by the MAJCOM fuels officer and civil engineer. Those locations that have large amounts of dormant storage and cannot rotate the product to empty tanks due for inspection without severe operational problems can request a time extension from their command fuels officer and civil engineer if fuel sample results are satisfactory.

NOTES: 1. During the inspection or cleaning operation on open top type floating roof tanks, the interior roof drain piping and fittings or hose must be checked for leaks. To do this test, make sure the roof drain plug is removed. Then slowly inject water through the roof drain valve located on the side of the tank shell. Roof drain piping must be completely filled with water to get an adequate test. When piping is completely filled, check the interior piping, swing joints, and flanges for leaks. Static head pressure from the water is adequate for this test. If leaks are detected, action must be taken to correct this discrepancy. Intervals for this inspection vary according to information outlined in table 10-2. Results of this test must be reported in the remarks section of AF Form 172, Conventional Fuel System Component and Tank Cleaning Summary.

2. Aviation fuel tanks without manway openings will be altered to provide access for internal inspection.

3. Those tanks being visually inspected through manway openings must be pumped down to remove all possible product. Visual inspection will be performed when tank solids content is determined to be excessive; this is noted by a rapid or unusual rise in differential pressure in downstream filter separator, or an analysis of fuel from continuous line samples taken immediately downstream of deep well pumps and upstream of filter separators indicates high concentration of solids.

4. The heating systems maintenance shop maintains tanks for oil-fired boilers, space heaters, and similar individual heaters, piping, appurtenances, etc., connected to the burner.

5. Table 10-2 applies to aviation fuel only.

10-10. Tank Gages (Bulk Storage Area). Check the tank gage for any accumulation of moisture in the head (gage reading housing); remove moisture if found. Observe the reading for any obvious error in measurement. Adjust, repair, or replace as required. FREQUENCY: ANNUALLY OR AS REQUIRED.

10-11. Tank Vacuum and Pressure Vents (Bulk Storage Area). Inspect, clean, and repair. Perform task outlined in paragraph 2-9. FREQUENCY: SEMIANNUALLY.

10-12. Dikes:

a. Earthen:

(1) Inspect condition for signs of erosion. FREQUENCY: ANNUALLY.

(2) Survey to make sure dikes are of proper size. FREQUENCY: AS REQUIRED.

b. Concrete or Cement Brick. Inspect condition and repair as needed. FREQUENCY: ANNUALLY.

10-13. Piping (General):

a. Exposed (on-Base):

(1) Check all exposed piping, valves, and appurtenances for corrosion. Prepare surface and repaint if necessary. FREQUENCY: SEMIANNUALLY.

(2) Comply with requirements of MIL-STD-161 for identification systems. Repaint when necessary. FREQUENCY: QUARTERLY.

b. System Components. Put the entire components of the fueling system under pressure and test for leaks by starting pumps to maintain pressure on dispensing systems. The following items should be visually checked for leaks at this time. FREQUENCY: QUARTERLY

NOTE: Fuels Management Personnel perform daily leak checks on active systems (TO 37-1-1). Requirements identified above apply only to systems in standby status.

(1) Packing glands on all valves.

(2) Strainer covers.

(3) Plugs and caps on air chambers.

(4) Pump shaft packing glands.

(5) Exposed tank connection and fittings.

(6) Exposed piping (fueling pits, truck fillstands, etc.).

NOTE: Expose any buried gasket to check for leaks. Construct a pit so that the gasket will remain exposed.

(7) Flanges on valves, filter separators, and strainers.

(8) Swing joints.

(9) Surge arrestor.

c. **Underground Piping (Both on and off Base):**

(1) Pressure checks will be done as directed in paragraph 8-11c. FREQUENCY: ANNUALLY.

NOTES: 1. Pressure checks on cross-country pipeline will be made once a year unless sooner checks are determined to be necessary; this will also depend on the operating cycle of the system.

2. The need for pipelines cleaning is indicated by a loss in line efficiency (paragraph 8-6) and will vary with pipe size and liquids transferred. Another important indicator of the need for pipeline cleaning is the difference in sediment content between the product entering and this same product discharging from a pipeline. Cross-country pipelines will be cleaned on an as required basis or whenever differences in sediment or solids content between entering and discharging product exceeds 2 mg gal for JP-4 or 4 mg gal for aviation gasoline.

(2) Hydrostatic Pressure Test. In addition to the above annual pressure test, all underground piping in the POL system will be pressure tested at the 5-year intervals as follows (see paragraph 8-11d): FREQUENCY: EVERY 5 YEARS:

(a) Isolate section to be tested with blind or spectacle flange. NOTE: If block valves will positively hold pressure, flanging is not required.

(b) Using a hydrostatic pump, perform static pressure test at 150 percent of operating pressure for a minimum of 4 hours.

(c) Record pressure every 15 minutes for the first hour, then hourly thereafter. If at the end of steps a, b, and c, no leak is indicated, further testing is not required. If a leak or pressure drop is indicated, then do a flow test. This is done by pressurizing the line to 150 percent of operating pressure, by using the hand hydrostatic pump with a separate reservoir. Measure and record the amount of fluid required to maintain this pressure for a 4-hour period. Send copies of all test results to the appropriate MAJCOM Liquid Fuels Engineer. NOTE: The 5-year test is done in place of the once a year testing. The actual test year for the 5-year test will be determined by the MAJCOM liquid fuels engineer.

★ **d. Submerged Sea Unloading Lines.** Inspect for evidence of leaks and corrosion. FREQUENCY: AS REQUIRED.

NOTE: Hydrostatically test marine lines at 1 ½ times operating pressure each 6 months. Inspect once a year, using a diver to determine the location and the extent of corrosion. Pressurizing a submerged sea hose with compressed air will readily locate the position of any line leaks.

10-14. Off-Base Pumping Stations. Preventive maintenance services of off-base pumping stations vary greatly with types of equipment and method of operation. Applicable maintenance forms will be prepared by the civil engineer for each pumping station under his or her control. FREQUENCY: AS REQUIRED.

★ **10-15. Pumps (General).** (Operating and defueling tanks, bulk storage area, control pits, tank car and truck unloading area, piers, and wharves):

a. During regular maintenance, check for unusual noise or vibration indicating trouble in motor or misalignment of pump rotors or shaft. Check motor and bearings for local heating. Check pump glands for leak and local heating. FREQUENCY: QUARTERLY OR AS REQUIRED.

b. Lubricate, if necessary, with lubricant recommended by pump manufacturer. This will be performed by LFM personnel only. FREQUENCY: QUARTERLY OR AS REQUIRED.

c. Check unusual noise or vibration (see a above). If necessary, adjust packing to prevent leakage. FREQUENCY: QUARTERLY OR AS REQUIRED.

d. Adjust or replace seal. FREQUENCY: AS REQUIRED.

★ **10-16. Valves.** (Operator maintenance identified in TO 37-1-1):

a. Lubricated Plug (General). Inspect all lubricated plug valves for ease of operation. If plug valve sticks or freezes, tighten packing gland and apply lubricant under pressure until plug lifts from seat (paragraph 2-29a). If the plug cannot be loosened, remove the valve for overhaul. FREQUENCY: QUARTERLY.

b. Nonlubricated Plug (General). Inspect for ease of operation. Adjust packing and lubricate gearing with lubricant conforming to Specification VV-L-757, Grade 2 (see paragraph 2-29b). FREQUENCY: AS REQUIRED.

c. Gate (General). Adjust packing gland on gate valves, nozzle valves, and the like as required to prevent leakage. Repack when necessary, using fuel resistant packing recommended by the manufacturer (see paragraph 2-31). FREQUENCY: AS REQUIRED.

d. Ball (General). Inspect for ease of operation, adjust packing (see paragraph 2-30). FREQUENCY: AS REQUIRED.

NOTE: Maintenance of these valves will be done by BCE maintenance personnel (LFM) only during repair of valve or on special request from the fuels management office (FMO).

e. Liquid Level Gage and Low Level Control (Paragraph 3-9). Operating Storage Tanks. In horizontal operating storage tanks up to 80,000 gallons capacity, these internal tank components will be checked twice a year except when maintenance records indicate adjustments and repairs have been required more often than every 6 months. Quarterly checks will be made in these instances. Vertical operating storage tanks up to 31,500 bbls capacity will be checked when tanks are emptied for scheduled inspections or repairs. Check operation of low pump stops when liquid level drops about 13 inches of fuel. Internal components of gage and control systems will be checked for condition when any tank is down for cleaning or for gage component inspection. FREQUENCY: SEMIANNUALLY OR AS REQUIRED.

f. High Level Control Valve (Paragraph 3-10). Operating Storage Tanks. When the tank is being filled, check for proper operation of high level control valve to ensure that fuel flow into tank stops when level of fuel reaches approximately 11 inches below top of tank. In horizontal operating storage tanks up to 80,000 gallons capacity, these internal tank components will be checked twice a year except when maintenance records indicate adjustments and repairs have been required more often than every 6 months. Quarterly checks will be made in these instances. High level control valves and alarm systems on all vertical operating storage tanks must be operationally checked twice a year. Internal components of tank alarm and shutoff systems must be checked when tanks are emptied for scheduled inspections, cleaning, or repairs. FREQUENCY: SEMIANNUALLY OR AS REQUIRED.

NOTE: All high level control valves on Type I Panero Hydrant Systems will be checked or tested in the same manner in which they usually operate. If the high level control valve closes only when the fuel is pumped from bulk storage, then this valve can be tested by pumping between tanks. If the high level control valve is used under conditions of gravity flow, then it will be tested under gravity flow only. Fuels management personnel will provide a tank truck in order to do gravity flow checks.

g. Dual Rate of Flow Control Valve, for Defueling System II, (Paragraphs 4-8 and 4-9). Test automatically while defueling aircraft or truck through hose cart. With the solenoid control deenergized, the rate of flow control valve should be set to control defueling rate of 180-200 gpm regardless of any rise in line pressure to the valve. (Note flow rate by observing meter on hose cart.) Flow rate can be varied, by turning adjusting screw on high flow control. Similarly, with the solenoid control energized, the rate of flow control valve should not permit any flow greater than about 50 gpm. Observe flow rate through hose cart meter. Flow rate can be varied by turning adjusting screw on low flow control. Consult the manufacturers manual for more detailed information and instructions. FREQUENCY: ANNUALLY.

NOTE: After hydrant system has been modified with the magnetic control switches (paragraph 4-14b note) the slow rate (50 gpm) is no longer required. Only testing for the 180 to 200 gpm rate is required.

h. Refueling Control Valve (System II), (Paragraph 4-7). This valve serves four functions listed below with individual test procedures: FREQUENCY: QUARTERLY:

(1) Pressure Reducing, energize solenoid control and simulate fueling conditions. Valve should open and maintain its discharge pressure at a constant preset pressure regardless of flow rate. This pressure can be varied by turning the pressure control pilot adjusting screw.

(2) Surge Shutoff. While fueling normally, close downstream shutoff plug valve quickly. Downstream pressure rise observed should be very slight above the normal controlled pressure while fueling.

(3) Excess Flow Shutoff. Using test procedures outlined in attachment 4, the refueling control valve should close when the predetermined setting is reached. See the manufacturer's manual for flow rate shutoff setting adjustment. The operation of this valve should be observed. It should reopen until the manual reset button has been actuated.

(4) Solenoid Shutoff. With solenoid control pilot deenergized, valve should remain closed tight, stopping all flow. When solenoid pilot control is energized, main valve should open and allow normal fueling.

i. Defueling Control Valve (System II, Paragraph 4-8). FREQUENCY: ANNUALLY.

(1) During a defueling operation, when solenoid control is energized, valve should open wide during defuel. Observe valve position indicator (VPI) on top of valve.

(2) Similarly, when solenoid pilot control is deenergized, the defueling control valve should close tight. Observe closing of valve by VPI on top of valve. All flow will be stopped.

(3) Repeat this procedure at least 5 times. Valve should function smoothly with no sticking or binding.

j. Combination Dual Pressure Relief, Solenoid Shutoff and Check Valve for Modified System II (Paragraph 4-10). FREQUENCY: QUARTERLY:

(1) Apply pressure to inlet greater than the high pressure relief control setting. Control should open valve to relieve excess pressure. Control should be set at approximately 97 psi.

(2) When pumps are stopped, check lateral pressure, 5 psi should be maintained. Pressure can be changed by adjusting the low pressure relief control.

k. Automatic Fueling and Defueling for System I (Paragraph 3-4). Test automatically, fueling and defueling valve hydrant System I. By reading the pressure gage downstream from the valve, determine whether the valves are maintaining the desired delivery pressure while fueling, and whether the defueling valve is functioning as a pressure relief valve. To check the defueling relief function of valve, pump against a closed head and observe the pressure gage. The pressure should not rise above the pressure observed when fueling. FREQUENCY: QUARTERLY.

1. **Pressure Relief.** Block the section of piping that is protected by the relief valve and apply a pressure equal to, or above, the opening pressure of the valve. The indicator on top of the cover indicates the position of the valve. Repeat this test 5 times, to ensure proper working of the valve (paragraph 4-12). FREQUENCY: ANNUALLY.

m. **Individual fueling and defueling control valves.** (Original type I system, see paragraph 3-7.) FREQUENCY: QUARTERLY.

(1) Fueling Valve. Follow procedures outlined in paragraph 10-16h.

(2) Defueling Valve:

(a) During a defueling operation, when solenoid pilot control is deenergized, valve should open wide during defuel. Observe stem indicator on top of valve to check this.

(b) Also, when solenoid pilot control is energized, the defueling control valve should close tight. Observe closing of valve by stem indicator on top of valve. All flow will be stopped.

(c) Repeat this procedure at least five times. Valve should function smoothly with no sticking or binding.

(d) During the fueling operation when the defueling valve is usually closed it will serve as a pressure relief valve when the pressure at the inlet of the valve rises above the set pressure of the relief pilot valve. If excess pressure is observed, check pressure relief control for proper operation.

NOTES:

1. All diaphragm actuated valves not listed above should be tested according to the manufacturer's instructions or quarterly if no information is available to ensure proper operation.
2. All sensing lines on diaphragm actuated valves must be inspected for and, if necessary, modified to include self-cleaning strainers.

n. **Fuel Discharge Valve** (discharge of filter separator, see paragraphs 2-13a(4) and 2-21, and figures 2-22 and 2-28). Perform flow testing to ensure the vessel and filter elements are not subject to excess flow rates. The following filter element flow rates are to be used to determine actual filter vessel capacity:

NSN	*Flow Rate Each*
4330-00-983-0998	20 gpm
4330-00-804-1502	25 gpm
4330-00-937-2071	10 gpm
4330-00-856-0518	74 gpm
4330-00-737-0225	50 gpm
4330-00-768-5347	36 gpm

Do not use the vessel rating alone to determine capacity. Example: If 24 each 10 gpm elements are installed in a 300 gpm vessel, the operational capacity is 240 gpm. If the total element flow rates are higher than the vessels rating, do not exceed the working gpm rating of the vessel. FREQUENCY: QUARTERLY.

10-17. Filter Separator:

a. **Filter Separator Element.** Replace elements at differential pressure PSI or time in months listed below, whichever occurs first: FREQUENCY: See table 10-1.

b. **Filter Separator Fuel Discharge Control.** Test filter separator fuel discharge control valve by allowing water to build up in separator sump to point of shutoff. (Follow procedures outlined in chapter 2.) Observe the water level in the sight glass and replace float if necessary. Drain remaining water from the separator through the manual valve after test is complete. When replacing elements, clean interior surfaces of the filter separator vessel. FREQUENCY: WHEN ELEMENTS ARE CHANGED.

c. **Water Drain.** Perform check specified in chapter 2. section D, making certain that the fuel discharge valve is closed before initiating test. Drain water and clean filter separator strainers. FREQUENCY: WHEN ELEMENTS ARE CHANGED.

NOTES:

1. Filter separators not equipped with a site gage to determine water level in the sump should be modified to include this requirement.
2. Excessive pressure in the filter separator is usually caused by thermal expansion of fuel within a closed and blocked system. Filter separators subjected to the direct rays of the sun should be modified with a pressure relief valve to eliminate this condition.

10-18. Micronic Filter. (Dispensing Area, or Filter Meter Pit.) Filter element replacement is mandatory when differential pressure across the filter elements reaches the maximum limit prescribed by the manufacturer's data plate, or after 2,000,000 gallons of fuel have been dispensed through the filter, whichever occurs first. FREQUENCY: AS REQUIRED.

10-19. Surge Arrestor (General). Maintain according to the manufacturer's instructions. Air type surge arrestors usually require periodic draining. Diaphragm types usually require checking of diaphragm pressure to determine whether the manufacturers' overall pressure requirements are being maintained. A pressure that is lower than, or equal to, the fuel pressure indicates a leak in the diaphragm. FREQUENCY: WEEKLY.

10-20. Truck Fillstand Swing Joints. Grease ball bearing swing joints with grease, general purpose Number 1, (CGL), Specification Number VV-G-632. FREQUENCY: MONTHLY.

NOTE: Greasing of swing joints is usually performed by operator personnel; however, LFM personnel may do this service.

Table 10-1. Filter Element Chart.

Vessel Nomenclature And Specification	*Filter Element Change Criteria*	*(Element) National Stock No.*	*End Item Application*
(1) Filter Separator Liquid Fuel FFU-1/E MIL-F-27629	20 PSI DIFF PRESS OR 3 YEARS	4330-00 983-0998	Fixed Hydrant Refueling Systems, Pumphouse, Truck Fillstands, etc.
(2) Filter Separator Vessel Liquid MIL-F-52666	20 PSI DIFF PRESS OR 3 YEARS	4330-00 983-0998	Fixed Hydrant Refueling Systems, Pumphouse, Truck Fillstands, etc.
(3) Filter Separator Liquid Fuel FFU-2/R MIL-F-27630	20 PSI DIFF PRESS OR 3 YEARS	4330-00 983-0998	Fixed Hydrant Refueling Systems, Pumphouse, Truck Fillstands, etc.
(4) Filter Separator Liquid Fuel FFU-25/E MIL-F-83402	15 PSI DIFF PRESS OR 3 YEARS	4330-NL	Pressurized Fixed Hydrant Refueling System (Types III and IV) for USAFE Horizontal filters separators change element to 20 PSI or 3 years,
(5) Filter Separator Liquid Fuel FFU-16 FFU-22 FFU-24 MIL-F-83243	15 PSI DIFF PRESS OR 3 YEARS	4330-00 983-0998	Panero Hydrant Refueling Pit Filter Replacement
(6) Filter-Element Fluid, Fuel Pressure FFU-3/E To be modified under either Specification MIL-M-83328 or MIL-M-83329 (KMU-416/F or KMU-417/F kits)	20 PSI DIFF PRESS OR 2 YEARS *AFER MODIFIED* 25 PSI DIFF PRESS OR 3 YEARS	4330-00 768-5347 (Element) 4330-00 983-0998	Horizontal Filter Vessels Installed in Hydrant Refueling System Pumphouse, Truck Fillstands.
(7) Filter-Element Fluid Pressure FFU-5/E MIL-F-27707	20 PSI DIFF PRESS OR 3 YEARS	Element 4330-00 804-1502 CANISTER 4330-00 168-1703	Fixed Hydrant Refueling Systems, Pumphouse, Truck Fillstands, etc. Vertical Units.
(8) Filter Element Luquid Fuel MXU-233/F MIL-F-38007	20 PSI DIFF PRESS OR 2 YEARS	4330-00 973-2071	Fixed Hydrant Refueling System Vertical Unit
(9) Filter Element Liquid Fuel MSU-234/X MIL-F-38008 to be modified under either Specification MIL-M-83328 or MIL-M-83329 (KMU-41 6/F or KMU-417/F kits)	20 PSI DIFF PRESS OR 2 YEARS *AFTER MODIFIED* 25 PSI DIFF PRESS OR 3 YEARS	4330-00 856-0518 4330-00 983-0998	Fixed Hydrant Refueling Systems Horizontal Units
(10) Filter Separator Element Kit Liquid Fuel FFU-11/E MIL-F-38009	20 PSI DIFF PRESS OR 3 YEARS COALESCER SEPARATOR	4330-00 *001-6315* 4330-00 001-6314	Horizontal Filter Separator Installed Fixed Hydrant Refueling Systems Truck Fillstands
(11) Filter Element Liquid Fuel 153/E MIL-F-27707	20 PSI DIFF PRESS OR 3 YEARS	4330-00 804-1502	Fixed Hydrant Refueling Systems Vertical Unit

NOTES:

1. Follow procedures in chapter 2 for the actual removal of cartridges from filter separator vessels and for stenciling requirements.
2. All filter separators (vertical and horizontal) installed in transfer lines will have elements changed at "25 PSI DIFF PRESS," or 36 months, whichever occurs first.

10–21. Electrical and Static Grounding:

★**a. Ground Cables** (Tank car, and tank truck unloading area, truck fillstands, fuel dispensing areas, piers, wharves). Inspect the ground cable connection points, wires and clips for condition. Replace the cables immediately if insulation or wires are damaged or broken and repair any damaged cable-ground connections. FREQUENCY: QUARTERLY.

★**b. Ground Connections (Bulk Storage Aboveground Tanks):**

(1) Visually inspect ground connections around periphery of base, tighten and clean any loose or corroded connection. FREQUENCY: QUARTERLY.

(2) (Floating Roof Tanks Only). Visually inspect the ladder bonding connections for tightness and condition of cable. FREQUENCY: QUARTERLY.

c. Rail Car Offloading Spur:

(1) Visually inspect rail joint bonding to ascertain that jumpers are intact at each joint. FREQUENCY: QUARTERLY.

(2) Visually inspect insulating rail joints for condition to make sure that fuel off-loading area is insulated from main rail systems. FREQUENCY: MONTHLY.

d. Disconnect Switches. (Power Control Center, Pumprooms, Piers, Unloading Area). Operate the disconnect switches several times to ensure ease of opening and closing circuit. Inspect the fuse clips, switch blades, and connections for condition and security of contacts. FREQUENCY: MONTHLY.

★**e. Starters and Contractors** (Power Control Center, Pumprooms, Piers, Loading Areas). Inspect all of the starters, contractors, and circuits. Inspect the contacts for local heating and condition of contact surface. Check the overload heaters and coils for local heating or discoloration. If roughness or pitting is evident, contacts will be cleaned by methods recommended by the electrical work center. FREQUENCY: ANNUALLY.

★**f. Wiring and Fuse Boxes.** (Same as above.) Inspect all exposed wire, conduit, fuse boxes, and switches for safe condition. FREQUENCY: ANNUALLY.

g. Ground Conductors. (See chapter 1, sections F and G.) Test the resistance of all of the ground conductors. Record test results. FREQUENCY: ANNUALLY (Electric Shop)

h. Emergency Switches. Check for proper operation by actually operating all emergency stop switches. FREQUENCY: QUARTERLY.

NOTE: Visual inspections and operational checks will be performed by LFM personnel. Actual ohm continuity, multimeter testing, and marking, will be done by qualified electric shop personnel.

10–22. Meters. Meters must be calibrated at intervals and in the way prescribed below. Calibration of installed meters is the responsibility of the LFM shop. The LFM shop will maintain meter calibration records on installed meters using embossing tape or stencil to include calibration due date and gallons dispensed. Calibration of mobile unit meters is the responsibility of the motor vehicle maintenance shop. The responsibility for calibration of installed meters may be delegated by base civil engineer to the motor vehicle maintenance shop whenever considered advantageous to the Air Force, and will be done by a Memorandum of Agreement:

★a. Calibration should be done each year.

b. Any time when improper performance is suspected; when unusual sounds or peculiar register actions develop; and after repairs and inspections that might affect their performance in any way.

c. Those meters with drain plugs will be drained of water and sediment once a week. FREQUENCY: WEEKLY. (Operator Maintenance.)

10–23. Signs and Markings:

a. Location of signs and markings should be recorded to facilitate ease of inspection. Check for condition, adequacy, possibility of deleting obsolete signs, and necessity of additional signs. FREQUENCY: MONTHLY.

b. Make sure installed fuel facilities (such as pipelines, tanks, fillstands, etc.) are properly marked according to current MIL–STD–161. FREQUENCY: MONTHLY.

NOTE: All safety or warning signs located in and around fuel storage and operating areas will conform to information outlined in AFOSH Standards, and TO 37–1–1. Warning signs for these areas are worded as follows: NO OPEN FLAME OR IGNITION SOURCE PERMITTED BEYOND THIS POINT. The sign is placed on the security fences surrounding the area. In those instances where security fences are not provided, signs will be posted 50 feet from the diked area or fuel vents of underground storage tanks. The number and location of these signs will be determined by the base civil engineer.

★**10–24. Pressure Gages.** Each pressure gage (calibrate differential pressure gauges according to manufacturer's recommended schedule) will be tested and calibrated at least once a year, or more often as indicated by obvious malfunctioning (such as erroneous readings). Testing and calibration should be done by the civil engineer work center or base precision measurement equipment laboratory (PMEL), using embossing tape or stencil including calibration due date for maintenance of calibration records. Piston type differential pressure gages do not require calibration. FREQUENCY: ANNUALLY.

10–25. Cathodic Protection. Cathodic protection systems are maintained by electric shop personnel. General information is in chapter 9. Maintenance of cathodic protection systems is covered in AFM 85–5. FREQUENCY: AS REQUIRED (Electric Shop).

10–26. Tank Entry Safety Equipment. Tank entry safety equipment for personnel entering hazardous areas (masks, blowers, boots, goggles, etc.) is inspected before issue and at turn in for cleanliness and serviceability. These inspections are necessary for protecting personnel entering hazardous areas and to prevent damage from improper storage (also see chapter 11). FREQUENCY: ANNUALLY OR BEFORE USE.

10–27. Fuel Conversions in Storage Dispensing Systems. See TO 42B-1-1 and MIL-HDBK-201 for procedures to follow when converting systems from the use of one fuel to another. FREQUENCY: AS REQUIRED.

Table 10–2. Tank Inspection Chart (Aviation Fuels).

Tank Nomenclature	Inspection Frequency
Bulk Storage	4 years
Bulk Storage w/Filter Separator or Micronic Filter on Inlet OR Internal Coating	6 years
Bulk Storage w/Filter Separator or Micronic Filter or Inlet AND Internal Coating	8 years

NOTES:
1. For bulk storage with direct receipt of fuel from barge or tanker, frequencies will be 3, 5, and 8 years, respectively.
2. For operating tanks, frequencies will be 3, 5, and 8 years respectively.
3. All inspections will be by physical entry.
4. Filter separator/micronic filter will be within 1 mile from base.
5. JPTs and JP–7 tanks will be cleaned at the time of scheduled entry regardless of tank condition.
6. Tank inspection for all fuels may be more frequent if sample results indicate contamination in excess of those use limits in T.O. 42 B–1–1 and T.O. 42 B1–1–16.

Chapter 11

ENTRY FOR INSPECTING, CLEANING, REPAIRING, COATING, AND STRAPPING LIQUID PETROLEUM TANKS

SECTION A—INSPECTION AND CLEANING

11-1. General Information. All petroleum storage tanks will be considered to have at one time contained leaded gasoline unless accurate records to the contrary are available. The tank cleaning supervisor will reproduce sufficient copies of the checklist included as attachment 3, for use during tank work. This checklist will be used to ensure that all safety precautions are followed and that all areas of concern are presented.

a. **Personnel Hazards.** Anyone engaged in the cleaning of petroleum storage tanks may suffer accidental injury as a result of:

(1) Explosion or fire (paragraph 1-21).

(2) The presence of toxic liquids, vapors, or dusts (paragraph 1-16).

(3) An excess of petroleum vapor or a deficiency of oxygen.

(4) Physical hazards, such as:

(a) A discharge of petroleum products into a tank while people are at work.

(b) Failure to use personal protective equipment.

(c) Dropping of swing lines.

(d) Objects that fall from the upper part of a tank.

(e) Falling from scaffolding, stairways, or ladders.

(f) Falling from or through the roof of a tank.

(g) Tripping over hose lines or over other objects.

(h) Slipping on tank floors.

(i) Colliding with structural tank supports or piping.

(j) Structural failure of a tank or its appurtenances.

(k) Insufficient light or defective electrical cord.

(l) Failure to use good judgment.

b. **Sources and Causes of Explosions and Fires:**

(1) Basic principles of combustion are discussed in paragraph 1-21.

(2) Mixtures of petroleum vapor and air in certain limits can be ignited. For gasoline vapors in air, these limits are approximately 1 percent and 7.6 percent by volume: JP-4 fuel is in the explosive range at temperatures of $-10°$ to $+80°F$. Combustible gas or vapor indicators are used to measure the percentage of petroleum vapors present in air. The manufacturer's instructions on the use of such equipment should be consulted. (See paragraph 11-5c.)

(3) Ignition does not occur in fuel vapor and air mixtures that are richer than the upper flammable limit or leaner than the lower flammable mixtures. Such mixtures may be ignited and burn at points of escape at hatches, manholes, or other openings. At these points, air is present in sufficient quantity to dilute the "rich" vapors and produce a flammable mixture.

(4) A tank may contain a "rich" mixture after fuel has been removed. A mixture "too rich" for ignition in a closed tank may quickly reach the flammable range after the tank has been opened, and when the mixture has been diluted with air.

(5) Even after vapor concentration is below the lower flammable limit, flammable mixtures again may be formed by the admission of vapor or fuel from other sources, as through an unblanked line or connection, a leak in the bottom of the tank, or the evolution of vapor within the tank (for example, from sludges, sediment, sidewall scale, hollow roof supports, oil-soaked wooden structures, or other absorbent materials). Tanks are very rarely ventilated to the point that they have been vapor freed.

(6) Vapors that issue from a shell manhole may travel a considerable distance from the tank. (Petroleum vapors are heavier than air.) Any source of ignition may ignite such vapors, and the resultant fire may flash back.

c. **Toxic Hazards:**

(1) Leaded Compounds. Tetraethyllead (TEL) and other organic lead compounds contained in gasoline pose a health hazard to personnel cleaning storage tanks. Lead compounds may be present in residual fuel, and deposits may accumulate in the tanks. These compounds may exist as vapors from the liquid fuel or solid deposits may be dispensed into the air in the form of dust particles during scraping or abrasive cleaning procedures. If welding is performed, the lead may be present in fumes. The use of proper respiratory protection protects against inhalation hazards. Organic lead compounds are also readily absorbed through the skin. Thus, this route of exposure must also be prevented.

NOTE: All tanks that have been used for the blending or storage of gasoline to which TEL has been added should be considered as a potential lead hazard throughout the cleaning process, regardless of whether they have been freed of hydrocarbon vapors. A gasoline-vapor-free tank is not a lead-vapor-free tank.

(2) Benzene. All fuels contain benzene to some degree (1.0 percent to 5 percent by volume). Gasolines usually contain higher concentrations of benzene that do JP-4 or heavier distillate fuels; however, the toxicity of benzene is such that even when present in fuels in very low concentrations, it must be considered the controlling vapor hazard during fuel handling. This is particularly true in confined spaces such as petroleum storage tanks. AFOSH Standard 161-7, Exposure to Benzene, discusses the hazards and precautions required during potential benzene exposures. Because the exact concentration of benzene in fuels varies from batch to batch and refiner to refiner, it is impossible to specify a single permissible exposure level for fuel vapors below which work may be done in a tank without using an atmosphere-supplied respirator. This will have to be determined by specific measurements of air contamination on a case-by-case basis.

(3) Oxygen Deficiency. All tanks are usually oxygen-deficient from the mere displacement of air by hydrocarbon vapors, aside from the consumption of oxygen resulting from tank metal oxidation. No one should enter such a tank before it has been vapor freed without wearing an approved supplied air respirator (see AFOSH Standard 161-1).

d. Excess Fuel Vapors and Deficiency of Oxygen:

(1) If fuel vapor in strong concentration is breathed, a reaction results that produces a stage of excitement leading to unconsciousness (similar to that produced by alcohol or chloroform). Although with rest and fresh air there may be recovery in a few hours, all physical reactions resulting from fuel-vapor inhalation should be reported promptly to a physician. If breathing has stopped, artificial respiration should be applied by a competent person before medical attention.

(2) The maximum safe concentration of fuel vapor in air is controlled by the amount of benzene in the fuel. The maximum 8-hour, time-weighted average (TWA) airborne concentration of benzene to which personnel may be exposed is ten parts per million. Personnel entering a tank should wear a hose mask of the blower type unless it has been determined that an unprotected exposure would not exceed the TWA.

(3) When first opened, tanks are usually oxygen deficient because of displacement of air by hydrocarbon vapors, aside from the consumption of oxygen resulting from tank metal oxidation. No one should enter such a tank before it has been vapor freed, without wearing appropriate respiratory protection. This means that the fuel vapor content should be essentially 0 percent LEL for both leaded and unleaded tanks.

11-2. Personnel Selection:

a. Tank Entry Supervisor. The major command (MAJCOM) liquid fuels engineer will certify or license certain base level liquid fuels maintenance (LFM) personnel as qualified to supervise liquid fuels tank inspection or cleaning according to requirements prescribed herein. This individual is responsible for all aspects of a tank inspection or cleaning operation.

(1) Tank cleaning by Air Force personnel (military or civilian) will be supervised by qualified civil engineer LFM personnel who have been certified or licensed by the command liquid fuels engineer. A medical service bioenvironmental engineer (AFSC 9124), environmental health superintendent (AFSC 90790), or health technician (AFSC 90770), referred to hereafter as the bioenvironmental engineer, will be designated by the command surgeon to help him or her on medical aspects affecting tank inspection or cleaning. Assistance may also be requested from base ground safety or fire department as deemed necessary by the tank cleaning supervisor.

(2) Tank cleaning by contract will only require surveillance by a command certified tank entry supervisor, who is certified by the command liquid fuels engineer.

b. Physical Requirements (All Tank Entry Personnel):

(1) Prior to tank cleaning operations, an AF Form 422, Physical Profile Serial Report, or an appropriate medical statement from the local medical facility stating that the applicant meets or exceeds the following criteria for PULHESX (see AFR 160-43), must be obtained for each individual (military or civilian) scheduled for tank entry. Medical statements are valid for 1 year.

(2) Poor health, colds, fatigue, overheating, or lowered physical resistance from any source increases a person's susceptibility to hazards encountered in tank inspection or cleaning.

(3) Psychological Requirements. Anyone with a medical documented history of claustrophobia will be disqualified from entering any tank for inspection or cleaning.

★**c. Training (Supervisor).** The MAJCOM should certify individuals after they have completed ATC Tank Entry Supervisor Course or MAJCOM equivalent training. Retraining should be accomplished as determined by the MAJCOM Fuels Engineer.

11-3. Preentry Safety Briefing. All personnel involved will be briefed by the tank entry supervisor before the start of a tank inspection or cleaning operation. As-built drawings will be reviewed by the supervisor for any tank components or appurtenances considered hazardous to personnel, together with all other potential hazards and emergency procedures.

11-4. Housekeeping:

a. General Area. The manhole and adjacent area will be kept clean of any equipment or material that would hamper rescue operations in an emergency situation.

b. Equipment Cleaning. At the end of each day and upon completion of the job, gloves, boots, and all parts of mask sets (including hoses, harnesses, and life lines) will be washed with warm water and soap, dried to prevent deterioration, and be ready for reuse. All tools and equipment will be cleaned of residual material daily during tank operations.

11-5. Tank Entry Equipment:

a. Electrical Equipment. All electrical equipment and conductors to be used within 50 feet of any fuel pipes or storage tanks, or where a hazardous accumulation of flammable vapors may exist, will be Class I, Division I, Group D, with maximum temperature rating of "T2D" - 419°F, as defined in the National Electrical Code for use in hazardous (explosive) areas.

b. Gasoline Engine Driven Equipment. All gasoline engine driven equipment used in a tank cleaning operation will be equipped with a flame arrester and a protected ignition system.

c. **Combustible Gas (Vapor) Indicator**. The manufacturers of combustible gas or vapor indicators have used various descriptive trade names. These have lead to the acceptance in the industry of the following terms: "Vapor indicator," "Explosion meter," "Combustible-gas indicator," "Gas indicator," and "Gasoline-vapor indicator." The instruments used to detect a vapor-air mixture will be equivalent to MSA's Model 2A or R2, NSN 6665-00-941-6554 for unleaded petroleum vapors and Model 5 instrument for leaded petroleum vapors.

d. **Air Movers**. All air movers used will be of the eductor type capable of educting vapors from the tank, and will be either explosion-proof electrically operated or air driven.

e. **Portable Lights**. Explosion-proof portable battery-powered lights are the only lights authorized for tank entry.

11-6. Personnel Clothing and Equipment. The tank cleaning supervisor makes sure that all necessary clothing and equipment is on hand. Clothing and equipment will be inspected and approved before actual tank work. The tank cleaning supervisor makes sure that the equipment includes (but is not limited to) the following:

a. Acid-resisting rubber gloves, (gauntlet type) and boots, for each person entering or working inside the tank or handling sludge materials on the exterior of the tank. If liquid depth is over 6 inches, ¾-length is preferred, however, knee-length boots can be used. One extra pair of each will be available for emergency use.

(1) Before using, boots and gloves will be inspected to make sure they are made of a material impermeable to tetraethyllead (acid proof rubber) and that they are in serviceable condition. Boot soles should be inspected for excessive wear, to prevent slipping while inside the tanks. Gloves should be pliable to ensure against cracking while in use.

b. Two changes per person of underwear, cotton coveralls (light color preferred), and painter's cap or equivalent.

NOTE: NSN 8405-00-037-9184, coverall, cotton sateen white, knitted closure bottoms and wrists, size x-small is for basic allowance in TA 016 part B. For other sized items refer to stock list for NSN.

(1) Anyone in a tank is to wear clean clothing from the skin outward, as well as the prescribed gloves, boots, harness and mask. Outer clothing must meet requirements mentioned above. All clothing should be changed and laundered each day. A hot soapy bath should be taken every day at the end of the day's work and when the job has been completed. If at any time clothing becomes soaked with gasoline or sludge, such clothing should be removed promptly after the worker is outside the work area and away from explosive vapors and ignition sources. Clothing that has been heavily contaminated will not be removed until completely drenched in water. Clothing will be removed slowly to prevent buildup of static electricity. Remove jet fuel and gasoline from the skin by washing or showering with soap as soon as possible after contact. A bath should be taken promptly, followed by a complete change to clean clothing. Before food or tobacco is handled, outer clothing (coveralls) should be removed, and face and hands should be washed thoroughly.

(2) Before using, inspect coveralls to make sure they are not equipped with metal fasteners, and that the coveralls are in serviceable condition.

c. Supplied air respirators for tank cleaning operations will be selected and used according to AFOSH Standard 161-1, Respiratory Protection Program. In addition to the respirators provided for the people inside the tank, one extra respirator will be available for emergency use. One approved-type phone and one mask phone attachment will be provided and used when cleaning underground tanks larger than 50,000 gallon capacity, or when manhole accesses are deeper than 10 feet from ground (working) level.

(1) The face piece (mask) will be visually inspected for holes, tears, or breaks in mask; stretched or torn straps; damaged buckles; aged rubber; cracked lens; and loose clamps. All loose clamps will be tightened and damaged parts replaced. If the mask is unrepairable, it will be discarded. The breathing tube(s) will be checked for holes or weakness by blocking one end and blowing in the other end with some pressure. If pressure does not hold, replace the faulty tube(s).

NOTE: Prescription lenses or spectacle kits are available from the manufacturer.

(2) Communications equipment will be compatible with approved respiratory protective equipment. Communications equipment will be labeled by Factory Mutual or Underwriter Laboratory as intrinsically safe for class I, division I, group C and D of the National Electric Code.

d. Hoses and Air-Lines. The hose for the blower type mask or the air-line for other supplied air respirators have a limited life and must be of a material impermeable to gasoline (acid-proof rubber). All sections of hose or air-line will be tested by manual flexing.

(1) If the hose or air-line is stiff or shows signs of cracking, it should be discarded. It should be noted that these respirators are approved as a complete unit, such as, the hose or air-line, mask regulator, etc.

(2) When a component must be replaced, it

must be replaced with an identical item (same manufacturing and part number), otherwise the approval is voided.

(3) Deteriorated gaskets in air hose connections will be replaced.

(4) The length of hose or air-line for each mask will not exceed the NIOSH approved length, unless specific approval has been obtained from the bioenvironmental engineer or a designated representative.

(5) Air-line or hose must be inspected to make sure there are no restrictions or leaks and to ensure air is freely discharged from the hose outlet.

NOTE: Hose and masks, when prepared for storage, will be cleaned and carefully put in their carrying cases, properly identified by tag or markings on the case, and placed in an accessible, safe, and fairly cool (40-70°F) place (See AFOSH Standard 161-1).

e. Only Type "A" or "C" NIOSH approved respirators will be used for Air Force Petroleum tank cleaning operations. The blower is equipped with a calibrated pressure release valve to provide even flow and a bypass valve, that operates automatically to permit wearer to breathe through the hose in the event of blower stoppage.

CAUTION: Portable oxygen tanks and masks, portable gas masks or "walk-around" oxygen bottles and masks will not be used by personnel cleaning Air Force petroleum storage tanks.

★f. Safety harness (leather or cotton webbing only for type A respirators) for each person working inside the tank, plus one extra for emergency use. (NSN 4240-01-009-8634 or MSA number 5272 or 8478.)

(1) Safety harnesses will be inspected before use to ensure the maximum useable time does not exceed 10 years from the date on the metal tag located on back of harness.

NOTE: Harnesses without metal date tags will be considered to be 10 years old and will be discarded as prescribed in (2) below. Harness constructed of leather is inspected for the following defects, any of which is cause for rejection of the piece of equipment being inspected:

(a) Deep cuts or deep open scratches and cracks.

(b) Damaged grain.

(c) Loose or missing rivets or stitching.

(d) Open holes or tears.

(e) Burnt leather.

(f) Broken, cracked, or deformed D rings, snaphooks, plates, and buckles.

(g) Snaphook keeper latch—bent, broken, or missing.

(2) Harnesses are inspected before use or periodically, not to exceed 1 year. Harnesses found to be unserviceable as a result of inspection will be tagged as condemned property. To prevent reuse they shall be rendered useless by cutting across webbing on straps.

g. A dacron or nylon life rope of required length for use when inspecting or cleaning an underground tank, or aboveground tank with no ground level manholes. The use of life ropes on an aboveground tank is optional, provided ground level manholes are available for use. On all other tanks, the rope need not be attached to the personnel harness, but one end will be attached to the manhole or adjacent to it; the other end will be coiled and tied with a breakable cord at the bottom of the tank access ladder. Tank cleaning personnel will wear a wrist-type harness assembly equal to that shown in MSA catalog as number 46510 (NSN 4240-00-498-5342). When an emergency situation arises requiring removal of these personnel from the tank, the end of the life rope located at the bottom of the ladder will be hand carried over the "prone" individual and attached to the wrist harness assembly. He or she can then be pulled out of the tank.

(1) Life-lines (ropes) shall have a 5-year service life from date of use. They must be inspected and identified or marked before being used and checked for the following defects, any one of which is basis for rejection:

(a) Any cut, chafe, or nicks.

(b) Bulged strands.

(c) Knots in individual strands.

(d) End fittings not properly attached—(severed, spliced, wrapped, etc.).

(e) Abnormal weakness detected visually.

(f) Discoloration or rotting.

(2) The wrist harness will be inspected according to the same instruction for safety harnesses outlined in f above.

h. Air-movers, either explosion-proof and electrically operated, or air-driven eductor type only. All air-movers used will be the eductor type capable of educting vapors from the tank. (Air-movers blowing air into the tank will not be used during the vapor freeing or cleaning periods of work). Additional information on this subject is in paragraph 11-9.

★i. One combustible gas (vapor) indicator calibrated to pentane or manufacturer's recommendations. An oxygen indicator will be required for inert tank entries.

j. Explosion-proof portable battery-powered lights.

k. Cleaning equipment (for example, buckets, scrapers, squeegees, rags, mops, brooms, brushes, and scoops) is provided where necessary. Brass and aluminum brooms or brushes that have plastic or synthetic bristles will not be used, because synthetic material is not authorized.

l. Additional buckets or other suitable containers will be required to hold soapy water used for cleaning equipment. Also, an adequate supply of disinfectant solution and cotton swabs will be needed to clean face masks.

NOTE: The disinfectant solution will either be a hypochlorite solution (50 ppm chlorine) or an aqueous iodine solution (50 ppm iodine).

11-7. Safety Precautions:

a. All tanks begin cleaned, regardless of the type of stored fuel will be considered leaded and explosive until all sludge and loosely adhering rust scale have been removed. The vapor reading must be essentially zero before tank entry without protective equipment is authorized.

b. Before entering into the tank, permission from the command liquid fuels engineer or a designated representative must be obtained. This permission must be requested 15 workdays before desired entry date.

c. The tank cleaning supervisor is at the job site and makes sure the following conditions are met:

(1) Personnel have been briefed by the tank cleaning supervisor on what is to be done; what each worker is to do in the event of an emergency; and how long each person or cleaning crew remains in the tank under normal conditions.

(2) All required equipment is approved and properly located.

(3) Personnel are equipped with properly fitted protective equipment.

(4) The entire area adjacent to the tank is secured.

(5) Eductor type, air-movers, have been operating continuously for at least 1 hour, and continue to operate throughout the entire period personnel are cleaning the tank. High noise units may be turned off after the first hour of operation with continuous monitoring of the lower explosive limit.

(6) A large enough sludge pit or weathering area is ready to receive the amount of tank sludge expected (if this disposal method has been approved by the BCE Environmental Coordinator and does not violate local pollution control regulations).

(7) There are emergency shower facilities available in the immediate area.

(8) There are enough personnel available to provide at least one safety person with protective equipment outside for each person inside (until tank is vapor freed) regardless of tank size or location. (One person in tank: minimum crew size of five persons; two persons in tank: minimum crew size of seven persons.) Deviation from these requirements must be approved by MAJCOM liquid fuels engineer.

d. In addition to personnel selected for tank entry and the tank cleaning supervisor, the following positions must be filled: manhole observer, fresh air blower monitor, and a safety (emergency) person. These positions will be required for inspecting as well as cleaning the storage tanks. Individuals assigned these duties will not leave their positions anytime personnel are in a tank that is not considered vapor freed.

e. Anyone entering a tank must wear approved air respirators through which air is supplied under positive pressure; he or she must continue to wear this equipment until all material has been removed that may cause hazardous vapors. (Type A hose mask with blower is currently specified in AFOSH standard 161-1 for use under NON-IDLH conditions.)

NOTE: IDLH conditions exist above 40 percent LEL. Use only type C respirators following paragraph 11-15.

f. Protective equipment will be in good condition. Hose lines for masks of the blower-type will be clean. If anyone wearing such equipment detects an odor (such as that from fuel), he or she must leave the tank immediately and not reenter until the cause has been determined and satisfactory equipment supplied.

g. Under no circumstances will the person who operates the blower leave the job until he or she is replaced by an alternate, such as safety observer or tank cleaning supervisor. An uninterrupted air supply must be maintained to the mask until all persons are out of the tank and have removed their facepieces.

h. The air blower for the mask will always be upwind of the tank opening, so that only fresh, uncontaminated air is supplied. (If wind direction changes, blower equipment will be moved to maintain an upwind location.)

i. The mask user may remove his or her hat or cap to help secure a tight fit of the face piece (the use of a skull cap is recommended). It is essential that such articles as tobacco and chewing gum be removed from the mouth. After the facepiece has been adjusted and tightened, it should be tested for leaks. This is accomplished by closing the end of the tube with the palm of the hand, or by pinching the tube and inhaling. If the facepiece collapses against the face, the fit is satisfactory. If it does not, leaks should be located and eliminated.

j. Under no circumstances will anyone remove the mask while in the tank.

k. Anyone entering a tank must wear clean clothing from the skin outward, with first quality impermeable gloves and boots that are in perfect condition. (Acid-proof rubber is an acceptable material.) Outer clothing (coveralls) preferably should be light-colored.

l. Freshly laundered clothing is worn at the beginning of the job and at the start of each workday thereafter. At the end of the day, such clothing will be removed and laundered. A shower must be taken by each person doing this work at the end of each day's work and at the end of the job.

m. Clothing becoming soaked with sludge or fuel must be removed promptly. Before work is continued, a shower and a fresh change of clothing are necessary.

n. Hose mask sets, boots, gloves, and tools are cleaned at the end of each day's work and at the end of the job. Face pieces and connecting breathing tube are to be cleaned with soapy water, rinsed and swabbed with an aqueous hypochlorite or iodine disinfectant solution before being transferred between personnel.

o. Sludge removed to disposal area will be kept wet. (See paragraph 11-13 on disposal method.) Physical contact must be avoided, and maximum care must be taken to prevent contamination of water supplies or streams. Physical contact with leaded sludge is dangerous due to the toxicity of the lead alkyl compounds, either in liquid or gaseous state. Tests for lead in the air above any sludge have shown that values are low at all times, even with no apparent wind. The sludge, therefore, is safe with regard to air contamination as soon as it is spread in the open.

p. There is no smoking; and matches or cigarette lighters must not be carried by the tank cleaning crew or other persons entering the tank cleaning area. Brooms or brushes that have plastic or synthetic bristles are not used.

q. All tank cleaning equipment is protected against dirt, water, chemical, or mechanical injury.

r. At the end of each day, and when completing each job, all parts of mask sets (including hoses, harnesses, and life-lines) should be washed with warm water and soap, with face piece and breathing hose being swabbed with an aqueous hypochlorite or iodine disinfectant solution and dried to prevent deterioration. Drying should be by natural ventilation. The mask set is then ready for reuse. Equipment should be protected against exposure to excessive heat. Any repairs or replacements should be made as soon as the need for them has been determined.

s. Goggles should be worn during the scraping and wire brushing of scale, cutting of rivets, and spreading of sawdust or other absorbent, unless a hose mask of the blower type or approved sandblasting equipment is worn. Goggles should be cleaned and sterilized frequently and at the end of each day's work.

t. Petroleum products irritate and burn the skin and may cause serious discomfort and injury. Clothing contaminated by contact with petroleum products should be kept away from any source of ignition because vapor given off by such clothing is a serious fire hazard. Skin that has been in contact with such clothing should be washed with soap and water.

u. If hands are frequently wet with fuel and it is not practical to wear rubber gloves, the hands may be coated with mutton tallow, anhydrous lanolin, or any commercial nongreasy cream that gives the desired protection. If tanks have contained leaded gasoline, however, approved rubber gloves or other impermeable gloves must be worn throughout tank cleaning operations.

v. It is required, during all tank cleaning work, that someone be available who is qualified to administer artificial respiration and simple first aid.

w. Tools and equipment should be cleaned thoroughly at the end of each day and immediately after a job has been completed.

x. Each precaution mentioned above should be weighed by qualified supervisory personnel in the light of the circumstances. To ensure a reasonable degree of safety, constant supervision of a high caliber will be available on the jobsite, and the best judgment of supervisors and crews should be exercised in every emergency.

11-8. Cleaning Procedures. (Also to be used when necessary during repairs and coating operations):

a. Planning and vigilance in the cleaning of petroleum storage tanks help avoid injury (or property damage) that may result from: fire or explosion, the presence of petroleum vapors, the presence of toxic materials, or the misuse of equipment.

b. Health and safety surveillance of tank cleaning operations is a coordinated responsibility of the civil engineer, medical service, ground safety, and fire protection personnel. Such surveillance, along with a specific training program for all tank cleaning and supervisory personnel, will do much to prevent or reduce the number of accidents that result from poor judgment, error, or misuse of equipment. These personnel, therefore, are obligated to help the liquid fuel systems and maintenance work center supervisor in ensuring safe and efficient completion of tank cleaning operations as pertaining to their area of responsibility.

c. The supervisor of the tank cleaning operation should find out how long the tank has been in service, the approximate amount of fuel and sediment in the tank, and the physical condition of the tank itself.

d. Sources of ignition should be removed from the surrounding area. Consideration should be given to wind and weather conditions. Work should not be started if the direction of the wind might carry vapor into any area where it could produce hazardous conditions, nor when an electrical storm is threatening or in progress.

e. As much of the petroleum product should be removed as possible. This is usually done by operator personnel using existing installed pumps. Any remaining fuel will be removed by portable pumps. Fuel will be pumped or drained off to the lowest possible level through the water draw-off or pump out connection. Equipment used for pumping sludge and excess water-fuel effluent from tanks should be air operated double diaphragm type with an exhaust outside the tank. Electric explosion-proof motor driven or gasoline driven engines, if used during tank cleaning operations, prior to tank being completely vapor freed, will be located upwind and at least 50 feet from an opened manhole, or just outside the dike. All remaining on-specification fuel will be disposed of on instructions from the fuels management office (FMO). Disconnect all pipelines connected to the tank; remove valves, when feasible, and install a bonding cable between pipe flanges before its removal. Blind flange or plug the ends of the pipe to prevent the return of any favors or fuel to the tank. (Do not rely on closed valves alone to serve this purpose.) The blind flanges must be thick enough to withstand any system pressure to which they may be subjected. Spectacle blinds if used, must be inserted between the tank valve and the flange nearest the tank. Gaskets will be inserted on both sides of the spectable blind.

CAUTION: DO NOT REMOVE VALVES OR DISCONNECT PIPING FROM ANY TANK UNTIL POSITIVELY CERTAIN THE LINE HAS BEEN EMPTIED OF FUEL, AND BONDING CABLE HAS BEEN INSTALLED BETWEEN PIPE FLANGES.

f. Before taking down a floating roof tank for internal inspection or cleaning, the tank cleaning supervisor inspects the pin location on the floating roof's adjustable legs, to ensure level settlement of the roof of the tank bottom.

g. On underground tanks, where connecting lines are buried, blind off the lines at the nearest exposed valve box.

h. The tank entry supervisor, by physically surveying the entire area around the tank to be cleaned, makes sure that no vapors are present in pits or low places; that unauthorized personnel are cleared from the area; and that there is no possibility of anyone smoking in the immediate vicinity. All personnel entering the area will leave all cigarettes and flame-producing devices ~~at~~ a previously determined location.

i. The tank entry supervisor makes sure that all equipment is placed upwind of the tank openings. Equipment will be placed at the highest elevation possible; never in an area lower than the surrounding terrain. Internal combustion engine-drive equipment is not used unless it can be placed a minimum of 50 feet from the tank, for tanks without dikes, or just outside the dike on diked tanks.

j. The tank entry supervisor is responsible for reviewing "as-built" or engineering drawings of the tank to be cleaned. He or she briefs personnel on the location of floor pits, sumps, or other tank appurtenances (such as pantograph hanger weights) considered hazardous to personnel.

k. No artificial lights, other than battery-powered safety lanterns are used inside the tank until the tank has a vapor reading below 4 percent of the lower explosive limit (LEL) of the fuel.

(1) Portable lights used outside the tank in the potential vapor travel from the tank opening (or from inside the tank after it has a vapor reading below 4 percent LEL) will be of the explosion-proof type, and will be connected to 3-wire extension cords that are equipped with connectors or switches approved for hazardous locations. Such equipment, when used, should be thoroughly inspected before use for shorts, proper grounding (3-wire system), and any defects, by a qualified electrician. All lighting equipment used is specifically identified for tank cleaning purposes only.

NOTE: Select only explosion proof lighting for use during coating operations.

l. Motors must be inspected before they are used, to make sure they are explosion-proof and designed for use in hazardous areas. Motor and bearings will be checked for local heating, and lubricated if necessary with lubricant recommended by manufacturer.

m. Before using, inspect the grounding and bonding cable connection points, wires, and clips for good condition and check electrical continuity with a voltage ohm-meter. Replace the cables immediately if insulation or wires are damaged or broken, and repair any damaged cable-clip connections.

n. Before using, gasoline engine-driven equipment is inspected to ensure the engine is equipped with a flame arrester and a protected ignition system. The engine is also to be inspected for gasoline and oil leaks, and all leaks must be repaired before the engine is started. Equipment will also be tested to make sure it is in proper operating condition.

11-9. Tank Ventilating and Vapor-Freeing:

a. Eductor type air-movers are used. Tank fuel vapors are heavier than air, and except on hot days (80°F to 110°F), accumulate in the bottom portion of the tank. Blowing air into the tank tends to stir the vapors, requiring a long period of time before any appreciable drop in vapor-air ratio is noted. Eductor type air-movers (with flexible oilproof canvas hoses attached) inserted in the tank near the bottom will educt vapors from the tank in a short period of time. On hot days, a fog type water spray over the opening, admitting fresh air into the tank, condenses vapors and facilitates removal. All tank openings, except the one used to insert the oilproof flexible hose and the one admitting fresh air into the tank, should be kept closed until workers have entered the tank.

b. Although eductors may be used through bottom manholes on the aboveground tank, it is preferred that top manholes or vent piping be used on both above- and underground tanks. Using eductors on top of the tank allows for dispersing the vapors, thus preventing them from settling in low places at ground level.

c. Natural ventilation may be used to help in the removal of tank vapors. The roof and shell manhole covers should be removed, and air allowed to circulate freely through the tank.

(1) Ventilation may be accelerated by a windsail or by an eductor type air-mover. If a gasoline engine-driven blower is used, place it at least 50 feet from the tank on undiked tanks or just outside the dike for diked tanks. To decrease any fire or explosion hazard, it must be placed upwind, and be equipped with a flame arrester and a protected ignition system. All electric motor-driven blowers and switch gear will be explosion-proof and should be located upwind from the tank.

(2) The LFM shop is authorized one of the following portable blowers for tank ventilation:

(a) NSN 4140-01-004-0566, Air operated.

(b) NSN 4140-00-302-9534, Electric, 220/440 Volt.

(c) NSN 1730-00-213-9137, Gasoline-driven. NOTE: When replacement of blower is required, the air operated type will be requisitioned.

d. The location of tank-ventilating equipment is determined by local conditions. In most instances it is preferable to exhaust the vapors through the roof manholes; this assures maximum diffusion of vapors into the surrounding air and thereby reduces the possibility of a flammable mixture concentrating at ground level. Regardless of the method used, possible sources of ignition in the path of vapors will be eliminated.

e. Ventilation is continued until the tank is essentially vapor free or the fuel vapors in the tank have been replaced with fresh air. The principal consideration in vapor freeing a tank is the removal of fuel-sludge and the disposal of displaced vapor in a way that will minimize the possibility or any hazardous condition (toxicity, asphyxiation, fire, and explosion) inside the tank and in the surrounding area.

11-10. Vapor Testing:

a. Initial testing of the tank atmosphere with a combustible gas indicator will be made at the manway opening where vapors are being exhausted, or at the exhaust of the ventilating equipment. The tester must be trained and thoroughly familiar with the reading and handling of the instrument. Before taking a reading, he or she should determine that the instrument is in proper working condition and is calibrated correctly. It is important to follow the manufactuer's recommendations for checking and calibrating the instrument.

b. If the vapor indicator registers 20 percent or less of the lower explosive limit (LEL), initial entry must be made to perform further testing, provided the individual is equipped with a hosemask of the blower type.

c. Since vapor will be present as long as any fuel, scale, or sludge remains inside the tank, forced ventilation must be continued until all such material has been removed.

11-11. Initial Cleaning From Outside the Tank:

a. After the foregoing steps have been completed (in the order outlined), initial cleaning from outside the tank may be started. Ventilation should be continued to maintain inflow of air at shell manways during this process, and frequent tests should be made for explosive vapors. Stirring of sludge releases vapors and increases vapor concentration. If the concentration rises to above 50 percent of the lower flammable limit, ventilation should be augmented and washing temporarily suspended until a safe concentration has again been affected.

b. Water hose streams will be directed through the open manways to dislodge scale, sludge, and fuel residual, and float it to a water drawoff or pump-out connection. The fuel-water-sludge mixture must be contained in drums or a portable tank, and disposed of as directed by the BCE Environmental Coordinator.

c. Hosing down of the tank should not be continued when the vapor indicator registers 50 percent of the LEL or above. NOTE: If it is not possible or feasible to vapor free below the 50 percent LEL, notify the command liquid fuels engineer for further guidance.

d. Pumping equipmennt used for the removal of sludge and excess water from tanks should be air-driven double diaphragm type with air exhaust to be located outside the tank. If it becomes necessary to use open-type electric-power or gasoline-engine-driven equipment, the following special precautions are recommended to decrease the potential hazards:

(1) Steps should be taken to make sure that an adequate flow of fresh air enters the tank at the shell opening, and be exhausted from the roof manway for above-ground tanks, making sure that explosive vapors will not flow out of the tank shell manway at ground level. For an underground tank, insert flexible canvas hoses to the bottom of the tank, so that the vapors are educted from the bottom with an air mover.

(2) Equipment should be located on the windward side of the tank and out of range of the probable vapor level.

(3) Test the area around the tank for explosive vapors, with a combustible gas indictor before any equipment is started which may be a source of ignition.

(4) If a pump is used to remove residuals from the tank, it should be attended and properly maintained for continuous operation during the period of tank cleaning. Each time the equipment is to be started, the area should first be tested for explosive vapors. A gasoline engine should always be stopped for refueling.

(5) Throughout the pumping period, close checks should be made to make sure that a flow of air is entering the shell manway, for aboveground tanks or educted from the manway of underground tanks. If at any time the inflow or exhaust or air is stopped, the pump should be stopped immediately. The pumping operation should not be resumed until ventilation has been reestablished and the area has been tested and found to be free of explosive vapors.

11-12. Entry for Completing Cleaning:

a. After initial cleaning of tank from the outside, ventilation is continued and vapor readings taken at the manhole or equipment exhaust to determine when entry can be made for completing cleaning. If vapor levels are below 20 percent of LEL, workers may enter the tank if they are equipped with approved air supplied respirators. Workers should never enter a tank without proper respiratory protection unless the bioenvironmental engineer has determined that airborne benzene and other toxic vapors are below permissible exposure limits. It should be noted that in many cases the sophisticated instrumentation required to make on-the-spot determinations of this type will not be available.

b. No work should be started within the tank until the vapor readings are below 20 percent LEL. However, in those tanks where it is not possible or feasible to obtain vapor readings below 20 percent LEL, the command fuels engineer is notified by the base civil engineer tank cleaning supervisor. The command liquid fuels engineer after consulting with the command bioenvironmental engineer, determines whether tank entry is permissible under these conditions.

(1) If tank entry is permitted under these conditions, the precautions prescribed in paragraph 11-15 must be followed strictly during the period the workers are in the tank. Determining factors for not being able to obtain vapor readings below the 20 percent LEL, or in some cases below 50 percent LEL, are:

(a) The time involved to reduce vapor concentrations (which in turn can affect base mission requirements and maintenance costs).

(b) The size and type of tank and the amount of fuel and solid sludges to be removed.

(c) The methods and facilities available for floating and removing fuel-sludges, and hosing down tank.

(2) It would not be feasible to try and float residual fuel for the purpose of removing it unless: there is sufficient water available; the water could be admitted to the tank in a safe and easy manner; the floating fuel and water could be removed in a reasonable length of time; and getting rid of large quantities of fuel-water effluent in order to meet state and federal environmental laws would not present a problem.

(3) In connection with the removal of solid sludge, it would probably be impossible to hose down a large diameter tank adequately and remove fuel, water, solids, and sludges from a single roof or side wall manhole, particularly if the tanks bottom slope or sumps are inadequate.

c. For these tanks that have been brought down to 20 percent LEL or less (and above 0 percent LEL), tank cleaning personnel must wear hose masks of the blower type during all periods they are in the tank.

(1) Tests for explosive vapors should also be repeated at frequent intervals during all tank cleaning periods while the workers are in the tank, because the stirring of sludge releases vapors and increases the vapor concentration. When vapor concentration rises to above 20 percent LEL, but no higher than 50 percent LEL, additional ventilation capability will be used to expedite vapor removal. The tank cleaning operations will then proceed with caution until vapor readings are stabilized below 20 percent LEL. The expeditious removal or any remaining puddles of fuel-water-sludge should reduce vapor readings to below 20 percent LEL.

(2) Under no circumstances will any tank cleaning operations be continued inside the tank when the vapor indicator registers above 50 percent LEL. When the vapor concentration reaches this level, additional ventilation capability will be used, and cleaning inside the tank will be suspended temporarily until a vapor reading of 50 percent LEL or below is reached.

d. After sludge has been removed from the tank, and with personnel wearing protective equipment, the bottom of the tank and 3 feet up on the sides will be scraped until all loosely adhering rust and scale have been removed and placed with sludge removed from the tank. The remainder of the tank sides, and all metal supports and braces, will be washed down with a high pressure water hose until the water flowing or pumped out of the tank is clean. The entire upper portion of horizontal tanks will be washed down. Decks (tops) of vertical tanks will also be washed.

★ e. Water used to wash down a scraped tank must be contained. It may be channeled from the tank through a spillway (pump may also be used) into a drainage system having an oilwater separator of adequate capacity, if there are noticeable amounts of petroleum products in the effluent. The discharged effluent containing the petroleum product is processed in this manner to prevent the fuel products from entering any above- or belowground water courses. The separated petroleum products are placed in drums or tanks provided for this purpose and will be disposed of (with fuel tailings) by the contractor or base group responsible for its disposition. Running or pumping sludge or waste water into natural waterways, sewers, storm drains or onto ground is prohibited.

f. After the tank has been washed, the floor will be dried out. If the vapor readings indicate that the atmosphere in the tank is at 0 percent of the lower explosive limit on unleaded tanks, personnel will be allowed to enter the tank without protective equipment.

g. Pipes used for center poles and braces, pontoons and leaking bottoms are a potential source of explosive vapors even after the tank is cleaned. The tank may be determined to be below the explosive range, but after 1 or 2 hours explosive readings could again be obtained from these sources. Because of this, the supervisor takes readings (at least every half hour) when working in underground tanks after they have been cleaned, and each pontoon of above ground floating roof or pan is checked individually with a combustible gas indicator.

11-13. Disposal of Sludge and Sediment:

a. Sludge and sediment from tanks that have contained gasoline to which tetraethyllead (TEL) has been added are dangerous to handle even after the residual material has been removed (see paragraph 11-1c). These should be kept wet, and disposed of as directed in this paragraph.

b. Depending on the construction of the tank and the number of openings, sludge may be removed by various methods or by a combination of methods. Possibly the simplest is to sweep, wash, and "squeegee" the sludge into piles, shovel it into buckets, remove from the tank, and dispose of as directed by the BCE Environmental Coordinator. Any method of disposal selected must comply with applicable state and federal environmental pollution control regulations.

(1) If disposal is by the weathering method, select a site on which the sludge can be spread on the surface. Site selection must be approved by the BCE environmental coordinator in concert with the bioenvironmental engineer.

(a) The site selected for sludge disposal should be on a remote part of the property, and in property limits where it will be fenced off to unauthorized personnel. It should also be located in a remote area outside the surrounding firewall or dike of the tank being cleaned, so that the possibility of petroleum vapors affecting the tank cleaning operations will be eliminated.

(b) It should be located so that personnel working in, on, or around the tank will not get into the spreadout sludge.

(c) A pit will be constructed or dug and lined to prevent soakage into the ground of any petroleum product.

(d) The total area, whether in one or several patches, must be sufficiently large to permit spreading the sludge in a layer not over 3 inches thick. The total area required is determined by the amount of sludge in the tank.

(e) It should be located so that air circulates freely over the surface of the sludge. Exposure to the sun is desirable but not mandatory.

(2) The sludge can be moved from the tank to the spreading area in available plant equipment. Wheelbarrows, buckets, or other small containers may be used for moving it a short distance. Dump trucks, trailer mounted tanks, lugger buckets, etc., may be used for longer distances. The containers used should be metal. After use, they should be washed thoroughly with water.

(3) The sludge can be spread with hoes, rakes, or shovels. It should be spread as uniformly as possible to a maximum thickness of 3 inches. If the area permits, a thinner spreading is desirable.

(4) After completion of spreading, area should be roped off and conspicuously marked so that no one walks through or stands in the sludge. Personnel handling and spreading sludge should be dressed in special clothing as recommended for tank cleanings. Masks are not necessary unless there is no air movement and vapors can be detected by odor at face level.

(5) The spread sludge should be left for at least 4 weeks. After that, sludge will require disposal in state approved landfill either by inhouse personnel or service contract. The 4-week weathering period applies when the ambient temperature is above 32°F. Therefore, if temperatures under 32°F exist during the period of weathering, this period of subfreezing temperatures will not be included in the recommended 4-week period of weathering.

(6) The site selected must be located so that drainage from it cannot enter a stream or other waterway, but will remain or other waterway, but will remain in the pit until liquid has evaporated.

11-14. Special Instructions for Cleaning Tanks Storing JP-5 Fuel:

a. All of the precautions and procedures for cleaning petroleum storage tanks are to be followed in cleaning tanks that contain JP-5 fuel.

b. Since JP-5 fuel has a relatively low (Reid) vapor pressure, the combustible gas vapor indicators will not ordinarily indicate any vapors present in the tank at any time during the entire tank cleaning work. This does not mean that hazardous flammable fuel vapors are not present, or that personnel are allowed to clean the tank without the same respiratory equipment used when vapors are present.

c. Tank cleaning personnel must continue to wear the protective masks and equipment until the tank sides and bottom have been throughly cleaned, washed, and dried.

d. If the repair work is to be performed on floating roof tanks storing JP-5 fuel, the interior of each pontoon on the roof is thoroughly cleaned of fuel, rust, water, and debris.

11-15. Special Precautions for Cleaning or Repairing Without Vapor-Freeing (Inert Entry). Cleaning tanks that are not completely vapor-free should be avoided when possible. When the facilities for cleaning storage tanks are limited (for example, if water is not available for floating out residual oil, or for washing the tank shell, or the tank bottom is poorly sloped and has inadequate drainage), the disposal problem may be difficult; cleaning such tanks may require only the removal of sludge from the bottom of the tank. In these instances it may be necessary to clean the tank without first removing the explosive vapors down to below 50 percent LEL. When cleaning or repairing these tanks the precautionary measures prescribed in the previous paragraphs also apply. The following special precautions are only supplemental to the requirements of the previous paragraphs:

a. Tanks that have not been ventilated to remove vapors are likely to contain an explosive atmosphere. Therefore, while entry is in progress, special precautions must be taken (in addition to those already outlined in chapters 1 and 11).

b. The area surrounding the tank should be kept free of possible sources of ignition from the time the tank-cleaning operation starts until the tank is closed and ready for service.

c. Under no circumstances should any electric power tools or lights, or any other equipment operated from an extension cord, be permitted in the tank. Only dry cell-powered explosion-proof flashlights, safety lanterns, or explosion-proof cap lamps are used.

d. Before tank-cleaning operations are started, personnel concerned shoud be instructed on potential hazards such as explosive or toxic vapors, fire, or lead. They should be informed also on how to cope with existing hazards, by employing proper methods and procedures, and by the correct use of the various types of equipment provided.

e. The tank should be pumped out and drained of fuel to the lowest possible level. In some cases, it may be possible to remove additional product through the water-draw off connections. Such operations should be completed before the manway covers are removed.

f. Workers who are removing manway covers or working near an open manway, should keep to the upwind side and avoid inhaling any vapors that may issue from the tank. Under certain conditions, respiratory equipment should be used.

g. Every possible effort should be exerted to perform the necessary cleaning without entering the tank. Sometimes sediment or scale may be removed from the tank by directing a stream of water from a bonded hose through a manway in the tank being cleaned, while the tank is being pumped out or drained.

h. Workers who must enter a tank should use protective gloves and boots, type c airline supplied respirators NIOSH approved for use in atmospheres immediately dangerous to life and health (IDLH), and safety wristlets. If the tank is entered through the roof manway or manhole in the case of underground tanks, a ladder (if none is installed) should be inserted through the manway or manhole and be secured. Workers in the tank should be under the constant observation of a responsible individual who is outside the tank, and enough help must be immediately available to rescue a worker in an emergency. Spare respiratory equipment must be immediately available for this purpose.

11-16. Inactiviation. Tanks being cleaned or prepared for inactivation are treated according to AFR 85-9.

11-17. Cleanup and Putting Tank Back in Service. After all water and sludge materials have been removed from the tank, and the tank entry supervisor has inspected the tank entry work, the supervisor will subject the liquid fuels system to such operational tests as required to demonstrate functional operating efficiency as existed before the work was started. All valves, piping, manhole covers, etc., removed at start of the job to facilitate ventilation, will be reinstalled, using new gasket material resistant to aircraft fuel. This gasket material must comply with federal specification HH-P-46b asbestos sheeting, and must not be less that the thickness of the gasket removed. The entire tank area will be restored to its original condition.

11-18. Stenciling the Tank. At the completion of the tank inspection or cleaning work, the supervisor makes sure the tank is stenciled in either ¾-inch or 1-inch letters adjacent to the manhole openings, with the essential information shown in the following examples:

a. DATE LAST CLEANED—15 APRIL 1974
IN-HOUSE/999 CES
SUPERVISOR—TSGT J. JONES

b. DATE LAST INSPECTED—19 FEBRUARY 1977
IN-HOUSE/999 CES
SUPERVISOR—TSGT F. JONES

NOTE: Since the last cleaning date may vary from the last inspection date, it may be necessary to have both dates stenciled on the tank. Also, additional information can be stenciled on the tank showing that the tank was cleaned by a contractor and inspected by in-house forces. (For contract related tank work, see chapter 12.) On underground tanks necessary information is stenciled on manhole covers or pitwalls.

Section B—Repair, Coating, and Strapping

11–19. Repairs (General):

a. Tanks that have never contained leaded gasoline (information obtained from certified accurate records) and have been cleaned, may be regarded as safe for entry without respiratory equipment, provided the atmosphere registers not more than 0 percent of the lower explosive limit (LEL) on the combustible gas indicator.

b. A tank that has contained leaded gasoline must be free of sludge, and all nonadherent material must be removed from the inside of the tank surface before a 0 percent LEL reading on a combustible gas indicator can be reached. A minimum of 16 hours natural ventilation is recommended before using powered air movers. It is a recommended practice after the tank has been vapor freed to use blower type hose masks at all times during inspection, cleaning and repair operations regardless of the vapor reading.

c. If cold repair work in or on a tank results in perceptible dust, an approved dust respirator and goggles should be worn. A hose mask of the blower type is also satisfactory protection.

d. If repairs involving hot work (welding) are to be made, or if tanks are to be sandblasted or shotblasted before such work, they must be sufficiently cleaned to be safe for entry without protective equipment. In addition, all surfaces of the tanks that have been in contact with leaded gasoline should be cleaned down to bare metal over any area that might be rendered excessively hot by welding, or by operations requiring application of intense heat. Close attention should be given to every possible source of explosive vapor. Frequent tests should be made to make sure that the atmosphere of the entire tank remains substantially free of hydrocarbon vapors. Wooden roof supports could be ignited easily. Keeping such supports and other wood parts wet should prevent ignition. Vapor may enter through leaks in the tank bottom, or vapor pockets may exist in hollow roof support columns or floating pan pontoons.

★(1) Contract welders must be certified by the American Petroleum Institute (API) before welding on POL facilities.

★(2) For Air Force employees (military and civilian), the MAJCOM Fuels Engineer determines who is qualified to weld on POL facilities.

(2) Before any hot work (welding), advanced approval must be obtained from MAJCOM liquid fuels engineer. This includes repair work on any portion of the POL facilities. This is required for both in-house or contract type work.

e. When the interior tank coating is to be removed from the tank walls, it should be cleaned and grit-blasted to bare metal. If the coating has a high lead content, the method used for removal (burning, cutting, or grit blasting) may result in a significant and additional hazard from lead vapor. An approved lead-vapor respirator should be used in working on inside surfaces, provided the tank has been freed of hazards from both petroleum and tetraethyllead (TEL). The welder's face piece that is used with a supplied air respirator will protect against the hazards of TEL, as well as those resulting from the lead fumes from coatings.

f. Any area suspected of leakage (seams and new repair work) may be tested with a vacuum box. The vacuum box is a rectangular frame (generally 12 inches wide, by 30 inches long, by 6 inches deep) that is fitted with a glass top, and with a rubber seal around the bottom edge. A manual or motor-driven pump is used to create a 2 to 4 inch vacuum within the box. Soap suds are placed over the area to be tested, and the vacuum box is placed over the area with the rubber seal making an airtight contact between the tank surface and the box. A vacuum is then developed within the box. If the vacuum box is moved over a leak, the leak will be indicated by activity in the soap bubbles over the leak.

g. Corrosion can cause the bottom of a steel storage tank to deteriorate until the metal is perforated, and thus render the tank useless and a source of ground pollution. This results from the collection of water in the bottom from ground water and soil conditions outside the tank bottom, or from a combination of those factors.

11-20. Repairing Steel Tanks:

a. Leaks and defects are easily located in the tank shell of both aboveground or underground tanks. Once the tank, appurtenances and floating roof pontoons, have been cleaned and freed of flammable vapors, the affected areas can then be abrasive blasted or hand cleaned to bare metal and either hot or cold repairs made as required.

b. If fuel losses have occurred from a tank and inspection of the tank shell does not indicate any defects, the leak is probably in the tank bottom. The tank should be cleaned and freed of all flammable vapors. After the tank floor (bottom) has been completely dried, the supervisor should make a visual inspection of the tank floor for spots showing moisture. When these spots are detected, they should be wetted with a detergent solution and a vacuum box should be placed over the area to detect the leak. If the leak(s) cannot be found in this manner an air test may have to be performed by forcing air under the tank bottom and covering the floor with 2 to 3 inches of fresh water. Air bubbles can then be detected at the leak. Care must be taken to make sure that no more than 1 to 3 psi air pressure is built-up underneath the tank floor. Temporary earth fill may have to be placed around the edge of aboveground tank to prevent the air from escaping from under the floor.

c. On underground tanks, a hole is drilled near the center of the tank using a pneumatic drill. Large amounts of water must be used to keep the drill bit cool. Once the hole has been drilled, a combustible gas indicator (meter) must be used to determine if fuel vapors are trapped under the tank floor. If vapors are detected, all personnel in the tank should wear protective clothing and fresh air masks and no welding should be permitted inside the tank. In this event, a tap shall be used to cut threads on the edge of the drilled hole and a pipe nipple threaded on both ends should be threaded into the hole. A valve should then be fitted on the exposed end of the nipple and connected to a water hose. Flushing the area underneath the tank with water normally displaces the fuel under the tank bottom. After flushing with water, an air hose is then connected to the nipple and a 0 to 15 psi air gauge installed at the pipe nipple-air hose connection. Communications must be maintained between personnel inside the tank and the air compressor operator at all times during the test. The pipe nipple screwed into the tank floor can be tightened with plumbers (teflon) tape so that it does not leak. This can be determined by placing a pipe cap on the open end of the nipple and lacing a vacuum box over the nipple and soaping the threaded portion of the nipple protruding through the taped hole in the tank floor. If vapor tests taken from the open end of the pipe nipple indicate a vapor-free atmosphere, the pipe nipple may be removed and a plate welded over the hole. If vapors are detected and the nipple cannot be tightened to prevent it from leaking, the pipe nipple must be removed and the tank floor area around the hole must be cleaned to bare metal. The hole is then plugged with epoxy welding putty. After the putty is cured, the patch must be leak tested using the soap solution and vacuum box.

d. On aboveground tanks, three perforated ¾-inch pipe lengths, 8 to 10 feet long, can be driven under the tank floor at equal spaces around the tank perimeter.

CAUTION: The compressed air must be placed under the tank floor slowly and constant surveillance must be maintained to make sure not more than 1 to 3 psi pressure is placed under the tank floor. Personnel inside the tank will usually feel the tank floor start to rise when too much air pressure is placed under the floor. A quick closing ball valve should be used to control the air flow at the nipple-air hose connection.

e. The patch repair of small areas (such as open seams, holes, cracks, crevices and joints) may be made with the use of epoxy putty, manufactured for this purpose. (Apply epoxy material according to the manufacturer's recommended procedures.)

f. The welding of metal plates on tank bottoms is done only when large sections of the bottom require repair or replacement. All metal sections of the bottom to which heat is applied must be grit-blasted or wire-brushed to bare metal before heat is applied. The precautions on "hot work" cited in paragraph 11-19d apply.

g. The partial or complete replacement of tank bottoms may also be done by the fiberglass mat-epoxy or polyester resin method. Using this method, a tank bottom can be repaired or replaced at a fraction of the cost of the hot welding method. If a corroded condition of the tank bottom indicates extensive repair, or bottom replacement is necessary, consideration should be given to the repair or replacement of tank bottom by the fiberglass or resin method. Guidance on application procedures by this method is obtained from HQ AFESC/DEMM.

11-21. Repairing Concrete Tanks:

a. Locating leaks in concrete tanks is most difficult, and if a leak is suspected, requested the services of a qualified liquid fuels engineer from the MAJCOM or HQ AFESC/DEMM.

b. Repairs to concrete tanks are always made by applying a fiberglass mat-epoxy or polyester resin to the affected tank service.

CAUTION: Do not attempt to repair a concrete tank by pouring a layer of concrete over the tank floor or by grouting or plastering the affected areas on the tank wall. In each case where concrete tanks are to be fiberglassed, guide specifications and procedures to be used must be requested from HQ AFESC/DEMM by the MAJCOM liquid fuels engineer before any repair work is started.

11-22. Interior Coating of Aviation Fuel Storage Tanks:

a. Steel Tanks. If corrosion conditions inside existing tanks indicate the need for a protective coating, recommendations and approval must be obtained from the command liquid fuels engineer (or a designated representative). Tanks approved for application of an interior coating will be coated with a MIL-C-4556D (epoxy) or MIL-P-23236 ships Type I, Class 4 (urethane) system, as directed in AFM 88-15. Before surface preparation, the tank is cleaned as outlined in section A of this chapter (also see cleaning specifications in chapter 12). All newly constructed aviation fuel storage tanks will be internally coated as described in AFM 88-15.

b. Concrete Tanks. If the condition of the existing coating system inside the concrete tank indicates the need for repair or relining, approval and recommendations on cleaning, surface preparation, and application procedures is obtained from HQ AFESC/DEMM by the MAJCOM liquid fuel engineer.

c. Coating or Cleaning by Contract. The prime contractor on any coating application project is the coating applicator. The tank cleaning work may be subcontracted to a qualified tank cleaner if the prime contractor is not qualified to do this work.

11-23. Exterior Coating of Aviation Fuel Storage Tanks. Exterior coating of aviation fuel storage tanks is outlined in chapter 2, paragraph 2-8a(1).

11-24. Strapping Liquid Fuel Storage Tanks:

a. Tanks are calibrated and charts prepared either by the straping or volumetric methods, as applicable, according to API standards 2550, 2551, and 2555. The work may be done in-house or by contract.

b. Before starting the tank calibration work, the supervisor makes sure that the tank is free of explosive vapors (below 0 percent LEL no air mask required; above this level an air mask is required). If the tank contains such vapors, personnel will not enter the tank without an airmask until it is free of explosive vapors.

c. Safety requirements related to proper use and type of scaffolding must conform to AFOSH Standards 127-7 and 127-9.

d. Gage charts are prepared based on data compiled on the tank capacity. The tank charts are calibrated in US gallons and show the tank capacity in ⅛-inch graduation. One reproducible and three copies of the gage chart are prepared for each tank.

e. When the calibration of underground tanks (of 50,000 gallons capacity or less) is required, the volumetric calibration method may be used.

f. No open flame or conventional electric lighting will be used within 50 feet of any tank or pipeline containing fuel. Explosion-proof electrical equipment is used in all areas where smoking or open flames are not permitted.

g. When the gage charts are completed, they must be signed by a responsible engineer to show that calibration was done according to applicable API standards, and he or she must list specific standard use.

Chapter 12

CONTRACT GUIDE SPECIFICATION FOR PETROLEUM TANK CLEANING, REPAIR, CALIBRATION OR COATING

Section A—Petroleum Tank Cleaning

12-1. Scope:

a. The work covered by this specification consists of the contractor furnishing all plant, labor, equipment, appliances and materials (except water and electricity), and performing all operations in connection with the complete and thorough cleaning of (above) (under) ground petroleum storage tank No(s) ________ at ________.

b. The above work will be accomplished in strict accordance with:

(1) This specification and subject to contract terms and conditions.

(2) Instruction in the American Petroleum Institute (API) Bulletin, API Publication RP 2015, Cleaning Petroleum Storage Tanks.

(3) Instructions in AFM 85-16, Maintenance of Permanently Installed Petroleum Storage and Dispensing Systems, and AFOSH Standards 127-7, 127-40, 161-1, and 127-66.

(4) Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901, and state hazardous waste disposal laws.

12-2. Conditions:

★a. All prospective contractors for fuel projects will submit a contractors' qualification statement according to section D.

b. The following are special considerations for removal and disposal of sludges which are classified as hazardous wastes. Prior to drafting of contract specifications for removal or initiating in-house efforts, the bioenvironmental engineer and the environmental coordinator will determine if the residue to be removed is a hazardous waste regulated by the Resource Conservation and Recovery Act. This determination may be made by sampling and analyses of the material stored in the tank. If all constituents of the material and their characteristics are known, the determination may be made without analyses. If the material to be removed is determined to be a hazardous waste, then the contract performance work statement (PWS) will provide for a breakout of costs for:

(1) Placing the waste in Department of Transportation (DOT) approved containers.

(2) Transport to and disposal of the waste in an Environmental Protection Agency (EPA) or State permitted hazardous waste disposal facility. The costs identified for disposal will then be compared with costs furnished by the Defense Property Disposal Regional Office (DPDRO) to determine whether contract disposal is less than DOD incurred costs of disposal through the Defense Property Disposal Office (DPDO). If the DPDO costs are less (this cost will include packaging by the contractor), the material will be packaged by the contractor in DOT approved containers and transported to the DPDO for disposal.

c. The command liquid fuels engineer or designated representative will be the quality assurance evaluator (QAE) in all technical matters pertaining to tank work. A medical service bioenvironmental engineer (or other agent designated by the major command surgeon) and the base civil engineer (or designated representative) will provide advice as needed on environmental pollution control requirements. Any contractor noncompliance, regarding either protection of property or environmental pollution will be basis for stopping work.

d. The selected bidder will, upon request of the contracting officers and before notice to proceed is issued, submit the following information for approval:

(1) The names and qualifications of each contractor's representative who will be in charge of the work and be present at the jobs site when any tank work is being accomplished.

(2) A complete list of equipment, with adequate nomenclature by item, to be used or available at the job site.

e. The contractor will not perform any tank cleaning work at the job site unless authorized by, and in the presence of, the command liquid fuels engineer or designated representative.

12-3. Government Furnished Services:

a. The base fuels officer will remove as much fuel as possible with the fixed pumping system. Liquid fuels maintenance personnel will remove any clean, useable fuel below the tank issue line. Any fuel remaining in the tank, after the tank has been released to the contractor, shall be considered as contaminated and placed in (government supplied) (contractor supplied) containers. The contractor shall pump the fuel remaining in the tank into these containers, and deliver them to a location designated by the contracting officer, or remove them from the base and dispose of the fuel in a manner consistent with applicable pollution control regulations (see paragraph 12-2b.)

b. Water. All reasonable required amounts of water will be made available to the contractor by the government at the nearest available hydrant or connection to the job site. It will be the contractor's responsibility to furnish all hoses, piping or other type vehicle to transport water to the job site from the nearest hydrant or connection.

c. Electricity. All reasonable required amounts of electric power will be made available to the contractor by the government from the nearest suitable and available connection. The contractor will furnish all connectors, switches, conductors and other required equipment to provide electricity at the job site from the approved government source. All electrical equipment and conductors used by the contractor within 50 feet of any fuel pipes or storage tanks shall be approved for use in Class 1, Division 1, Group C, hazardous areas.

12–4. Tank Entry Equipment. The contractor will furnish all necessary clothing and equipment required for the work and protection of personnel, regardless of whether they enter a tank or handle materials outside the tank. Before any tank cleaning work is performed, the QAE will inspect and approve the contractor's equipment at the job site, to ensure that the equipment includes but is not necessarily limited to the following:

a. Air-movers, either explosion-proof and electrically operated, or air-driven, eductor type only. One air-driven type is listed in the MSA Catalog as a "Lamb Air-Mover Ventilator." All air-movers used will be the eductor type capable of educting vapors from the tank. Air-movers blowing air into the tank will not be used during the vapor freeing or cleaning periods of work.

b. One combustible gas indicator.

c. Explosion-proof portable battery-powered lights (Mining Enforcement and Safety Administration approved).

d. Buckets for soapy water, adequate supply of denatured alcohol, and cotton swabs.

12–5. Precautions to Follow:

a. All tanks being cleaned, regardless of the type of fuel stored therein, will be considered leaded and explosive until all sludge and loosely adhering rust scale have been removed.

b. Prior to entry into any tank, contractor will obtain permission from the command liquid fuels engineer or designated representative. This permission will be granted only when, or after:

(1) The contractor's qualified supervisor is present.

(2) The contractor personnel have been briefed by the supervisor on what is to be done; what each employee is to do in the event of an emergency; and how long each person or cleaning crew will remain in the tank under normal conditions.

(3) All required equipment is approved and properly located.

(4) Personnel are equipped with properly fitted protective equipment.

(5) The entire area adjacent to the tank is secured.

(6) Air-movers, eductor type only, have been operating continuously for at least one hour, and will continue to operate throughout the entire period personnel are cleaning the tank. The command liquid fuels engineer or designated representative may allow air-movers to be turned off after one hour with continuous monitoring of the vapor level below 20 percent of the lower explosive limit (LEL).

c. See paragraph 12–7h on waste fuel disposal method. Physical contact must be avoided and maximum care will be taken to prevent contamination of water supplies or streams. Physical contact with leaded sludge is dangerous due to the toxicity of the lead alkyl compounds, either in liquid or gaseous state.

(1) Tests for lead in the air above any sludge which is deposited on the open ground have shown that values are low at all times, even with no apparent wind. The sludge, therefore, is safe with regard to air contamination as soon as it is spread in the open.

(2) Industrial standards of 20 ppm of organic lead is the limit in the sludge that can be considered safe after sludge has been weathered. If weathering is a treatment process, it must be done according to RCRA. If this disposal method is used, maximum care will be taken to ensure that there is no run-off to contaminate water supplies or streams before the end of the weathering period.

d. There will be no smoking; matches or cigarette lighters will not be carried by the tank crew or other persons entering the tank area. Brooms or brushes that have plastic or synthetic bristles will not be used.

e. All government equipment will be protected against dirt, water, chemical or mechanical injury.

12–6. Tank Ventilation:

a. Air-movers of the eductor type described earlier will be used. Tank fuel vapors are heavier than air and except on hot days (80°F to 110°F), accumulate in the bottom portion of the tank. Blowing air into the tank tends to "stir" the vapors, requiring a long period of time before any appreciable drop in vapor-air ration is noted. Eductor type air-movers, with flexible oilproof canvas hoses attached, inserted in the tank near the bottom will educt vapors from the tank in a short period of time. On hot days, a fog type water spray over the opening, admitting fresh air into the tank, will condense vapors and facilitate removal. All tank openings, except the one used to insert the oilproof flexible hose and the one admitting fresh air into the tank, should be kept closed until workmen have entered the tank.

b. Although educators may be used through bottom manholes on an aboveground tank, it is preferred that top manholes or vent piping be used on both above and underground tanks. Using eductors on top of the tank will allow for dissipation of the vapors, thus preventing them from settling in low places at ground level. All other manholes and tank openings should be closed when the tank is initially ventilated. They should be opened, however, when work is stared to take advantage of the light these openings let into the tank.

12–7. Preparation and Tank Cleaning:

a. The contractor will provide and install blind flanges or spectacle blinds on each pipeline connected to the tank. When blind flanges are used, they will be placed on the end of the pipe and not on the tank opening. Spectacle blinds will, if used, be inserted between the tank value and the flange nearest the tank. Gaskets will be inserted on both sides of the spectacle blind.

CAUTION: DO NOT REMOVE VALVES OR DISCONNECT PIPING FROM ANY TANK UNTIL POSITIVELY CERTAIN THE LINE HAS BEEN EMPTIED OF FUEL. DO NOT REMOVE BLIND OR SPECTACLE FLANGES UNTIL ALL INTERIOR WORK IS COMPLETE AND THE SYSTEM IS READY TO BE PUT BACK INTO SERVICE.

b. On underground tanks where connecting lines are buried, blind off the lines at the nearest exposed valve box.

c. The contractor, by physically surveying the area within 50 feet of the tank to be entered or cleaned, will assure that no vapors are present in pits or low places, and that unauthorized personnel are cleared from the area. This area will be posted with "No Smoking" signs by the contractor. All personnel entering the area will leave all cigarettes and flame-producing devices at a previously determined location.

d. The contractor will place all equipment upwind of the tank openings. Equipment will be placed at the highest elevation possible; never in an area lower than the surrounding terrain. Internal combustion engine-driven equipment will be equipped with flame arrestors and protected ignition systems and must be positioned a minimum of 50 feet from an open manhole.

e. The contractor will be responsible for reviewing "as built" drawings of the tank to be cleaned. The contractor will brief personnel on the location of floor pits, sumps or other tank appurtenances, such as swinging suctions, considered hazardous to personnel.

f. Explosion proof battery-powered safety flashlights, or safety lanterns may be used inside the tank or within 50 feet of the tank during any tank cleaning operation. Explosion proof lights approved for use under Class I, Division I, Group C and D, of the National Electric Code, may be used inside the tank during tank coating operations with exclusive permission from the MAJCOM liquid fuels engineer or designated representative.

g. After waste fuel has been removed from the tank, and personnel wearing protective equipment, the bottom of the tank and 3 feet up on the sides will be scraped until all loosely adhering rust and scale have been removed and placed with waste fuel removed from the tank. The remainder of the tank sides, and all metal supports and braces, will be washed down with a high pressure water hose until the water flowing or pumped out of the tank is clean. The entire upper portion of horizontal tanks will be washed down. Decks or tops of vertical tanks will also be washed.

h. Water used to wash down a scraped tank must be contained. It may be channeled or pumped from the tank through a spillway into a drainage system having an oil/water separator of adequate capacity. The discharge effluent containing the petroleum products is processed in this manner to prevent the fuel products from entering any above or below ground water sources. All water will be discharged into the sanitary sewer or industrial waste only. The separated petroleum products are placed in drums or tanks provided for this purpose and will be disposed of with the fuel tailings by the (government) (contractor). Drums or tanks used for containing waste fuel will be furnished by the (contractor) (government). Running or pumping waste fuel into natural waterways, sewers, storm drains, or onto ground is prohibited (see paragraph 12-2b.)

i. After the tank has been washed, the floor will be dried out.

j. Pipes used for center poles and braces, pontoons and leaking bottoms are a potential source of explosive vapors even after the tank is cleaned. The tank may be determined to be vapor free below 4 percent of lower explosive limit; but after one or two hours, explosive readings must again be obtained from these sources. Because of this, the contractor will take readings at least every half hour when working in tanks after they have been cleaned and each floating roof or pan pontoon will be checked individually with a combustible gas indicator.

12-8. Inactivation. Tanks being cleaned and prepared for inactivation will be treated in accordance with AFM 85-9, Inactive Installations—Inactivation and Maintenance.

12-9. Clean-Up and Acceptance. After all water and sludge materials have been removed from the tank, and the government representative has inspected and accepted the tank cleaning, the contractor will subject the liquid fuels system to such operational tests as required to demonstrate functional and operating efficiency as existed before the work was started. All valves, piping, manhole covers, etc., removed at start of the job to facilitate ventilation, will be reinstalled, using new gasket material resistant to aircraft fuel, and will not be less than the thickness of the gasket removed. The entire tank area will be restored to its original condition.

12-10. Stenciling Tank. At the completion of the tank cleaning work, contractor will stencil the tank, in ¾ to 1-inch letters adjacent to the manhole openings, with the essential information as shown in the following example:

DATE CLEANED—1/16/71 CONTRACTOR—JOHN DOE
ADDRESS—1017 CHESTNUT ST.
CHICAGO, ILLINOIS

12-11. Special Instructions for Cleaning Tanks Storing JP-5, JP-7, JP-8; and JPTS:

a. All of the precautions and procedures outlined above for cleaning petroleum storage tanks must be followed in cleaning tanks that contain all jet fuels.

b. Since non JP-4 fuels have a relatively low Reid vapor pressure, the combustible gas indicators will not ordinarily indicate any vapors present in the tank at any time during the entire tank cleaning work. This does not mean that hazardous flammable fuel vapors are not present.

c. If the repair work is to be performed on floating roof tanks storing jet fuel, the interior of each pontoon on the roof will be thoroughly cleaned of fuel, rust, water and debris.

Section B—Petroleum Tank Repairs

12-12. Scope. The contractor will furnish all plant, equipment, labor and materials required to repair—each (above) (under) ground tanks(s) in strict accordance with these specifications, conditions of the contract and applicable drawings.
NOTE: Portions of section A above may be extracted for inclusion into a tank repair specification. Paragraph 12-2a applies to this section.

12-13. Conditions:

a. Before allowing anyone to enter a tank used for storing petroleum fuel, the contractor will take combustible gas readings with an approved indicator. If the indicator shows that any concentration of gas vapors is present in the tank, personnel will not be permitted to enter or perform work on any part of the tank, either on the interior or exteriors. If gas vapors are present within the explosive range, the contracting office will be notified immediately.

b. If the tank to be repaired has a pontoon-type floating roof, the interior of each individual pontoon shall be tested for gas vapors with an approved combustible gas indicator. If the indicator shows fuel vapors are present, no personnel will be permitted to enter the tank or perform any repair work on either the interior or exterior of the tank and the contracting officer will be notified immediately of the unsatisfactory condition.

c. Written permission from the contracting officer or designated representative is required before any "hot work," such as flame cutting or welding, is performed on any part of the tank. This permit will be issued only when or after:

(1) The combustible gas tests required have been completed and negative results were obtained. Welding and cutting on the tank bottom will be preceded by combustible gas tests under the tank in at least four locations surrounding the area to be welded.
NOTE: Coordinate with LFM engineer on proper method of making combustible gas tests.

(2) All metal areas to be repaired have been cleaned down to bare metal either by wire brushing, machine cleaning, or abrasive blasting.

(3) Necessary safety instructions have been issued by the contractor to personnel who will accomplish the work.

12-14. Work Description:
NOTE: The civil engineer will complete this paragraph outlining the work to be accomplished. Maximum effort will be made to require repair of small holes and pits be made with epoxy patching putty rather than by welding. Additional paragraphs may be used if needed to outline work to be accomplished. For specific technical information on tank repair or coating, contact HQ AFESC/DEMM.

12-15. Clean-Up. The contractor will remove all debris from the interior of the tank and in all other areas the contractor has used, or where debris has accumulated during the work. The tank interior will be washed down and made acceptable for storing clean dry fuel petroleum products.

Section C—Tank Calibration by Strapping or Volumetric Methods and Certified Gage Charts
NOTE: Portions of section A above may be extracted for inclusion into a tank calibration specification. Paragraph 12-2a applies to this section.

12-16. Work Description. The contract will furnish all plant, equipment, labor and materials required to calibrate the following listed tank(s) located at ________________________. Charts will be prepared either by the strapping or volumetric methods, as applicable, in accordance with American Petroleum Institute Standards (API Stds 2550, 2551, 2555):

Type of Construction	Tank(s) Number	Capacity
(Aboveground, steel or concrete)		
(Underground, steel, concrete, or fiberglass)		

a. Before starting the tank calibration work, the contractor will assure that the tank is free of explosive vapors. If the tank contains such vapors, personnel will not enter the tank and the contracting officer (or designated representative) will be notified immediately of this unsatisfactory condition.

b. The contractor will furnish the gauge charts based upon data compiled on the tank capacity. The tank charts will be calibrated in gallons and show the tank capacity in 1/8-inch graduations. The contractor will prepare, and furnish to the contracting officer in individual soft back binders, one reproducible and three copies of the gauge chart for each tank.

c. When the calibration of underground tanks (of 50,000 gallons capacity or less) is required, and the contractor uses the volumetric calibration method, all reasonable amounts of water and electricity will be furnished by the government at the nearest available outlet to the job site.

d. The area within 50 feet of any fuel tank or pipeline is considered Class I, Division I, Group C hazardous area. Electrical equipment (including portable and mobile equipment) must be approved for use in such areas. Additionally, no open flame or spark producing appliances or device is permitted within the hazardous area.

e. A responsible official of the contracting firm must sign the gauge charts to show that calibration was accomplished in accordance with applicable API standards and must list the specific standard used.

★Section D—Petroleum Tank Contractors Qualifications

★12-17. Scope. All prospective contractors for fuel projects must submit a contractor's qualifications statement similar to that shown in figure 12-1 to the command liquid fuels engineer's designated representative (typically the liquid fuels maintenance supervisor). To qualify the contractor must:

a. Show proof of having completed similar work on three previous projects. The work falls into three categories; tank entry, coating, or petroleum system welding. The contractor's experience must fall into one or all of the three categories of work as required by the contract. For example, if welding on the POL system is required by this contract, the contractor or subcontractor must have proof of three similar projects involving welding on a petroleum handling or storage system.

b. Submit proof that welders are API certified (if welding is to be performed).

c. Certify that before commencing work, the contractor supervisor on the job site will be thoroughly familiar with JP-4 fuel characteristics and worker safety requirements outlined in chapter 1, paragraph 1-12 and section D; and chapter 11.

★12-18. Special Contract Provisions. Tank entry, inspection and clean or any welding by a contractor must comply with this manual. The work will be under control of the liquid fuels maintenance supervisor or a command certified tank entry supervisor. The designated supervisor must notify the contracting officer of any safety practices observed not in compliance with this manual.

CONTRACTOR'S QUALIFICATIONS STATEMENT

1. Name of firm.

2. State briefly why firm is qualified to clean, calibrate, repair or coat petroleum storage tanks.

3. List the volume of tank(s) on which the firm has successfully completed work; also, give the location of each tank, the owner's name and the name of a person(s) that may be contacted regarding the tank(s) listed.

4. Since gauge charts are to be individually certified by the firm, what guarantee backs the firm's certificate?

5. The Owner or Owners must furnish the following statements, signed, dated, and notarized:

a. I(We) ______________ have (have not) had a loss of life or injury requiring hospitalization of any employee of this or any other contracting firm that I(we) have owned or managed separately or together.

b. I(We) ______________ have (have not) been involved in a contract where a loss of property occured under this or any other company name.

c. I(We) ______________ have completed tank cleaning, repair, or calibration of the following Department of Defense installations. This list must be complete for the past eight (8) years.

NOTE: If the statements to Items a and b are positive, furnish a detailed explanation.

d. I(have) (will obtain prior to bidding) a copy of the American Petroleum Institute—API 2015, Cleaning Petroleum Storage Tanks.

6. List the make and model numbers of the following pieces of equipment:
   a. Respirators (furnish NIOSH approval number).
   b. Safety Harnesses.
   c. Combustion Gas Indicators.
   d. Air Compressors.
   e. Air Purifiers.

7. Furnish at least three letters of competency from contracts accomplished within the last five years.

I hereby certify that the foregoing statements are true and complete.

____

Signed

Maximum penalty for knowingly and willfully making any false, fictitious, or fraudulent statement or representation is a $10,000 fine and five years imprisonment.

Figure 12-1. Sample Format of Contractor's Qualifications Statement.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

LEW ALLEN, JR., General, USAF
Chief of Staff

VAN L. CRAWFORD, JR., Colonel, USAF
Director of Administration

SUMMARY OF CHANGES

This manual has been revised to include many important technical changes and additions. Major revisions include guidance of new fueling systems (chaps 5 and 6), clarification and changes to preventive maintenance requirements (chap 10) and procedures to improve tank cleaning operations and equipment (chap 11).

GLOSSARY

Absolute Viscosity: The force required to move a plane surface of one square centimeter over another plane surface at the rate of one centimeter per second when the two surfaces are separated by a layer of liquid one centimeter in thickness.

Absorption: The physical assimilation of one or more components of a gaseous or vapor phase into a second phase (liquid or solid).

Absorption Oil: An oil with a high solvent power for light hydrocarbons that are present in natural or refinery gas.

Absorption Plant: A plant for recovering the condensable portion of natural or plant gas, by absorbing these hydrocarbons in an absorption oil (often under pressure), followed by separation and fractionation of the absorbed material.

Accelerated Gum: The nonvolatile material remaining in glass beaker after a sample of oxidized and filtered fuel has been evaporated in accordance with the test method prescribed in the applicable specification.

Acid: The term as used in connection with petroleum usually means sulfuric acid (H_2SO_4) and its aqueous solutions.

Acidity: The amount of free acid in any substance. In lubricating oils, acidity denotes the pressure of acid type constituents whose concentration is usually defined in terms of neutralization number.

Acid Treating: A process for removing undesirable constituents of oil by contacting with sulfuric acid. The acid sludge that is formed by the action of the acid on the oil is separated from the oil and takes with it coloring matter, some sulfur compounds, and unstable bodies, leaving the oil, after finishing by neutralizing, rerunning, or clay treating, lighter colored and a more stable product than before (if not treated too far).

Additives: Chemicals that are added in minor proportions to a parent substance to create, enhance, or suppress a certain property or properties in the parent material.

Additive Type Oil: A lubricating oil to which chemical agents have been added in the refining process to make it particularly suitable for its intended use.

Adsorption: The adhesion of molecules of gases or liquids to the surface of other bodies, usually solids, resulting in a relatively high concentration of the gas or solution at the point of contact.

AFOSH: Air Force Occupational Safety and Health.

Agitator: A vertical tank with conical bottom, with or without lead lining, equipped for agitation by air blowing, used in the treatment of oils where chances for loss by evaporation are negligible, or sometimes with mechanical mixer and floating roof for more volatile stocks.

Alkali: Any substance such as ammonia, hydrated lime, or caustic soda containing a reactive oxide, which forms salts when reacted with acids. In chemical circles it is often spoken of as a base.

Alkaline: Having the properties of an alkali.

Alkalinity: The amount of free alkali in any substance.

Aluminum Base Grease: A grease composed of a mineral oil thickened with aluminum soaps.

Ammonia: An extremely pungent gaseous compound composed of hydrogen and nitrogen, with formula NH_3.

Anhydrous: Destitute of water, especially water of crystallization.

Aniline Point: The minimum temperature at which equal volumes of dry, freshly distilled aniline and petroleum prodcuts are completely miscible.

Antiknock: Resistance to detonation or "pinging" in spark-ignited engines.

Antiknock Agents: Chemical compounds that, when added in small amounts to the fuel charge of an internal combustion engine, have the property of suppressing or at least of strongly depressing knocking. The principal antiknock agent that has been developed for use in fuels is tetraethyllead. Iron carbonyl and aniline (and other aromatic amines) have had limited use.

Antioxidants: Chemicals added to gasoline, lubricating oils, waxes, and other products to inhibit oxidation.

API: The initials of the American Petroleum Institute.

API Gravity: Arbitrary scale for measuring the density of oils, adopted by the American Petroleum Institute. Its relation to specific gravity is expressed as follows:

$$\text{Degrees API} = \frac{141.5}{\text{sp. gr. at } 60°/60°\text{F.}} - 131.5$$

$$\text{Sp. Gr. at } 60°/60°\text{F.} = \frac{\quad}{131.5 \text{ degrees API}}$$

Aromatic Hydrocarbons: Hydrocarbons derived from or characterized by the presence of the benzene ring. Many of this large class of cyclic and polycyclic organic compounds are odorous.

Aromatization: Rearrangement of saturated or unsaturated straight-chain hydrocarbons (provided they contain the necessary number of carbon atoms) into ring structures, with subsequent dehydrogenation to form aromatic hydrocarbons of excellent antiknock characteristics or dehydrogeneration of naphthenes for form aromatics.

ASTM: The initials of the American Society for Testing Materials.

ASTM Distillation: A distillation test made on such products as gasoline and kerosene to determine the initial and final boiling points and the boiling range.

Atmosphere: The mass of air surrounding the earth. The pressure of the air at sea level is used as a unit of measure.

Atmospheric Pressure: The pressure of air exerted equally in all directions. The standard pressure is that at sea level under which a mercury barometer stands at 760 mm equal to 14.7 lb/sq.

Average Boiling Point: Unless otherwise indicated, it is the sum of the ASTM distillation 10 percent boiling temperatures (starting at the 10 percent and ending with the 90 percent, inclusive) divided by nine. (Sometimes half the initial and half the maximum are also added, and the sum then divided by 10.

Average Samples: A sample so taken as to contain parts from all sections of a container or pipe, in proportion to the volume of each part.

Avgas: Common expression for aviation gasoline.

Ballast: Water, usually salt water, carried in tanker cargo tanks when free of petroleum products in order to reduce buoyancy and improve stability and sea-keeping qualities. Ballast may be clean or dirty, depending on whether it is contaminated with petroleum products.

Barrel: Petroleum industry uses 42-gallon barrel as the standard barrel.

Baumé Gravity: Specific gravity expressed on the Baumé scale for liquids lighter or heavier than water. However, the API scale is now used for liquids by the petroleum industry instead of the Baumé scale. Both scales are identical for liquids as dense as water, but for very light oils, there is a difference.

B/D: Abbreviation for barrels per day.

Benzene (Benzol): A hydrocarbon of the composition C_6H_6 and the initial member of the aromatic or benzene series.

Benzene: A colorless, flammable, and volatile liquid obtained from petroleum by fractional distillation and consisting of various hydrocarbons. The term has been applied to various petroleum distillates lighter than kerosene, especially when these are used as solvents. It is totally distinct from the aromatic hydrocarbon benzene. ASTM states that this term is archaic and misleading and should not be used.

Black Cargoes (Dirty Cargoes): A general term used to describe liquid cargoes of crude oil, diesel fuel, or fuel oils.

Black Oil: A general term applied to crude oil and the heavier and the darker-colored petroleum products such as diesel fuel and fuel oils.

Blended Fuel Oil: A fuel oil which is a mixture of residual and distillate fuel oils.

Bloom: The bloom of an oil is its color by reflected light when this differs from its color by transmitted light. It is not known that bloom has any beneficial or detrimental effect on the oil.

Blow-By: In internal combustion engines, leakage of combustion gases from combustion chamber, past the rings, into the crankcase.

Boiling Point: The temperature at which the vapor pressure of a liquid is equal to the pressure of the atmosphere. The temperature varies with the atmospheric pressure.

Bomb: Steel cylinder with screwed-on head used as testing device for conducting oil tests under high pressure. Used for test methods such as Reid Vapor Pressure and gum in gasoline.

Booster Stations (Pumping Stations): Suitable storage tanks, motive power, and pumps for pumping oil through pipelines.

Bottom Sediment and Water (BS&W): A test made on fuel oils, crude oils, and used crankcase oils to show the approximate amount of sediment and water.

Breathing: The movement of gas (oil vapors or air) in and out of the vent lines of storage tanks due to alternate heating and cooling.

Bright Stocks: Pressure distillate bottoms which have had petrolatum wax removed and which have been filtered so that the stock has a low cold test and a good color (dark red by transmitted light and green by reflected light). Bright stock constitutes the body of lubricants manufactured for internal combustion engines.

Btu: Abbreviation for British thermal unit, a unit of heat commonly used in heat engineering. It is the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit.

Bunker: *n.* A compartment below deck for storing fuel used in the boiler-firing of a ship; *v.i.* to load fuel into a vessel's bunker for its own use as distinguished from loading it as cargo.

Bunkering Fuel: Fuel used in the boiler-firing of ships.

Burner Fuel Oil: A fuel oil used primarily in oilburning equipment for the generation of heat in furnaces for heating buildings.

Butterworth: A commercially developed method of cleaning and gas-freeing tanker cargo tanks with hot salt water sprayed from a special machine at about 175 psi and 175°F.

Calcium Base Grease: A grease composed of a mineral oil thickened with calcium (lime) soaps.

Calibration: The act of adjusting a meter register to coincide with a given quantity passing through the meter.

Carbon Residue: The residue remaining after volatilizing an oil under specified conditions.

Catalyst: A substance that effects, provokes, or accelerates reactions without itself being altered.

Caustic: An aqueous solution of sodium hydroxide (lye) used for the neutralization of oils following acid treatment.

Centrifugal Separator: A machine utilizing centrifugal force to separate two phases of differing gravity—such as wax from oil or acid sludge from treated oil.

Centrifuge: An instrument for separating liquids of different specific gravities by use of centrifugal force.

Cetane: A saturated liquid hydrocarbon used as the primary reference fuel when determining the ignition characteristics of diesel fuels.

Cetane Number: Diesel fuel ignitability performance measured by the delay of combustion after injection of the fuel.

CFR: Abbreviation for Cooperative Fuel Research Committee.

Chromometer: An instrument used for determining the color of gasolines, kerosenes, and white oils.

Clean Cargoes: Cargoes such as aviation and motor gasolines, diesel oils, jet fuels, kerosenes, and lubricating oils.

Cleavage Line: The separation point or dividing line between two immiscible fluids, such as water and gasoline.

Coal Oil: A light oil obtained by the destructive distillation of bituminous coal. (The term is frequently misused to designate a light oil—correctly called kerosene—obtained from crude petroleum.)

Cohesive: When referring to grease or oil, good cohesive properties mean that the various particles of the lubricant hold tightly together and resist being pulled apart by mechanical action such as occurs in gears and bearings.

Cold Set Grease: A grease made without heating. An example is axle grease.

Colorimeter: An apparatus used to determine the color of petroleum products.

Combustible: The general term describing any material that will burn. However, in the case of petroleum products only those which give off flammable vapors above 80°F are classed as combustible.

Combustion: The act or process of burning. Chemically, it is the process of rapid oxidation caused by the union of the oxygen of the air, which is the supporter of combustion, with any material that is capable of oxidation.

Commingling: The admixture of two or more petroleum products resulting from improper handling, particularly in pipeline or tanker operations.

Composite Sample: A sample that is a mixture of samples taken from the upper, middle, and lower thirds of a container.

Compound: A substance formed by the union of two or more chemical elements in definite proportions by weight.

Compound Oil: A mineral oil to which animal or vegetable fat has been added. (Later usage has included the addition of other additives.)

Condensate: The liquid product coming from a condenser.

Conradson Test: A carbon residue test method for determining the amount of carbon deposited after oil has burned. In this method, a sample of oil is tested by driving off volatile portions, weighing the residue, and calculating the percentage of original oil.

Consistency: A measure of the solidity or fluidity of semisolid products such as grease, petroleum, and asphalt.

Contamination: The addition to a petroleum product of some material not normally present, as dirt, rust, water, or another petroleum product.

Corrosion: Detrimental change in the size or characteristics of material under conditions of exposure or use. It usually results from chemical action either regularly and slowly as in rusting, or rapidly as in metal pitting.

Cracking: Breaking down an organic compound with a high molecular weight to form compounds of smaller molecular weight.

Crude Petroleum: A naturally occurring mixture, consisting predominately of hydrocarbons, and/or of sulfur, nitrogen and/or oxygen derivatives' of hydrocarbons, which is removed from the earth in liquid state or is capable of being so removed. Crude petroleum is commonly accompanied by varying quantities of extraneous substances such as water, inorganic matter, and gas.

Cup Grease: Originally used to indicate a grease for use in compression cups, but usage now indicates a grease having a calcium fatty acid soap base.

Cut: Same as fraction.

Cut-Back: To reduce the viscosity of a heavy product by adding and blending a lighter product with it.

Cylinder Oils: Oils used to lubricate the cylinders and valves of steam engines.

Cylinder Stock: A class of highly viscous oils so called because originally their main use was in the preparation of products to be used for steam cylinder lubrication.

Degras: A fat exuded from the skin of a sheep and taken from the wool. It is used as a compound of compounded lubricating oils and rust preventives.

Dehydrogenation: The process of removing hydrogen from adjacent carbon atoms of an organic compound with resultant formation of a double bond.

Demulsibility: The ability of an oil to separate from any water with which it is mixed.

Density: The mass of a unit volume. Its numerical expression varies with the unit selected.

Detergents: Compounds (typically alkalyl sulfonates, fatty alcohol sulfates, etc.) that act to wet, disperse, and deflocculate solid particles.

Detergent Oil: A lubricating oil possessing special sludge-dispersing properties for use in internal combustion engines.

Deterioration: Any undesirable chemical or physical change that takes place in petroleum products while in storage or in use.

Detonation: Sharp explosion. The term is applied to the knock-producing type of combustion in spark-ignited internal combustion engines that may be induced by low octane rating of fuel, high air-fuel ratio, advanced spark, or excessive engine or mixture temperature.

Dielectric Strength: The rating of the insulating power of insulating oils. Thus, oils with the highest dielectric strength (expressed in kilovolts) are the best electrical insulators.

Dilution of Crankcase Oils: The percentage of fuel in used internal combustion engine oil.

Dirty Cargoes: (See black cargoes.)

Distillate: That portion of oil that is removed as a vapor and condensed during a distillation process.

Distillate Fuel Oils:: Fuel oils that are distillates derived directly or indirectly from crude petroleum (chiefly from the gas oil fraction).

Distillation: Distillation generally refers to vaporization processes in which the vapor evolved is recovered, usually by condensation, and a separation effected between those fractions which vaporize and those which remain in the bottoms.

Downgrading: Assigning a petroleum product for use where a lower grade of product would normally be employed, provided it meets the requirements for the lower grade.

Emulsibility: The ability of an oil to mix readily with water.

Emulsifying Agents: Surface-active substances that help to promote an emulsion and to keep it stable after formation.

Emulsion: Intimate mixture of two immiscible liquids, one of them being dispersed in the other in the form of fine droplets.

E P Lubricant: Extreme pressure lubricant.

Ester: A compound formed by the action of an alcohol and an acid.

Ethyl Fluid: (See tetraethyllead.)

Evaporation Loss: The loss of petroleum products—particularly gasoline—through the evaporation of the most volatile fractions.

Explosive limits (Explosive Range): The limits of percentage composition of mixtures of gases and air within which an explosion takes place when the mixture is ignited.

Extreme Pressure Lubricant: Lubricating Oil or grease that contains a substance or substances specifically introduced to prevent metal-to-metal contact in the operation of highly loaded gears.

Fatty Oil: A fat that is liquid at room temperatures.

Fiber Grease: Grease of distinctly fibrous nature which is noticeable when portions of the grease are pulled apart. (Greases having this fibrous structure resist being thrown off gears and bearings.)

Film Strength: The ability of lubricant to form a film, which separates bearing surfaces, without breaking down and causing metal-to-metal contact. (The higher the film strength, the greater the load the lubricant can carry.)

Fire Point: The lowest temperature at which, under specified test conditions, a petroleum product vaporizes sufficiently rapidly to form above its surface an air-vapor mixture that burns continuously when ignited by a small flame.

Fixer oils: Animal and/or vegetable oils.

Flammable: Term describing any combustible material that can be ignited easily and which will burn rapidly. Petroleum products that have a flash point of 80°F or lower are classed as flammable.

Flash Point: The lowest temperature at which, under specified test conditions, a petroleum product vaporizes rapidly enough to form above its surface an air-vapor mixture that gives a flash or slight explosion when ignited by a small flame.

Flushing Oil: Oil or a compound designed for the purpose of removing used oil, decomposition products, and dirt from lubrication passages, crankcase surfaces, and moving parts of automotive engines accessible to the lubrication system.

Freeboard: The distance measured vertically downward at the side of a vessel, amidships, from the upper edge of the deck line to the upper edge of the load line.

Freezing Point: The temperature at which a substance freezes.

Fuel Depot (Storage terminal, tank form); Bulk storage installation composed of storage tanks and related facilities, such as docks, loading racks, and pumping units.

Fuel Oil: Any liquid petroleum product used for the generation of heat in a furnace or firebox.

Gas Indicator (Vapor Indicator): An instrument used to detect the presence of flammable gases or vapors in the atmosphere. (Also known by various trade names as explosimeter, vapotester, etc.)

Gasol: German term meaning liquefied petroleum gas.

Gasoline: A volatile liquid hydrocarbon fuel generally made from petroleum.

Go-Devil: A scraping device which is forced through pipelines to insure that there are no obstructions.

Gravity: (See API gravity.)

Grease: A combination of a petroleum product and a soap, or a mixture of soaps, suitable for certain types of lubrication.

Gum: Resin-like, naphtha-insoluble deposits formed by the oxidation and polymerization of certain petroleum products, particularly gasoline.

Heavy Duty Oils: Lubricating oils that were originally developed for use in certain types of high-speed diesel engines and spark-ignition engines subject to high piston and crankcase temperatures. They combine the properties of detergency, resistance to oxidation, and relative freedom from corrosive action on alloy type bearings. Normally they contain special additives that confer these properties.

Hydraulic Fluid: Fluids that may be of petroleum or nonpetroleum origin intended for use in hydraulic systems. Low viscosity, low rate of change of viscosity with temperature, and low pour point are desirable characteristics.

Hydrocarbon: Any of the components made up exclusively of hydrogen and carbon in various ratios.

Hydrogenation: The process of adding hydrogen to the hydrocarbon molecule

Hydrometer: An instrument for determining the specific gravity of a liquid.

Hydrostatic Head: That portion of existing pressure at a point that is attributable to the weight of the superimposed column of fluid.

Hydrous: Containing water chemically combined, as in hydrates or hydroxide.

Ignition Quality: The abilily of a fuel to ignite on injection into the cylinder.

Inhibiters: Chemical compounds that, when added in small amounts, reduce rates of chemical reactions.

Innage: Depth of liquid in a tank, measured from the surface of the liquid to the tank bottom.

Inorganic Acid: An acid of nonorganic origin, hence containing no carbon.

Inorganic Compound: A compound containing no carbon hence composed of matter other than animal or vegetable, such as clay or glass.

Insoluble: Incapable of being dissolved in a liquid.

Insoluble Oils: Oils that do not form stable emulsions or collodial solutions with water.

Iso-Octane: A hydrocarbon showing 100 octane value, used primarily as a reference fuel in determining the octane rating of gasoline.

JP Fuel: Fuel used in jet aircraft engines.

Kerosene: A general term covering the class of refined oils boiling between 370°F and 515°F used primarily in domestic oil lamps and cooking stoves.

Kinematic Viscosity: The ratio of viscosity of a liquid to its specific gravity at the temperature at which the viscosity is measured.

Knock: In gasoline engines, detonation caused by sudden burning of the last remaining portion of the fuel in the combustion chamber.

Knock Characteristics: Tendency of a gasoline to knock. (See octane number).

Lacquer (Varnish): A coating similar to a natural varnish, left on engine parts as a result of high temperature of oil and gasoline.

Lampblack: A solid product, consisting largely of carbon, obtained by the incomplete combustion of hydrocarbon materials. It is substantially different from carbon blacks and channel black, being greyish in color.

Lead Susceptibility: The ability of gasoline to respond to the addition of tetraethyllead, as reflected in the increase in octane number per increment of lead added.

Liquefied Petroleum Gas: Gaseous forms of petroleum that have been converted into liquids by changes in temperature and pressure.

Liquid Fuel: Any liquid used as fuel that can be poured or pumped.

LPG: Abbreviation for liquefied petroleum gas.

Lower Toxic Limit: The maximum permissible content of petroleum vapor (0.1 percent by volume) in a tank or compartment that is to be entered by persons.

Lower and Upper Explosive Limit: For vapors defined as the lower and upper limits of vapor concentration that will propagate flame if ignited (synonymous with flammable limits).

Lubricant: Material, especially oils, grease, and solids such as graphite, used to decrease friction.

Lubricating Grease: A solid or semisolid material consisting of fluid lubricant(s) and soap or thickening agent(s) with or without additives or fillers, suitable for reducing friction between mechanical moving parts.

MBPC: Initials of Munitions Board Petroleum Committee.

Military Specification: Guides in determining the quality requirements of products used by the military services, published by the Standards Agency of the Department of Defense.

Mill Scale: A magnetic product formed on iron and some steel surfaces during the manufacturing process.

Mineral Oil: A wide range of products derived from petroleum and within the viscosity ranges of products spoken of as oils.

Mixture: The combination of two or more substances united in such a way that each retains its original properties.

Mogas: Common expression for motor (automotive) gasoline.

Naphtha's: Oils of low boiling range (80°F to 440°F) usually of good color and odor when finished. Sometimes refers to gasoline components and sometimes to special products, solvents, etc.

Nonsparking Tools: Tools made of a metal alloy which, when struck against other objects, will not usually cause sparks of sufficient temperature to ignite flammable vapors.

NIOSH: National Institute for Occupational Safety and Health.

NPA: Initials of National Petroleum Association.

Octane: The eighth member of the paraffin or saturated series of hydrocarbons, having a boiling point of 258°F, and the chemical formula C_8H_{18}.

Octane Number: Term used to indicate numerically the relative antiknock value of automotive gasolines, and of aviation gasolines having a rating below 100. It is based on comparison with the reference fuels, iso-octane (100 octane number) and normal heptane (0 octane number). The octane number of an unknown fuel is the volume percent of iso-octane with normal heptane that matches the unknown fuel in knocking tendencies under a specified set of conditions.

Off Specification: Term describing a product that fails to meet the requirements of the applicable specification.

Organic: Pertaining to compounds produced in plants and animals of carbon compounds of artificial origin.

OSHA: Occupational Safety and Health Administration.

Outage: See ullage.

Oxidation: In general, the process in which oxygen is added to a compound. The oxidation reaction in petroleum may lead to gum or resin formation that is of importance in the utilization of gasoline, particularly those that contain unsaturated compounds.

Oxidation Inhibiters: Chemical compounds added to petroleum products in small quantities to reduce the rate of oxidation.

Permeability: A measure of the ease with which a fluid can flow through a porous medium. The easier the flow, the greater the permeability of the medium.

Petrol: Term used, particularly in England, to designate petroleum or its derivatives.

Petroleum: A compound consisting of a mixture of hydrocarbons.

POL: A broad term that includes all petroleum products used by the Armed Forces. It originated as an abbreviation for petrol, oil, and lubricants.

Pour Point: The lowest temperatures at which an oil will pour or flow when chilled without disturbance under specified conditions. By ASTM instruction, it is taken as the temperature 5°F above the solid point.

Precipitate: Material, formed during the accelerated oxidation of loaded fuel, which is insoluble in both the fuel and the gum solvent.

Psi: Abbreviation for pounds per square inch.

Pumping Stations: (See booster stations.)

Reclamation: Procedure required to restore or change the quality of contaminated petroleum products to meet desired specifications.

Reid Vapor Pressure: The measure of pressure exerted on the interior of a special container (Reid Vapor Pressure apparatus), under specified test conditions, because of the tendency of the product to vaporize.

SAE: Initials of Society of Automotive Engineers.

SAE Viscosity: An arbitrary system for classifying motor oils according to their viscosities, established by the Society of Automotive Engineers.

Scupper Plugs: Plugs of various types, tightly fitted or cemented in all scupper holes on the weather deck of tankers while loading, discharging, or shifting cargo in port. In the case of a spill of oil, the plugs usually prevent harbor pollution by retaining the spill on decks.

Sediment and Water: Solids and aqueous solutions that may be present in an oil and that either settle out on standing or may be separated more rapidly by a centrifuge.

Sludge: Deposits (which may be hard and lumpy, grainy, and/or pasty) in a lubricating system. These deposits, which are insoluble in the oil, may be the result of contamination of the oil or of deterioration of the oil itself.

Slushing Oil: An oil or greaselike material used as a temporary protective coating against corrosion.

Soluble Oils: Oils that readily form stable emulsions or colloidal solutions with water. They usually contain metallic or ammonium soaps or sulfonated oils and may be used for cutting oils, detergents, insecticides, etc.

Specific Gravity: The ratio of the weight of a given volume of the material at 60°F to the weight of an equal volume of distilled water at the same temperature, both weights being corrected for the buoyancy of air.

Stability: Property of product which gives it the ability to retain its physical and chemical properties intact, even during extended storage.

Strapping: Measuring storage tanks and cargo carriers for capacity.

Synthetic Fuels: Term commonly used to indicate fuels manufactured from sources other than crude petroleum (such as shale or coal).

Tank Farm: (See fuel depot).

Tetraethyllead: A volatile lead compound PB $(C_2H_5)4$ which, when added in small proportions to gasoline, increases the octane rating.

Tetraethyllead Susceptibility: (See lead susceptibility).

Thermal Value: Calories per gram or B T U per pound produced by burning fuels.

Thief: A sampling apparatus so designed that a liquid sample can be obtained within one-half inch of the bottom of a tank.

Thiefing: Taking a sample from the bottom on a tank, primarily to determine the amount of free water present. Also, commonly used to mean measuring the amount of water at the bottom of a tank by means of a tape and bob, or by gaging pole.

Tolerance: An allowable variation from a specified limit.

Triptane: One of the highest known antiknock fuels

Ullage (Outage): The distance from a given point at the top of a container down to the surface of the liquid.

Vapor Explosive Range: (See explosive limits).

Vaporization: Conversion of a liquid to its vapor, such as the conversion of water into steam.

Vapor Lock: Malfunctioning of carburetor and fuel feed systems of internal combustion engines caused by evolution of bubbles of vapor from the gasoline.

Vapor Pressure: The outward pressure of a mass of vapor at a given temperature when enclosed in a gastight vessel. It is an index to the volatility of the liquid from which the vapor was produced.

V.I.: Initials of viscosity index.

Viscosity: The property of resisting flow or deformation that all liquids possess.

Viscosity Index: A measure of the temperature coefficient of viscosity of a lubricating oil as expressed by the relationship between its viscosity at 100°F and its viscosity at 210°F.

Viscosimeter: An apparatus for determining viscosity.

Volatility: A measure of the propensity of a substance to change from the liquid or solid state to the gaseous state. A volatile liquid is one that readily vaporizes at comparatively low temperatures.

Weathering: Loss of the more volatile components of a product as a result of evaporation.

Wet Gas: A gas containing a relatively high proportion of readily condensable constituents.

HYDRAULIC DATA

1. CONVERSION TABLE BAUME—SPECIFIC GRAVITY—WEIGHT PER GALLON

CONVERSION TABLE BAUME — SPECIFIC GRAVITY — WEIGHT PER GALLON FOR LIQUIDS HEAVIER THAN WATER

A.P.I. or baume'	Specific gravity	Wght. per gal.	A.P.I. or baume'	Specific gravity	Wght. per gal.	A.P.I. or baume'	Specific gravity	Wght. per gal.	A.P.I. or baume'	Specific gravity	Wght. per gal.	A.P.I. or baume'	Specific gravity	Wght. per gal.
0	1.000	8.33	10	1.074	8.95	20	1.160	9.67	30	1.260	10.50	40	1.381	11.51
1	1.006	8.38	11	1.082	9.02	21	1.169	9.74	31	1.271	10.59	45	1.450	12.08
2	1.014	8.45	12	1.090	9.08	22	1.178	9.82	32	1.283	10.69	50	1.526	12.72
3	1.021	8.51	13	1.098	9.15	23	1.188	9.90	33	1.294	10.78	55	1.611	13.42
4	1.028	8.57	14	1.106	9.22	24	1.198	9.98	34	1.306	10.88	60	1.705	14.21
5	1.035	8.62	15	1.115	9.29	25	1.208	10.07	35	1.318	10.98	65	1.812	15.10
6	1.043	8.69	16	1.124	9.37	26	1.218	10.15	36	1.330	11.08	70	1.933	16.11
7	1.050	8.75	17	1.132	9.43	27	1.228	10.23	37	1.342	11.18	------	------	------
8	1.058	8.82	18	1.141	9.51	28	1.239	10.32	38	1.355	11.29	------	------	------
9	1.066	8.88	19	1.150	9.58	29	1.250	10.42	39	1.367	11.39	------	------	------

FOR LIQUIDS LIGHTER THAN WATER

A.P.I. or baume'	Specific gravity	Wght. per gal.	A.P.I. or baume'	Specific gravity	Wght. per gal.	A.P.I. or baume'	Specific gravity	Wght. per gal.	A.P.I. or baume'	Specific gravity	Wght. per gal.	A.P.I. or baume'	Specific gravity	Wght. per gal.
10	1.000	8.33	31	0.871	7.25	52	0.7712	6.42	73	0.6926	5.76	91	.636	5.29
11	0.993	8.27	32	0.865	7.21	53	0.7670	6.39	74	0.6893	5.73	92	.633	5.27
12	0.986	8.21	33	0.860	716	54	0.7637	6.35	75	0.6859	5.70	93	.630	5.25
13	0.979	8.16	34	0.855	7.12	55	0.7597	6.32	76	0.6826	5.68	94	.628	5.22
14	0.973	8.10	35	0.850	7.08	56	0.7556	6.28	77	0.6793	5.65	95	.625	5.20
15	0.966	8.04	36	0.845	7.03	57	0.7516	6.25	78	0.6750	5.62	96	.622	5.18
16	0.959	7.99	37	0.840	6.99	58	0.7476	6.22	79	0.6728	5.60	97	.619	5.15
17	0.953	7.94	38	0.835	6.95	59	0.7437	6.18	80	0.6696	5.57	98	.617	5.13
18	0.946	7.88	39	0.830	6.91	60	0.7398	6.15	81	0.6665	5.54	99	.614	5.11
19	0.940	7.83	40	0.825	6.87	61	0.7359	6.12	82	0.6634	5.52	100	.611	5.09
20	0.934	7.78	41	0.820	6.83	62	0.7310	6.09	83	0.6603	5.49	------	------	------
21	0.928	7.73	42	0.816	6.79	63	0.7283	6.06	84	0.6572	5.47	------	------	------
22	0.921	7.68	43	0.811	7.75	64	0.7246	6.03	85	0.6541	5.44	------	------	------
23	0.916	7.63	44	0.806	6.71	65	0.7209	5.99	86	0.6511	5.42	------	------	------
24	0.910	7.58	45	0.802	6.68	66	0.7172	5.96	87	0.6481	5.39	------	------	------
25	0.904	7.53	46	0.797	6.64	67	0.7136	5.93	88	0.6452	5.37	------	------	------
26	0.898	7.48	47	0.793	6.60	68	0.7090	5.90	89	0.6422	5.34	------	------	------
27	0.893	7.43	48	0.788	6.56	69	0.7065	5.87	90	0.6393	5.32	------	------	------
28	0.887	7.39	49	0.784	6.53	70	0.7020	5.85	------	------	------	------	------	------
29	0.882	7.34	50	0.780	6.49	71	0.6995	5.82	------	------	------	------	------	------
30	0.876	7.30	51	0.775	6.46	72	0.6950	5.79	------	------	------	------	------	------

The specific gravity of a substance is its weight as compared with the weight of an equal bulk of pure water.
For making specific gravity determinations the temperature of the water is usually taken at 62° F. when 1 cubic foot of water weighs 62.355 lbs. Water is at its greatest density at 39.2 F. or 4° Centigrade.

2. FRICTION OF LIQUIDS IN PIPES

Loss in head in feet of liquid due to friction per 100 feet of 15-year-old smooth iron pipe

Pipe Size	GPM	Velocity	Viscosity—Saybolt Universal Seconds (Approximate)										
			—	31	43	61	125	227	475	950	1425	1900	2400
			Kinematic Viscosity—Centistokes										
			.5	1	5	10	25	50	100	200	300	400	500
½ (.622)	5	5.3	35.8	40.2	51.5	56.8	66.5	105.5	211.0	-----	-----	-----	-----
¾ (.824)	5	3.0	9.3	18.3	13.2	14.7	17.3	34.6	69.2	138.4	207.6	-----	-----
	10	6.0	33.9	37.1	47.5	52.7	60.9	69.0	138.0	276.0	-----	-----	-----
	15	9.0	60.6	79.0	99.5	111.2	129.0	144.2	208.0	-----	-----	-----	-----
1 (1.049)	5	1.9	2.9	3.2	4.1	4.6	6.4	12.7	25.5	51.0	76.5	102.0	127.5
	10	3.7	10.2	11.4	14.6	16.3	18.9	26.2	52.4	104.8	152.2	209.6	-----
	15	5.6	21.6	24.1	30.9	34.4	39.6	44.7	79.3	158.6	237.9	-----	-----
	20	7.4	36.6	40.9	52.5	58.5	68.5	75.5	104.7	209.4	-----	-----	-----
	25	9.3	55.3	61.4	79.6	88.8	102.0	113.6	130.0	260.0	-----	-----	-----
1¼ (1.380)	5	1.1	-----	-----	1.1	1.2	2.2	4.4	8.8	17.5	26.2	35.0	43.7
	10	2.1	2.7	3.0	3.9	4.4	5.0	8.8	17.6	35.2	52.8	70.4	88.0
	15	3.2	5.7	6.5	8.2	9.2	10.6	13.2	26.4	52.8	79.2	105.6	132.0
	20	4.3	8.8	10.9	13.9	15.5	17.9	20.2	35.2	70.4	105.6	140.8	176.0
	25	5.4	14.7	16.7	21.0	23.4	27.2	30.4	43.9	87.8	131.7	175.6	219.5
	30	6.4	20.4	22.9	29.6	32.9	38.0	42.3	52.5	105.0	157.5	210.0	-----
	35	7.5	27.5	30.5	39.6	44.2	50.8	56.6	63.5	127.0	190.5	254.0	-----
	40	8.6	34.7	30.1	50.1	55.6	65.1	71.5	80.5	140.5	211.0	-----	-----
	45	9.6	43.5	48.5	62.5	69.5	79.5	90.5	100.5	154.0	231.0	-----	-----
1½ (1.610)	5	.8	-----	-----	-----	-----	1.2	2.4	4.8	9.6	14.3	19.1	23.9
	10	1.6	1.3	1.4	1.9	2.1	2.4	4.8	9.6	19.2	28.8	38.4	48.0
	15	2.4	2.7	3.0	3.9	4.3	5.1	7.1	14.2	28.4	42.6	56.8	71.0
	20	3.1	4.6	5.2	6.7	7.4	8.6	9.6	19.2	38.4	57.6	76.8	96.0
	25	3.9	6.9	7.9	9.9	11.1	12.8	14.4	23.8	47.6	71.4	95.2	119.0
	30	4.7	9.8	10.8	14.0	15.6	18.1	20.7	28.4	56.8	85.2	113.6	142.0
	35	5.5	12.9	14.4	18.6	20.7	24.0	26.6	33.1	66.2	99.3	132.4	165.5
	40	6.3	16.7	18.4	24.0	26.7	30.7	34.2	38.4	76.8	115.2	153.6	192.0
	45	7.1	20.6	23.1	29.8	33.1	38.2	41.9	47.9	85.2	127.5	170.0	213.0
	50	7.9	25.1	27.7	35.7	39.7	46.3	51.7	57.5	95.5	143.0	191.0	238.5
	60	9.4	35.4	39.1	50.2	57.0	64.6	72.4	81.0	113.5	170.0	227.0	-----
2 (2.067)	10	1.0	-----	-----	-----	-----	-----	1.7	3.5	7.0	10.4	13.9	17.4
	15	1.4	-----	-----	1.2	1.3	1.5	2.6	5.3	10.5	15.8	21.1	26.3
	20	1.9	1.3	1.5	2.0	2.2	2.5	3.5	7.0	14.0	21.0	28.0	35.0
	25	2.4	2.0	2.3	3.0	3.3	3.8	4.4	8.7	17.4	26.1	34.8	43.5
	30	2.9	2.9	3.2	4.2	4.6	5.3	6.0	10.5	21.0	31.5	42.0	52.5
	35	3.3	3.8	4.3	5.5	6.1	7.1	8.0	12.2	24.4	36.6	48.8	61.0
	40	3.8	4.9	5.5	7.1	7.9	9.2	10.3	13.9	27.9	41.8	55.8	69.7
	45	4.3	6.2	6.8	8.8	9.8	11.3	12.6	15.6	31.3	47.0	62.6	78.3
	50	4.8	7.5	8.3	10.7	12.0	13.8	15.3	17.4	34.8	52.2	69.6	87.0
	60	5.7	10.4	11.7	15.0	16.6	19.5	21.4	24.1	41.9	62.8	83.8	104.5
	70	6.7	13.8	15.4	19.8	22.0	25.5	28.2	32.0	48.8	73.0	98.0	122.0
	80	7.6	18.0	19.7	25.4	28.3	32.6	37.0	40.7	55.6	84.0	112.0	140.0
	90	8.6	22.3	24.4	31.6	36.3	40.8	45.4	50.4	62.6	94.0	125.0	157.0
	100	9.6	26.8	29.8	38.3	43.0	49.2	55.0	61.3	69.5	104.0	139.0	174.0
2½ (2.469)	20	1.3	-----	-----	-----	-----	1.1	1.7	3.4	6.8	10.2	13.8	17.0
	25	1.7	-----	-----	1.3	1.4	1.6	2.1	4.3	8.6	12.0	17.2	21.6
	30	2.0	1.2	1.4	1.8	2.0	2.3	2.6	5.2	10.4	15.6	20.8	26.0
	35	2.3	1.6	1.8	2.3	2.6	3.0	3.4	6.0	12.0	18.0	24.0	30.0
	40	2.7	2.1	2.3	3.0	3.3	3.9	4.3	6.9	13.8	20.7	27.6	34.5
	45	3.0	2.6	3.0	3.7	4.1	4.8	5.4	7.8	15.6	23.4	31.2	39.0
	50	3.4	3.1	3.5	4.5	5.0	5.8	6.5	8.5	17.0	25.5	34.0	42.5
	60	4.0	4.4	4.9	6.4	7.1	8.1	9.1	10.3	20.6	30.9	41.2	51.5
	70	4.7	5.7	6.5	8.4	9.3	10.9	12.0	13.5	23.9	35.9	47.8	59.8
	80	5.4	7.6	8.4	10.8	12.0	13.7	15.6	17.3	27.4	41.1	54.9	68.5
	90	6.0	9.4	10.4	13.2	14.8	17.1	19.7	21.5	30.9	46.4	62.0	77.4
	100	6.7	11.3	12.5	16.2	18.1	20.9	23.0	25.9	34.1	51.2	68.2	85.3
	125	8.4	17.3	19.2	24.6	27.8	31.4	35.4	39.4	42.3	63.5	84.5	105.5
	150	10.0	23.9	26.6	34.6	38.5	44.3	49.2	54.9	61.8	76.6	102.0	127.5
3 (3.068)	20	.9	-----	-----	-----	-----	-----	-----	1.4	2.9	4.6	6.1	7.6
	25	1.1	-----	-----	-----	-----	-----	-----	1.8	3.6	5.5	7.3	9.1
	30	1.3	-----	-----	-----	-----	-----	1.1	2.1	4.3	6.4	8.6	10.7
	35	1.5	-----	-----	-----	-----	1.1	1.3	2.6	5.2	7.8	10.4	13.0
	40	1.7	-----	-----	1.1	1.2	1.4	1.5	2.9	5.8	8.7	11.6	14.5
	45	2.0	-----	1.0	1.3	1.4	1.7	1.9	3.2	6.4	9.6	12.8	16.0
	50	2.2	1.1	1.2	1.6	1.8	2.1	2.3	3.6	7.2	10.8	14.4	18.0
	60	2.6	1.5	1.7	2.2	2.5	2.9	3.2	4.3	8.6	12.9	17.6	21.5
	70	3.0	2.0	2.3	2.9	3.3	3.8	4.2	5.0	10.0	15.0	20.0	25.0
	80	3.5	2.7	2.8	3.6	4.3	4.8	5.4	6.0	11.6	17.3	23.0	28.8
	90	3.9	3.2	3.7	4.7	5.2	6.0	6.7	7.6	12.9	19.4	26.0	32.4
	100	4.3	4.0	4.4	5.7	6.3	7.2	8.2	9.1	14.3	21.6	28.6	35.7
	125	5.4	6.0	6.6	8.5	9.6	11.0	12.2	13.6	18.0	27.0	36.0	45.0
	150	6.5	8.4	9.3	12.0	13.4	15.4	17.2	19.2	21.9	32.8	43.8	54.8
	175	7.6	11.2	12.3	16.2	17.7	20.5	23.0	25.2	28.5	37.6	50.2	62.7
	200	8.7	14.2	16.0	20.7	22.7	26.0	28.9	33.9	36.6	43.0	57.4	71.6
	225	9.7	17.7	19.0	25.3	28.1	32.6	36.2	40.5	45.4	48.4	64.5	80.6
4 (4.026)	40	1.0	-----	-----	-----	-----	-----	-----	-----	1.8	2.8	3.7	4.6
	50	1.3	-----	-----	-----	-----	-----	-----	1.2	2.4	3.6	4.8	6.0
	60	1.5	-----	-----	-----	-----	-----	-----	1.4	2.8	4.2	5.6	7.0
	70	1.8	-----	-----	-----	-----	1.0	1.1	1.6	3.2	4.8	6.4	8.0
	80	2.0	-----	-----	1.0	1.1	1.3	1.5	1.8	3.6	5.4	7.2	9.0

NOTES:

Values to left of irregular line should be multiplied by .7 for new, smooth, wrought iron pipe. For old, rough pipe, multiply by 1.6.

Values to right of irregular line are in streamlined flow area and do not vary with pipe conditions.

Multiply ALL values by specific gravity except when using Blackmer Pump Check Sheet in computing operating conditions.

Velocity values are in feet per second.

For viscosities above 2400 SUS or 500 CS - the friction loss increases in direct proportion to the viscosity increase.

Example - for 50 GPM through 2 inch pipe with viscosity of 2400, the friction loss is 87.0 feet per 100 ft. of pipe. For 4800 SUS, the friction loss would be 174.0 feet per 100 ft. of pipe.

FRICTION OF LIQUIDS IN PIPES

Loss in head in feet of liquid due to friction per 100 feet of 15-year-old smooth iron pipe

Pipe Size	GPM	Velocity	Viscosity—Saybolt Universal Seconds (Approximate)										
			—	31	43	61	126	237	475	950	1425	1900	2400
			Kinematic Viscosity—Centistokes										
			.5	1	5	10	25	50	100	200	300	400	500
4 (4.026)	90	2.3	-----	-----	1.1	1.4	1.6	1.8	2.1	4.2	6.3	8.4	10.5
	100	2.5	1.1	1.2	1.5	1.7	2.0	2.2	2.5	5.0	7.5	10.0	12.5
	125	3.1	1.6	1.8	2.3	2.5	3.0	3.3	3.5	6.1	9.2	12.2	15.2
	150	3.8	2.3	2.5	3.2	3.6	4.1	4.6	5.2	7.3	11.0	14.6	18.3
	175	4.4	3.0	3.3	4.3	4.8	5.5	6.1	6.8	8.5	12.8	17.0	21.3
	200	5.0	3.8	4.3	5.5	6.1	7.0	7.9	8.8	9.8	14.7	19.6	24.5
	225	5.7	4.7	5.3	6.9	7.6	8.8	9.8	10.7	12.3	16.3	21.8	27.2
	250	6.3	5.8	6.4	8.3	9.1	10.7	11.8	13.2	14.6	18.3	24.4	30.5
	275	6.9	6.8	7.3	9.3	10.4	12.1	13.5	14.9	16.9	20.0	26.7	33.3
	300	7.5	8.1	9.1	11.6	12.8	14.8	16.5	18.5	20.7	22.1	29.5	36.5
	325	8.2	9.4	10.4	13.3	15.0	17.2	19.1	21.1	23.7	25.6	31.6	39.5
	350	8.8	10.7	12.0	15.5	17.1	19.6	21.9	24.5	27.2	29.7	33.8	42.3
	400	10.0	13.7	15.3	19.2	21.9	25.2	28.0	31.4	35.0	37.2	39.3	40.1
5 (5.047)	70	1.1	-----	-----	-----	-----	-----	-----	-----	1.4	2.0	2.7	3.4
	80	1.3	-----	-----	-----	-----	-----	-----	-----	1.6	2.3	3.1	3.9
	90	1.4	-----	-----	-----	-----	-----	-----	-----	1.8	2.5	3.5	4.4
	100	1.6	-----	-----	-----	-----	-----	-----	-----	1.9	2.9	3.9	4.9
	125	2.0	-----	-----	-----	-----	-----	1.1	1.2	2.4	3.6	4.8	6.0
	150	2.4	-----	-----	1.1	1.2	1.4	1.5	1.7	2.9	4.4	5.8	7.3
	175	2.8	-----	1.1	1.4	1.6	1.8	2.0	2.3	3.4	5.1	6.8	8.5
	200	3.2	1.2	1.4	1.8	2.0	2.4	2.7	2.9	3.9	5.9	7.8	9.8
	225	3.6	1.6	1.7	2.3	2.5	2.9	3.3	3.6	4.4	6.6	8.8	11.0
	250	4.0	1.9	2.1	2.8	3.1	3.5	4.0	4.4	5.0	7.5	10.0	12.5
	275	4.4	2.3	2.5	3.3	3.7	4.2	4.7	5.3	5.9	8.1	10.8	13.5
	300	4.8	2.7	3.0	3.9	4.3	5.0	5.5	6.2	6.9	8.8	11.7	14.7
	325	5.2	3.1	3.5	4.6	5.0	5.7	6.3	7.2	8.0	9.5	12.7	15.8
	350	5.6	3.6	4.0	5.1	5.7	6.6	7.3	8.1	9.2	10.3	13.8	17.2
	400	6.4	4.6	5.2	6.6	7.3	8.2	9.3	10.6	11.7	12.5	15.6	19.5
	450	7.2	5.7	6.4	8.3	9.1	10.4	11.6	13.1	14.6	15.6	17.7	22.1
	500	8.0	6.9	7.7	9.9	11.1	12.7	14.2	15.8	17.6	18.8	19.8	24.8
	600	9.6	9.7	10.7	13.7	15.5	17.9	19.8	22.0	24.6	26.4	27.8	29.1
6 (6.065)	100	1.1	-----	-----	-----	-----	-----	-----	-----	-----	1.4	1.9	2.4
	125	1.4	-----	-----	-----	-----	-----	-----	-----	1.2	1.7	2.4	3.0
	150	1.6	-----	-----	-----	-----	-----	-----	-----	1.4	2.1	2.8	3.6
	175	1.9	-----	-----	-----	-----	-----	-----	-----	1.6	2.4	3.2	4.0
	200	2.2	-----	-----	-----	-----	-----	1.1	1.2	1.9	2.9	3.8	4.8
	225	2.5	-----	-----	-----	1.0	1.2	1.3	1.5	2.1	3.2	4.2	5.3
	250	2.8	-----	-----	1.1	1.3	1.5	1.6	1.8	2.4	3.6	4.8	6.0
	275	3.0	-----	1.0	1.3	1.5	1.7	1.9	2.2	2.6	3.9	5.2	6.5
	300	3.3	1.1	1.2	1.6	1.8	2.0	2.3	2.5	2.8	4.2	5.6	7.0
	325	3.6	1.3	1.4	1.9	2.1	2.4	2.6	3.0	3.3	4.6	6.1	7.7
	350	3.9	1.5	1.6	2.1	2.3	2.7	3.0	3.3	3.8	4.9	6.5	8.2
	400	4.4	1.9	2.1	2.7	3.0	3.4	3.8	4.4	4.8	5.6	7.5	9.3
	450	5.0	2.3	2.6	3.4	3.7	4.3	4.8	5.4	6.0	6.4	8.5	10.7
	500	5.5	2.9	3.2	4.1	4.5	5.2	5.9	6.4	7.2	7.8	9.4	11.7
	600	6.6	4.0	4.4	5.7	6.3	7.3	8.1	9.1	10.2	10.9	11.4	14.3
	700	7.7	5.2	5.9	7.6	8.6	9.7	10.9	12.2	13.4	14.3	15.1	16.8
	800	8.8	6.8	7.5	9.7	11.0	12.5	13.8	15.3	17.5	18.3	19.2	20.0
8 (7.981)	175	1.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.1	1.4
	200	1.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.3	1.6
	225	1.4	-----	-----	-----	-----	-----	-----	-----	-----	1.1	1.4	1.7
	250	1.6	-----	-----	-----	-----	-----	-----	-----	-----	1.2	1.6	2.0
	275	1.8	-----	-----	-----	-----	-----	-----	-----	-----	1.3	1.7	2.2
	300	1.9	-----	-----	-----	-----	-----	-----	-----	-----	1.4	1.9	2.3
	325	2.1	-----	-----	-----	-----	-----	-----	-----	1.0	1.5	2.0	2.5
	350	2.2	-----	-----	-----	-----	-----	-----	-----	1.1	1.7	2.2	2.8
	400	2.6	-----	-----	-----	-----	-----	1.0	1.1	1.2	2.0	2.6	3.3
	450	2.9	-----	-----	-----	-----	1.1	1.3	1.4	1.6	2.2	2.9	3.7
	500	3.2	-----	-----	1.1	1.2	1.4	1.5	1.7	1.9	2.4	3.2	4.0
	600	3.8	1.1	1.2	1.5	1.7	2.0	2.2	2.4	2.7	2.9	3.9	4.8
	700	4.5	1.4	1.6	2.0	2.2	2.5	2.8	3.2	3.6	3.4	4.4	5.5
	800	5.1	1.8	2.0	2.6	2.9	3.3	3.7	4.1	4.6	4.9	5.2	6.5
	1000	6.4	2.7	3.0	3.9	4.4	5.0	5.6	6.2	6.9	7.3	7.7	8.0
10 (10.02)	275	1.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	300	1.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	325	1.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.0
	350	1.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.1
	400	1.6	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.0	1.3
	450	1.8	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.1	1.4
	500	2.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.3	1.6
	600	2.5	-----	-----	-----	-----	-----	-----	-----	-----	1.1	1.5	1.8
	700	2.8	-----	-----	-----	-----	-----	-----	1.1	1.2	1.3	1.7	2.2
	800	3.2	-----	-----	-----	-----	1.1	1.2	1.3	1.5	1.6	2.0	2.5
	1000	4.0	-----	1.0	1.3	1.4	1.7	1.8	2.1	2.3	2.4	2.6	3.3
12 (12.0)	450	1.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	500	1.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	600	1.7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	700	2.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.1
	800	2.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.2
	1000	2.8	-----	-----	-----	-----	-----	-----	-----	-----	1.0	1.2	1.5

NOTES:

Values to left of irregular line should be multiplied by .7 for new, smooth, wrought iron pipe. For old, rough pipe, multiply by 1.6.

Values to right of irregular line are in streamlined flow area and do not vary with pipe conditions.

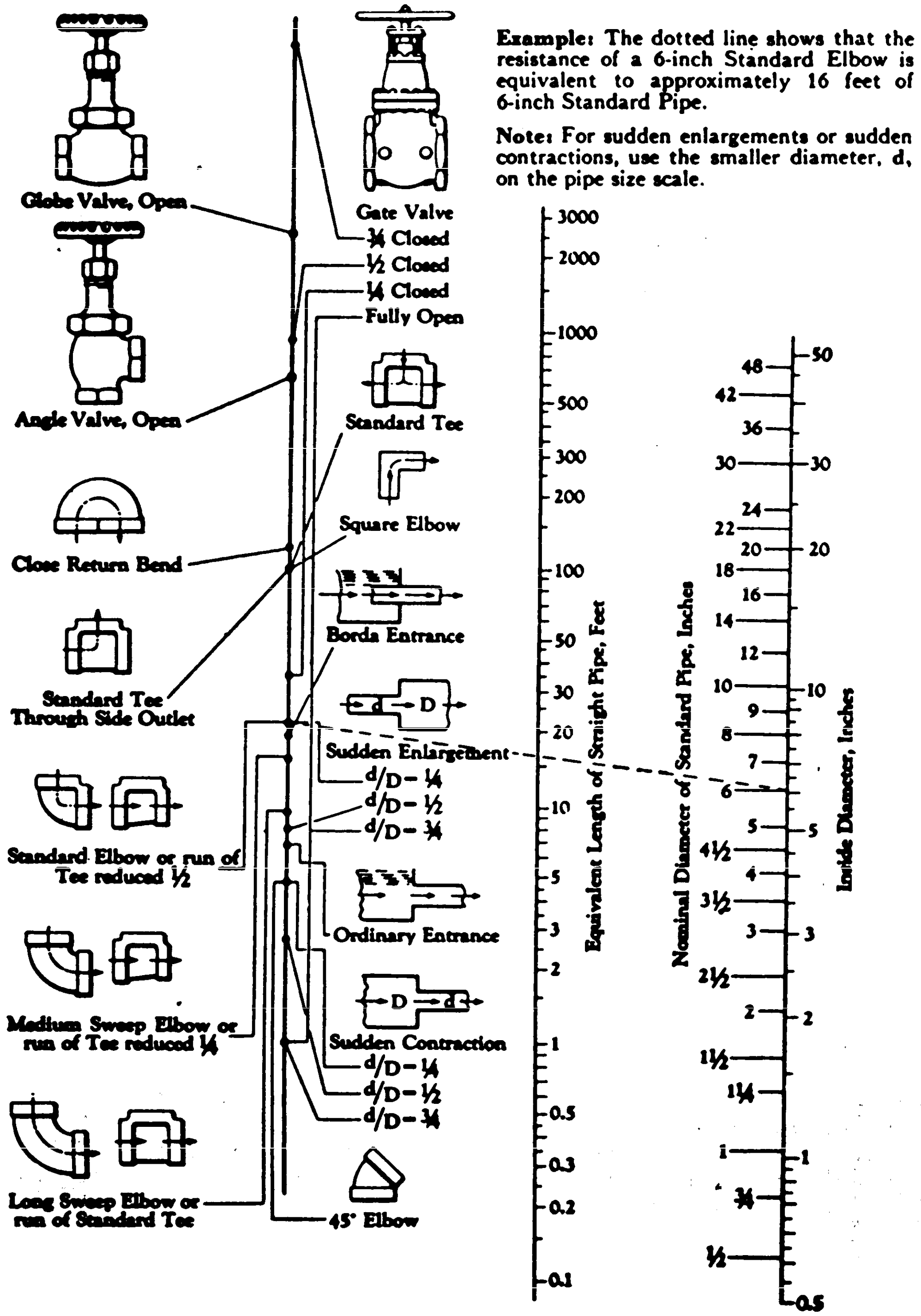
Multiply ALL values by specific gravity except when using Blackmer Pump Check Sheet in computing operating conditions.

Velocity values are in feet per second.

For viscosities above 2400 SUS or 500 CS - the friction loss increases in direct proportion to the viscosity increase.

Example - for 50 GPM through 2 inch pipe with viscosity of 2400, the friction loss is 87.0 feet per 100 ft. of pipe. For 4800 SUS, the friction loss would be 174.0 feet per 100 ft. of pipe.

3. RESISTANCE OF LIOUIDS IN FITTINGS



4. USEFUL ENGINEERING DATA

Head and Pressure Equivalents

Feet Head of Water and Equivalent Pressures

Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.
1	.43	30	12.99	140	60.63	300	129.93
2	.87	40	17.32	150	64.96	325	140.75
3	1.30	50	21.65	160	69.29	350	151.58
4	1.73	60	25.99	170	73.63	400	173.24
5	2.17	70	30.32	180	77.96	500	216.55
6	2.60	80	34.65	190	82.29	600	259.85
7	3.03	90	38.98	200	86.62	700	303.16
8	3.46	100	43.31	225	97.45	800	346.47
9	3.90	110	47.65	250	108.27	900	389.78
10	4.33	120	51.97	275	119.10	1000	433.09
20	8.66	130	56.30				

Pressure and Equivalent Feet Head of Water

Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head
1	2.31	20	46.18	120	277.07	225	519.51
2	4.62	25	57.72	125	288.62	250	577.24
3	6.93	30	69.27	130	300.16	275	643.03
4	9.24	40	92.36	140	323.25	300	692.69
5	11.54	50	115.45	150	346.34	325	750.41
6	13.85	60	138.54	160	369.43	350	808.13
7	16.16	70	161.63	170	392.52	375	865.89
8	18.47	80	184.72	180	415.61	400	922.58
9	20.78	90	207.81	190	438.90	500	1154.48
10	23.09	100	230.90	200	461.78	1000	2309.00
15	34.63	110	253.98				

Equivalent Values of Pressure

Inches of Mercury — Feet of Water — Pounds per Sq. In.

Inches of Mercury	Feet of Water	Pounds per Sq. In.	Inches of Mercury	Feet of Water	Pounds per Sq. In.	Inches of Mercury	Feet of Water	Pounds per Sq. In.
1	1.13	0.49	11	12.45	5.39	21	23.78	10.3
2	2.26	0.98	12	13.57	5.87	22	24.88	10.8
3	3.39	1.47	13	14.70	6.37	23	26.00	11.28
4	4.52	1.95	14	15.82	6.86	24	27.15	11.75
5	5.65	2.44	15	16.96	7.35	25	28.26	12.25
6	6.78	2.93	16	18.09	7.84	26	29.40	12.73
7	7.91	3.42	17	19.22	8.33	27	30.52	13.23
8	9.04	3.91	18	20.35	8.82	28	31.65	13.73
9	10.17	4.40	19	21.75	9.31	29	32.80	14.22
10	11.30	4.89	20	22.60	9.80	29.929	33.947	14.6960

Atmospheric Pressure, Barometer Reading and Equivalent Head of Water at Different Altitudes

Altitude Above Sea Level in Feet	Atmospheric Pressure Pounds Per Sq. In	Barometer Reading Inches of Mercury	Equivalent Head of Water Feet
0	14.7	29.929	33.95
1000	14.2	28.8	32.7
2000	13.6	27.7	31.6
3000	13.1	26.7	30.2
4000	12.6	25.7	29.1
5000	12.1	24.7	27.9
6000	11.7	23.8	27.0
7000	11.2	22.9	25.9
8000	10.8	22.1	24.9
9000	10.4	21.2	24.0
10000	10.0	20.4	23.1

For Ft. Hd. of liquid, multiply Ft. Hd. of water by specific gravity of liquid pumped.

5. PRACTICAL SUCTION LIFTS

PRACTICAL SUCTION LIFTS

This table gives the maximum permissible suction lift or the minimum head permitted on the suction side of a pump at various altitudes and liquid temperatures. A minus sign before a number indicates maximum suction lift. A plus sign before a number indicates minimum head. These figures are to be used as a guide and are not guaranteed.

WATER										
	Temperature in Degrees Fahrenheit									
Altitude	120	130	140	150	160	170	180	190	200	210
Sea level	−10	−7	−5	−2	0	+3	+5	+7	+10	+12
2000	−7	−5	−2	+1	+3	+5	+7	+10	+12	+15
4000	−5	−2	+1	+3	+5	+7	+10	+12	+14	
6000	0	+1	+3	+5	+7	+10	+12	+14	+16	
8000	0	+3	+5	+7	+9	+12	+14	+16		
10000	+2	+4	+7	+9	+11	+14	+16	+18		

When pumping volatile liquids such as gasoline and naphtha, special consideration must be given to the amount of suction lift and the size of the suction pipe used. On such liquids the suction lift, whether it is actual vertical lift or is caused by pipe line friction, must be kept as low as possible, and should never exceed 12 feet.
For liquids such as lube oil, molasses, etc. a suction lift up to 24 feet, at sea level, is usually satisfactory.

6. THEORETICAL HORSEPOWER REQUIRED TO RAISE OIL* TO DIFFERENT HEIGHTS

THEORETICAL HORSE-POWER REQUIRED TO RAISE OIL* TO DIFFERENT HEIGHTS

Feet Head / Gals. Per Min.	5	10	15	20	25	30	35	40	45	50	60	75	90	100	125	150	175	200	250	300	350	400
	THEORETICAL HORSEPOWER CONSUMPTION																					
5	.0054	.0108	.0171	.0225	.0279	.0333	.0387	.0450	.0540	.0540	.0630	.0810	.0990	.1080	.1440	.1710	.1980	.2250	.2790	.3330	.3960	.4500
10	.0105	.0225	.0333	.0450	.0558	.0675	.0783	.0900	.0990	.1080	.1350	.1710	.1980	.2250	.2790	.3330	.3960	.4500	.5580	.6750	.7830	.9000
15	.0170	.0333	.0504	.0675	.0846	.1008	.1179	.1350	.1530	.1710	.1980	.2520	.3060	.3330	.4230	.5040	.5940	.6750	.8460	1.0080	1.1790	1.3500
20	.0225	.0450	.0675	.0900	.1125	.1350	.1575	.1800	.1980	.2250	.2700	.3330	.4050	.4500	.5580	.6750	.7830	.9000	1.1250	1.3500	1.5750	1.8000
25	.0279	.0558	.0837	.1125	.1404	.1683	.1971	.2250	.2520	.2790	.3330	.4230	.5040	.5580	.7020	.8460	.9810	1.1250	1.4040	1.6830	1.9710	2.2500
30	.0333	.0675	.1008	.1350	.1683	.2025	.2358	.2700	.3060	.3330	.4050	.5040	.6030	.6750	.8460	1.0080	1.1790	1.3500	1.6830	2.0250	2.3550	2.7000
35	.0387	.0783	.1179	.1575	.1971	.2358	.2754	.3150	.3510	.3960	.4680	.5940	.7110	.7830	.9720	1.1790	1.3770	1.5750	1.9710	2.3580	2.7540	3.1500
40	.0450	.0900	.1350	.1800	.2250	.2700	.3150	.3600	.4050	.4500	.5400	.6750	.8100	.9000	1.1250	1.3500	1.5750	1.8000	2.2500	2.7000	3.1500	3.6000
45	.0504	.1008	.1512	.2025	.2529	.3033	.3546	.4050	.4590	.5010	.6030	.7560	.9090	1.0080	1.2690	1.5210	1.7730	2.0250	2.5290	3.0330	3.5460	4.0500
50	.0558	.1125	.1683	.2250	.2808	.3375	.3933	.4500	.5040	.5580	.6750	.8460	1.0080	1.1250	1.4040	1.6830	1.9710	2.2500	2.8080	3.3750	3.9330	4.5000
60	.0675	.1350	.2025	.2700	.3375	.4050	.4725	.5400	.6030	.6750	.8100	1.0080	1.2150	1.3500	1.6830	2.2500	2.3580	2.7000	3.3750	4.0500	4.7250	5.4000
75	.0837	.1683	.2529	.3375	.4221	.5058	.5904	.6750	.7560	.8400	1.0080	1.2600	1.5210	1.6830	2.1060	2.5290	2.9520	3.3750	4.2210	5.0580	5.9040	6.7500
90	.1008	.2025	.3033	.4050	.5058	.6075	.7083	.8100	.9090	1.0080	1.2150	1.5120	1.8180	2.2500	2.5290	3.0330	3.5460	4.0500	5.0580	6.0750	7.8300	8.1000
100	.1125	.2250	.3375	.4500	.5625	.6750	.7875	.9000	1.0080	1.1250	1.3500	1.6830	2.2050	2.2500	2.8080	3.3750	3.9330	4.5000	5.6250	6.7500	7.8750	9.0000
125	.1404	.2808	.4221	.5625	.7029	.8433	.9846	1.1250	1.2690	1.4040	1.6830	2.1060	2.5290	2.8080	3.5190	4.2210	4.9230	5.6250	7.0290	8.4330	9.8400	11.2500
150	.1683	.3375	.5058	.6750	.8433	1.0125	1.1808	1.3500	1.5210	1.6830	2.0250	2.5290	3.0330	3.3750	4.2210	5.0580	5.9040	6.7500	8.4330	10.1250	11.8080	13.5000
175	.1971	.3933	.5904	.7875	.9837	1.1808	1.3779	1.5750	1.7730	1.9710	2.3580	2.9520	3.5460	3.9330	4.9230	5.9040	6.8940	7.8750	9.8400	11.8060	13.7790	15.7500
200	.2250	.4500	.6750	.9000	1.1250	1.3500	1.5750	1.8000	2.0250	2.2500	2.7000	3.3750	4.0500	4.5000	5.6250	6.7500	7.8750	9.0000	11.2500	13.5000	15.7500	18.0000
250	.2808	.5625	.8433	1.1250	1.4058	1.6875	1.9683	2.2500	2.5290	2.8080	3.3750	4.2210	5.0580	5.6250	7.0290	8.4330	9.8400	11.2500	14.1480	16.8750	19.6830	22.5000
300	.3375	.6750	1.0125	1.3500	1.6875	2.0250	2.3625	2.7000	3.0330	3.3750	4.0500	5.0580	6.0750	6.7500	8.4330	10.1250	11.8060	13.5000	16.8750	20.2500	23.6250	27.0000

(*Based on lubricating oil, 7.55 lbs. per gallon)

Horse-power and head are directly proportional. For example, if you have a total head of 800 feet and the capacity you require is 100 G.P.M., follow the horse-power figures for 100 G.P.M., across the table to the point where they intersect the vertical column marked 400 foot head, and double the figure given.

The above data can be converted from feet head into pounds pressure by dividing foot head by 2.55.

7. CAPACITY OF TANKS

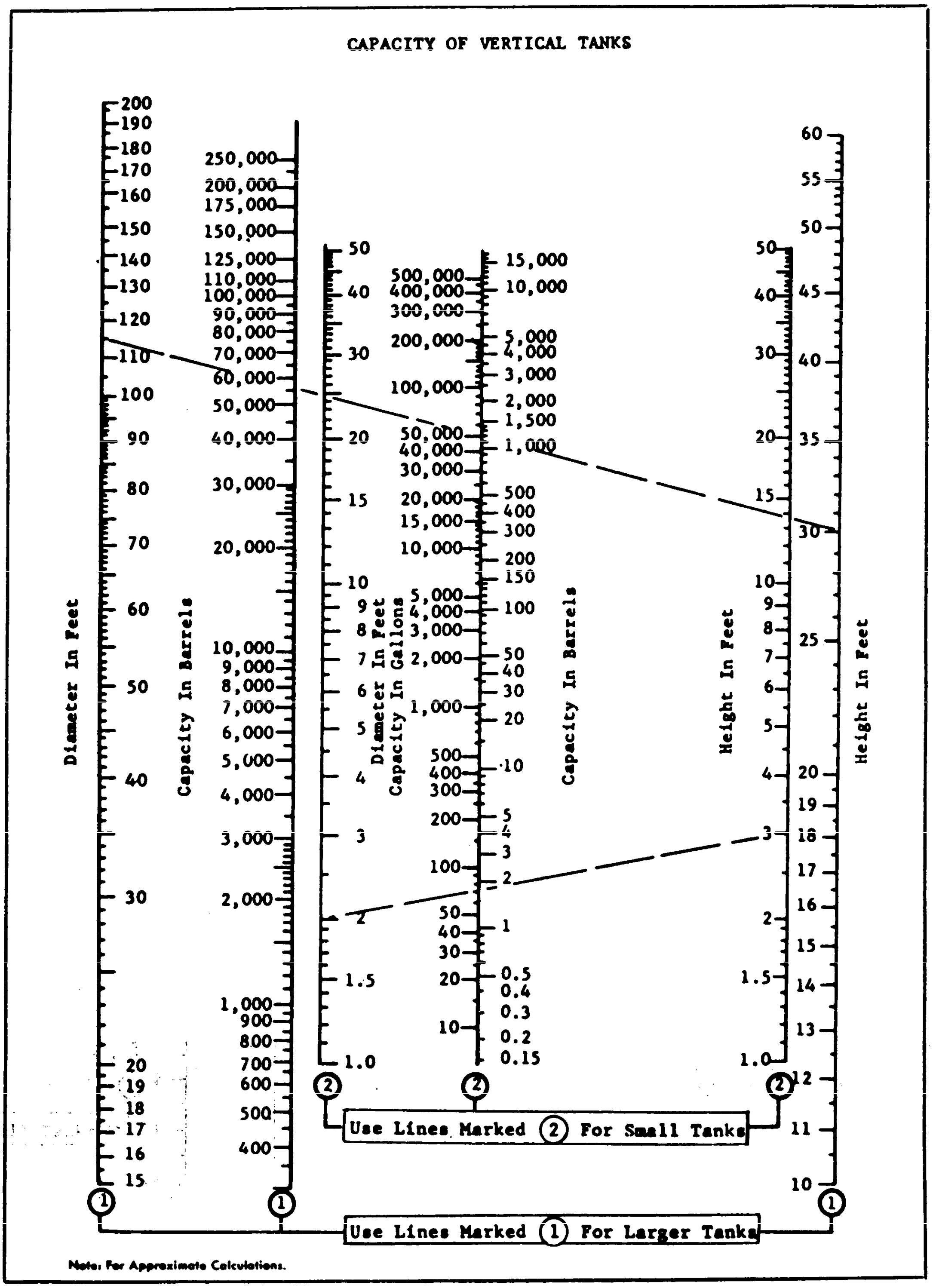
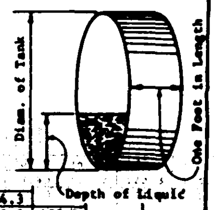
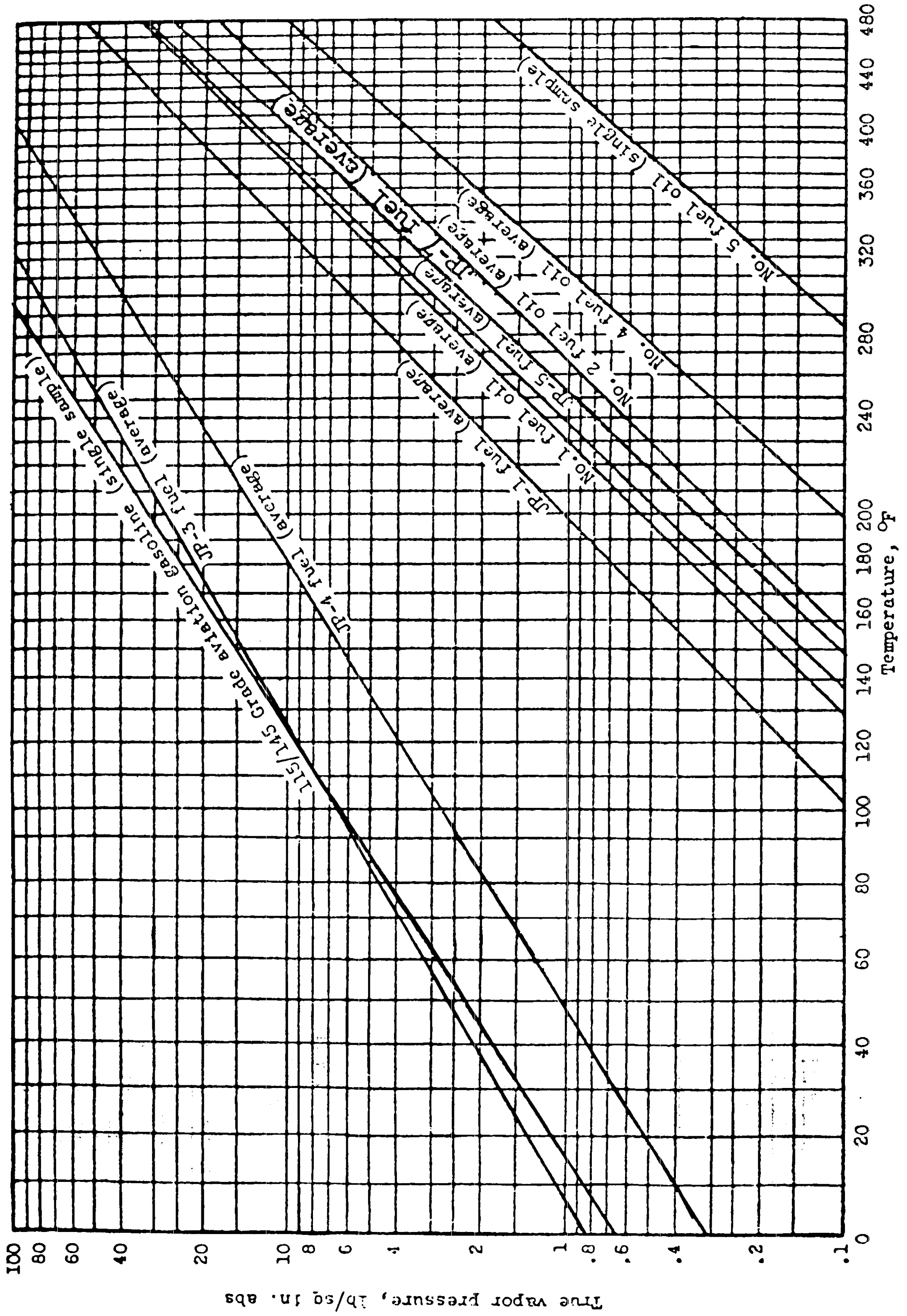


TABLE OF CAPACITY IN GALLONS OF CYLINDRICAL TANKS PER. FOOT IN LENGTH LAYING HORIZONTALLY

Diam. of Tank	Depth of Liquid																			
	6"	1'-0"	1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"
6"	1.46																			
1'-0"	2.94	5.88																		
1'-6"	3.85	9.36	13.22																	
2'-0"	4.60	11.75	18.85	23.50																
2'-6"	5.22	13.71	23.02	31.49	36.73															
3'-0"	5.81	15.41	26.40	37.47	47.05	52.88														
3'-6"	6.30	16.95	29.47	42.46	55.01	65.66	71.65													
4'-0"	6.78	18.37	32.16	46.97	61.86	75.62	87.22	94.02												
4'-6"	7.21	19.67	34.63	51.01	67.92	84.30	99.26	111.8	116.9											
5'-0"	7.63	20.90	37.03	54.85	73.38	92.08	109.9	125.9	139.1	146.9										
5'-6"	8.00	22.07	39.23	58.34	78.54	99.12	119.4	138.5	155.6	169.7	177.7									
6'-0"	8.38	23.19	41.36	61.64	83.36	105.8	128.1	149.8	170.1	188.3	203.1	211.5								
6'-6"	8.75	24.16	43.31	64.85	87.96	111.9	136.3	160.2	183.3	204.9	223.6	239.4	248.3							
7'-0"	9.13	25.21	45.62	67.84	92.25	117.8	143.6	169.8	195.9	219.9	242.6	262.5	279.0	287.9						
7'-6"	9.42	26.11	47.05	70.69	96.49	123.4	151.2	179.1	207.2	234.1	259.5	283.5	304.4	310.9	330.6					
8'-0"	9.80	27.08	48.77	73.45	100.2	128.8	158.1	187.7	217.6	274.2	275.3	302.2	326.9	348.6	366.1	376.2				
8'-6"	10.0	27.94	50.42	76.30	106.1	133.9	164.7	195.9	228.1	259.6	290.6	320.1	348.5	374.0	396.4	414.4	426.3			
9'-0"	10.4	28.86	52.06	78.61	107.8	138.4	171.1	204.3	237.9	271.5	304.7	336.6	368.1	397.2	423.4	446.6	465.5	475.9		
9'-6"	10.7	29.70	53.67	81.22	110.9	143.5	177.3	211.9	247.4	282.9	318.2	352.9	386.6	413.8	448.9	476.5	500.5	519.6	530.2	
10'-0"	10.9	30.57	54.66	83.62	114.8	148.3	183.2	219.5	256.4	293.7	331.1	368.0	404.2	439.2	472.7	503.7	532.2	556.9	576.5	587.5

Example; Diam of Tank 6'-0", Length of Tank 8'-0", Depth of Liquid 2'-0". From table, opposite 6'-0", and under 2'-0", the capacity for one foot in length is 61.64 gallons; for 8'-0", in length, the capacity equals 61.64x8 493.12 gallons for 2'-0", in depth.





VARIATION OF VAPOR PRESSURE WITH TEMPERATURE FOR DIFFERENT FUELS

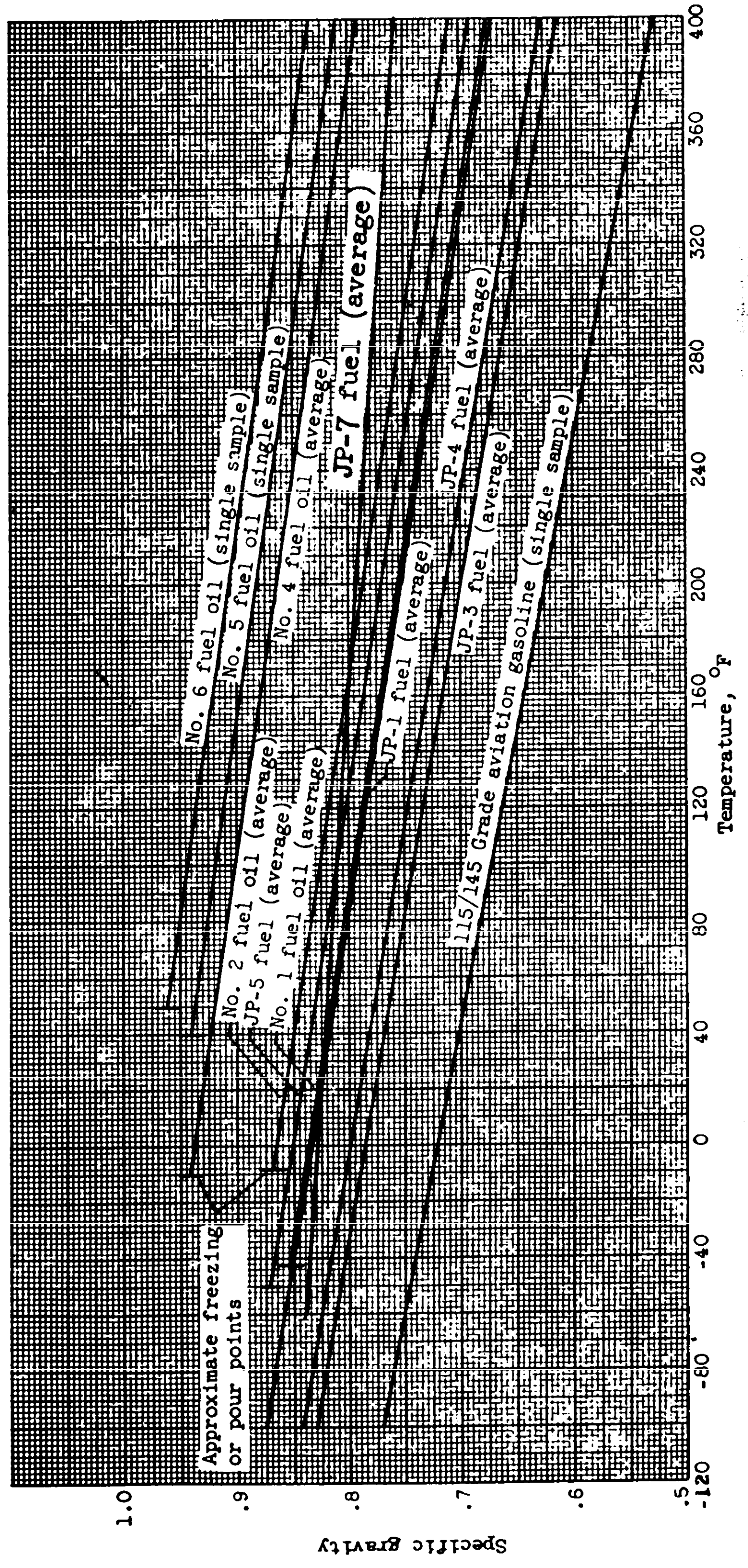


FIGURE 2

VARIATION OF SPECIFIC GRAVITY WITH TEMPERATURE

10. POWER REQUIRED FOR PUMPING

POWER REQUIRED FOR PUMPING

$$\text{WATER HORSEPOWER (Theoretical H.P.)} = \frac{\text{G.P.M. x Feet Head (Total)}}{3960}$$

$$\text{BRAKE HORSEPOWER (Actual H.P.)} = \frac{\text{G.P.M. x Feet Head (Total)}}{\text{3960 x Pump Effy.}}$$

Efficiency, Overall, takes into account all the losses in the pump and the driver and indicates the economy of the entire unit.

Overall efficiency = pump Eff. x driver Eff x transmission Eff.

Efficiency, Volumetric (symbol e). The ratio of the actual pump displacement to the theoretical pump displacement at the specified pumping conditions.

$$\text{Volumetric Eff. in \%} = \frac{\text{actual pump displacement in gpm}}{\text{Theoret. pump displacement gpm}} \times 100$$

$$\frac{\text{G.P.M. x Feet Head (Total)}}{\text{3960 x B.H.P.}} = \text{Pump Efficiency}$$

NOTE: These formulae apply to the pumping of water or liquids having a specific gravity of 1.0. For liquids *heavier* or *lighter* than water:

$$\text{Water Horsepower} = \frac{\text{G.P.M. x Feet Head x Sp. Gr.}}{3960}$$

$$\text{*Water horsepower} = \frac{\text{G.P.M. x total head in lbs. per sq. in.}}{1714}$$

*When this formula is used it is not necessary to correct for specific gravity.

In pumping thick or viscous liquids, a reduction in capacity and head must be made over that obtained in handling liquids of the consistency of water; and inquiries should be referred to Engineering Department.

INPUT

Horsepower, Brake (Symbol b-hp). The actual horsepower required at the pump shaft to drive the pump $= \frac{\text{whp}}{\text{e}}$

11. AREAS OF CIRCLES, ADVANCING BY EIGHTHS

AREAS OF CIRCLES, ADVANCING BY EIGHTHS

Diam.	AREAS 0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	Diam.
0	0	.0122	.0491	.1104	.1963	.3068	.4418	.6013	0
1	.7854	.9940	1.227	1.485	1.767	2.074	2.405	2.761	1
2	3.141	3.546	3.976	4.430	4.908	5.412	5.939	6.492	2
3	7.068	7.669	8.295	8.946	9.621	10.32	11.04	11.79	3
4	12.56	13.36	14.18	15.03	15.90	16.80	17.72	18.66	4
5	19.63	20.62	21.64	22.69	23.75	24.95	25.96	27.10	5
6	28.27	29.46	30.67	31.91	33.18	34.47	35.78	37.12	6
7	38.48	39.87	41.28	42.71	44.17	45.66	47.17	48.70	7
8	50.26	51.84	53.45	55.08	56.74	58.42	60.13	61.86	8
9	63.61	65.39	67.20	69.02	70.88	72.75	74.66	76.58	9
10	78.54	80.51	82.51	84.54	86.59	88.66	90.76	92.88	10
11	95.03	97.20	99.40	101.6	103.8	106.1	108.4	110.7	11
12	113.0	115.4	117.8	120.2	122.7	125.1	127.6	130.1	12
13	132.7	135.2	137.8	140.5	143.1	145.8	148.4	151.2	13
14	153.9	156.6	159.4	162.2	165.1	167.9	170.8	173.7	14
15	176.7	179.6	182.6	185.6	188.6	191.7	194.8	197.9	15
16	201.1	204.2	207.3	210.5	213.8	217.0	220.3	223.6	16
17	226.9	230.3	233.7	237.1	240.5	243.9	247.4	250.9	17
18	254.4	258.0	261.5	265.1	268.8	272.4	276.1	279.8	18
19	283.5	287.2	291.0	294.8	298.6	302.4	306.3	310.2	19
20	314.1	318.1	322.0	326.0	330.0	334.1	338.1	342.2	20
21	346.3	350.4	354.6	358.8	363.0	367.2	371.5	375.8	21
22	380.1	384.4	388.8	393.2	397.6	402.0	406.4	410.9	22
23	415.4	420.0	424.5	429.1	433.7	438.3	443.0	447.6	23
24	452.3	457.1	461.8	466.6	471.4	476.2	481.1	485.9	24
25	480.8	495.7	500.7	505.7	510.7	515.7	520.7	525.8	25
26	530.9	536.0	541.1	546.3	551.5	556.7	562.0	567.2	26
27	572.5	577.8	583.2	588.5	593.9	599.3	604.8	610.2	27
28	615.7	621.2	626.7	632.3	637.9	643.5	649.1	654.8	28
29	660.5	666.2	671.9	677.7	683.4	689.2	695.1	700.9	29
30	706.8	712.7	718.6	724.6	730.6	736.6	742.6	748.6	30
31	754.8	760.9	767.0	773.1	779.3	785.5	791.7	798.0	31
32	804.2	810.5	816.9	823.2	829.6	836.0	842.4	848.8	32
33	855.3	861.8	868.3	874.8	881.4	888.0	894.6	901.3	33
34	907.9	914.6	921.3	928.1	934.8	941.6	948.4	955.3	34
35	962.1	969.0	975.9	982.8	989.8	996.8	1003.8	1010.8	35
36	1017.9	1025.0	1032.1	1039.2	1046.4	1053.5	1060.7	1068.0	36
37	1075.2	1082.5	1089.8	1097.1	1104.5	1111.8	1119.2	1126.7	37
38	1134.1	1141.6	1149.1	1156.6	1164.2	1171.7	1179.3	1186.9	38
39	1194.6	1202.3	1210.0	1217.7	1225.4	1233.2	1241.0	1248.8	39
40	1256.6	1264.5	1272.4	1280.3	1288.3	1296.2	1304.2	1312.2	40
41	1320.3	1328.3	1336.4	1344.5	1352.7	1360.8	1369.0	1377.2	41
42	1385.4	1393.7	1402.0	1410.3	1418.6	1427.0	1435.4	1443.8	42
43	1452.2	1460.7	1469.1	1477.6	1486.2	1494.7	1503.3	1511.9	43
44	1520.5	1529.2	1537.9	1546.6	1555.3	1564.0	1572.8	1581.6	44
45	1590.4	1599.3	1608.2	1617.0	1626.0	1634.9	1643.9	1652.9	45
46	1661.9	1671.0	1680.0	1689.1	1698.2	1707.4	1716.5	1725.7	46
47	1734.9	1744.2	1753.5	1762.7	1772.1	1781.4	1790.8	1800.1	47
48	1809.6	1819.0	1828.5	1837.9	1847.5	1857.0	1836.6	1876.1	48
49	1885.7	1895.4	1905.0	1914.7	1924.4	1934.2	1943.9	1953.7	49
50	1963.5	1973.3	1983.2	1993.1	2003.0	2012.9	2022.8	2032.8	50

12. COMPARATIVE EQUIVALENTS OF LIQUID MEASURES AND WEIGHTS

COMPARATIVE EQUIVALENTS OF LIQUID MEASURES AND WEIGHTS

Measures and Weights for Comparison	Measure and Weight Equivalents of Items in First Column								
	U. S. Gallon	Imperial Gallon	Cubic Inch	Cubic Foot	Cubic Meter	Liter	*Vedro	*Pood	Pound
U. S. Gallon	1.	.833	231.	.1337	.00378	3.785	.308	.231	8.33
Imperial Gallon	1.20	1.	277.27	.1604	.00454	4.542	.369	.277	10.
Cubic Inch	.0043	.00358	1.	.00057	.000016	.0163	.00132	.001	.0358
Cubic Foot	7.48	6.235	1728.	1.	.02827	28.312	2.304	1.728	62.355
Cubic Meter	264.17	220.05	61023.	35.319	1.	1000.	81.364	61.023	2200.54
Liter	.26417	.2200	61.023	.0353	.001	1.	.08136	.06102	2.2005
*{Vedro	3.249	2.706	750.1	.4344	.01228	12.29	1.	.7501	27.06
*{Pood	4.328	3.607	1000.	.578	.01636	16.381	1.333	1.	36.07
Pound	.12	.1	27.72	.016	.00045	.454	.0369	.0277	1.

13. TABLE OF DECIMAL EQUIVALENTS OF 8THS, 16THS, 32NDS, AND 64THS OF AN INCH

TABLE OF DECIMAL EQUIVALENTS OF 8THS, 16THS, 32NDS, AND 64THS OF AN INCH

8ths	16ths	32nds	32nds	64ths	64ths	64ths	64ths
1/8 = .125	1/16 = .0625	1/32 = .03125	17/32 = .53125	1/64 = .015625	17/64 = .265625	33/64 = .515625	49/64 = .765625
1/4 = .250	3/16 = .1875	3/32 = .09375	19/32 = .59375	3/64 = .046875	19/64 = .297875	35/64 = .546875	51/64 = .796875
3/8 = .375	5/16 = .3125	5/32 = .15625	21/32 = .65625	5/64 = .078125	21/64 = .328125	37/64 = .578125	53/64 = .828125
1/2 = .500	7/16 = .4375	7/32 = .21875	23/32 = .71875	7/64 = .109375	23/64 = .359375	39/64 = .609375	55/64 = .859375
5/8 = .625	9/16 = .5625	9/32 = .28125	25/32 = .78125	9/64 = .140625	25/64 = .390625	41/64 = .640625	57/64 = .890625
3/4 = .750	11/16 = .6875	11/32 = .34375	27/32 = .84375	11/64 = .171875	27/64 = .421875	43/64 = .671875	59/64 = .921875
7/8 = .875	13/16 = .8125	13/32 = .40625	29/32 = .90625	13/64 = .203125	29/64 = .453125	45/64 = .703125	61/64 = .953125
	15/16 = .9375	15/32 = .46875	31/32 = .96875	15/64 = .234375	31/64 = .484375	47/64 = .734375	63/64 = .984375

14. VOLUMETRIC CAPACITY OF PIPE

STANDARD PIPE DIMENSIONS AND VOLUMETRIC CAPACITY

Size Inches	Diameter Inches		Wall Thickness	Volume	
	External	Internal		Gallons per foot	Barrels per mile
1	1.315	1.049	0.133	0.045	5.644
2	2.375	2.067	0.154	0.174	22
3	3.500	3.068	0.216	0.384	48
4	4.500	4.026	0.237	0.661	83
6	6.625	6.065	0.280	1.500	189
8	8.625	7.981	0.322	2.599	327
10	10.750	10.020	0.365	4.096	515
12	12.750	12.000	0.375	5.875	738
14	14.000	13.250	0.375	7.163	900
16	16.000	15.250	0.375	9.488	1193
18	18.000	17.250	0.375	12.141	1526
20	20.000	19.250	0.375	15.067	1900
22	22.000	21.250	0.375	18.424	2316
24	24.000	23.250	0.375	22.055	2773

EXTRA STRONG PIPE DIMENSIONS AND VOLUMETRIC CAPACITY

1	1.315	0.957	0.179	0.037	4.697
2	2.375	1.939	0.218	0.153	19.284
3	3.500	2.900	0.300	0.343	43.112
4	4.500	3.826	0.337	0.597	75.080
6	6.625	5.761	0.432	1.354	170.231
8	8.625	7.625	0.500	2.372	298.211
10	10.750	9.750	0.500	3.878	487.589
12	12.750	11.750	0.500	5.631	707.939
14	14.000	13.000	0.500	6.895	866.825
16	16.000	15.000	0.500	9.180	1154.057
18	18.000	17.000	0.500	11.791	1458.512
20	20.000	19.000	0.500	14.729	1851.597
24	24.000	23.000	0.500	21.583	2713.316

15. COMPARISON OF U. S. AND METRIC WEIGHTS AND MEASURES

COMPARISON OF U. S. AND METRIC WEIGHTS AND MEASURES

Millimeters × .03937 = inches.
Millimeters ÷ 25.4 = inches.
Centimeters × .3937 = inches.
Centimeters ÷ 2.54 = inches.
Meters × 39.37 = inches. (Act Congress.)
Meters × 3.281 = feet.
Meters × 1.094 = yards.
Kilometers × .621 = miles.
Kilometers ÷ 1.6093 = miles.
Kilometers × 3280.87 = feet.
Square Millimeters × .00155 = square inches.
Square Millimeters ÷ 645.16 = square inches.
Square Centimeters × .155 = square inches.
Square Centimeters ÷ 6.451 = square inches.
Square Meters × 10.764 = square feet.
Square Kilometers × 247.1 = acres.
Hectare × 2.471 = acres.
Cubic Centimeters ÷ 16.383 = cubic inches.
Cubic Centimeters ÷ 3.69 = Fl. drachms (U.S. Phar.)
Cubic Centimeters ÷ 29.57 = Fl. ounces (U.S. Phar.)
Cubic Meters × 35.315 = cubic feet.
Cubic Meters × 1.308 = cubic yards.
Cubic Meters × 264.2 = gallons (231 cubic inches).
Liters × 61.022 = cubic inches (Act Congress).
Liters × .2642 = gallons (231 cubic inches).
Liters ÷ 3.78 = gallons (231 cubic inches).
Liters ÷ 28.316 = cubic feet.
Hectoliters × 3.531 = cubic feet.
Hectoliters × 2.84 = bushels (2150.42 cubic inches).
Hectoliters × .131 = cubic yards.
Hectoliters ÷ 26.42 = gallon (231 cubic inches).
Grammes × 15.432 = grains (Act Congress).
Grammes ÷ 981 = dynes.
Grammes (water) ÷ 29.57 = fluid ounce.
Grammes ÷ 28.35 = ounce avoirdupois.
Grammes per cubic cent. ÷ 27.7 = lbs. per cu. inch.
Joule × .7373 = foot pounds.
Kilo-grammes × 2.2046 = pounds.
Kilo-grammes × 35.3 = ounces avoirdupois.
Kilo-grammes ÷ 907.18581 = tons (2000 lbs.) or × .00110231.
Kilo-grammes per sq. cent. × 14.223 = lbs. per sq. in.
Kilo-gram-meters × 7.233 = foot pounds.
Kilo per Meter × .672 = pounds per foot.
Kilo per Cubic Meter × .026 = pounds per cubic ft.
Kilo per Cheval × 2.235 = pounds per H. P.
Kilo-Watts × 1.34 = Horse-Power.
Watts ÷ 746 = Horse-Power.
Watts ÷ .7373 = foot pounds per second.
Calorie × 3.968 = B. T. U.
Cheval Vapeur × .9863 = Horse-Power.
(Centigrade × 1.8) + 32 = degree Fahr.
Gravity Paris = 980.94 centimeters per second.

CHECKLIST FOR LIQUID FUELS STORAGE TANK ENTRY

VAPOR FREE

I. Application: This checklist is to be used for all vapor free (up to 50% of the lower explosive limit) tank entries. The certified tank entry coordinator understands that should his or her authority over this hazardous work be compromised by any person(s), he or she is to notify the command liquid fuels engineer immediately. The command liquid fuels engineer shall also be notified of any unusual conditions encountered or if injury occurs to any personnel engaged in tank cleaning work.

II. Notification: Notify the following offices prior to tank entry.
a. Bioenvironmental Engineering.
b. Ground Safety.
c. Base Fire Department.

III. Special Equipment:
a. Respiratory Equipment.
NOTE: Use NIOSH approved Type A or Type C.
b. Combustion Gas Indicator.
c. Wristlets and safety line with tripod or "A" frame.
d. Lighting, if required, will be explosion proof, portable dry-cell, Class I, Division I, Groups C&D.
e. Extinguisher—150 lbs dry chemical or 150 lbs Halon 1211 (available at the Base Fire Department).
f. Eductor.
g. Grounding and bonding clips and cables. Receptacles and plugs may be used to expedite grounding and bonding.

IV. Site Preparation:
a. Rope off area and post signs.
b. Ensure all fuel possible has been removed through existing connections.
c. Remove all sources of ignition from the area.
d. Lock out and safety tag all electrical pumps.
e. Blind Flange.
f. Ground and bond equipment. Check all connectors and cables for continuity. Clean and inspect each connector and replace as needed.
NOTE: Always connect cables to the tanks first and to the equipment last. This will ensure that any sparks will occur away from the tank. Use the reverse order when removing cables—disconnect the tanks last.
g. Ensure electrical storms are a minimum of five miles from the site.
h. Remove manhole covers.
i. Connect and start ventilating system.

V. Personnel Preparation:
a. Brief all tank entry personnel on hazards and locally developed emergency procedures.
b. Assign job or duties.
c. Check personal protective clothing and equipment.

VI. Tank Entry:
a. Measure and record vapor concentration. Repeat at 15 minute intervals.
NOTE: Readings will be taken within 6 inches of the liquid level.
b. Secure safety rope at base of ladder.
c. Proceed with cleaning if required.
d. Return system to operational status.
NOTE: Slowly refill tank to avoid possible static generation. (This is a joint operator and civil engineer responsibility.)

VII. Cleanup:
a. Dispose of waste fuel IAW instructions from the environmental coordinator.
b. Prepare AF Form 172 to include recorded vapor readings.

CHECKLIST FOR LIQUID FUELS STORAGE TANK ENTRY

INERT ENTRY

I. Application: This procedure is to be used for all inert tank entries. The certified tank entry coordinator understands that should his or her supervisory authority over this hazardous work be compromised by any person(s), he or she is to notify the command liquid fuels engineer immediately. The command liquid fuels engineer shall also be notified of any unusual conditions encountered or if injury occurs to any personnel engaged in tank cleaning work.

II. Notification: Notify the following offices prior to tank entry.

a. Bioenvironmental Engineering.

b. Ground Safety.

c. Base Fire Department.

III. Special Equipment:

a. Respiratory equipment.

NOTE: Use only Type C National Institute for Occupational Safety and Health (NIOSH) approved for use in atmospheres Immediately Dangerous to Life and Health (IDLH).

b. Oxygen indicator.

c. Wristlets and safety line with tripod or "A" frame.

d. Lighting, if required, will be explosion proof, portable dry-cell, Class I, Division I, Groups C&D.

e. Extinguisher—150 lbs dry chemical or 150 lbs Halon 1211 (available at the Base Fire Department).

f. Nitrogen—4,000 cubic feet estimated for each 50,000 gallon tank.

g. Nitrogen Injector—½ inch minimum metallic pipe connected by hose through a pressure regulator to the nitrogen source. Pipe will connect to a tee fitting so that nitrogen can be directed toward the extremes of the tank. Provide bonding wire for connection between injector and manway flange.

h. Grounding and bonding clips and cables. Receptacles and plugs may be used to expedite grounding and bonding.

IV. Site Preparation:

a. Rope off area and post signs.

b. Ensure as much fuel as possible has been removed through existing connections.

c. Set up nitrogen source as near as possible to the injection point. Liquid nitrogen must *not* be injected into the tank. Secure nitrogen bottles in an upright position or lay in a horizontal position to avoid bottle damage.

d. Remove all sources of ignition from the area.

e. Lock out and safety tag all electrical pumps.

f. Blind Flange.

NOTE: Under inert entry applications where the pump house can be completely isolated, blind flanging of each tank is not required.

g. Ground and bond equipment.

Check all connectors and cables for continuity. Clean and inspect each connector and replace as needed.

NOTE: Always connect cables to the tanks first and to the equipment last. This will ensure that any sparks will occur away from the tanks. Use the reverse order when removing cables—disconnect the tanks last.

h. Ensure electrical storms are a minimum of 5 miles from the site.

i. Remove only one manhole cover. Typically, the manhole cover furthest from the high level float flange (measurement point).

V. Personnel Preparation:

a. Brief all tank entry personnel on hazards and locally developed emergency procedures. The tank will not be entered at any time without respiratory protection.

b. Assign job or duties.

c. Check personal protective clothing and equipment.

VI. Tank Entry:

a. Cover tank vents using a plastic bag to minimize nitrogen loss.

b. Inject nitrogen. Nitrogen will be added at the most remote location from the measurement point.

c. Measure and record oxygen (O_2) level. Oxygen measurement will continue prior to entry until the O_2

level is below 11 percent. During entry, oxygen levels will be measured at 15 minute intervals both at the original measurement point and at the manhole. If oxygen levels exceed 12 percent, personnel will exit the tank.

Special Notes for items a & b above:

(1) Vertical tanks (above ground)—Readings will be taken near the manway within 6 inches from the bottom. The manway must be kept covered to keep oxygen levels within safe limits.

(2) Underground tanks—Readings will be taken within 2 feet from the bottom of the tank at the high level float flange or similar opening located at the end of the tank most remote from the nitrogen injection point.

(3) The distance from the injection point to the measurement point must be at least 40 percent of the longest tank dimension. If this is not possible, oxygen levels must be taken to a maximum of 10 percent before entry.

d. Secure safety rope at base of ladder.

e. Proceed with cleaning if required.

f. Return system to operational status. Open tank vents.

NOTE: Slowly refill tank to avoid possible static generation. (This is a joint operator or civil engineer responsibility.)

VII. Cleanup:

a. Dispose of waste fuel IAW instructions from the environmental coordinator.

b. Prepare AF Form 172 to include recorded oxygen readings.

Test Procedures for Setting the Pressure Differential Control (CDHS-3)

1. Two recommended methods of testing the CDHS-3 control are mentioned below. The method considered best for your particular base should be used. Some additional test equipment must be obtained and installed before proceeding with the actual testing of the pressure differential (excess flow) control. What additional equipment you actually require will depend on which method is used.

a. Method 1:

(1) The CDHS-3 control operates from a differential pressure produced by the orifice plate on the inlet to the main valve. If the identification of the orifice plate is known, then the differential pressure it will produce at a given flow rate can be calculated or obtained from a flow chart (figure A-1). Knowing this differential pressure, it then becomes a matter of producing the differential pressure across the diaphragm of the CDHS-3 control and adjusting the control until it trips. By adding shutoff valves in the CDHS-3 sensing lines, the fuel supply to this control can be shut off and an external source of pressure equal to that produced by the differential across the orifice plate can be applied to the control, and the proper adjustment made. Figure A-1 shows the location of the shutoff valves and the equipment necessary to make the adjustment in this manner.

(2) The following numbers coincide with numbers shown in figure A-1. Shutoff valves (1) and (2) should be placed in the high and low pressure sensing lines to the control. Valve (3) is installed on a (T) in the high pressure sensing line on the control side of valve (1) and is used to connect the air pump and pressure gauge. Valve (4) is installed on a (T) in the low pressure sensing line and is used to vent the low pressure side of the diaphragm to atmosphere. The excess flow control can now be set without flowing fuel through the system.

(3) To obtain the correct differential pressure to set the CDHS-3 control, refer to the flow chart in figure A-1. Enter the chart at the flow rate in GPM at which the excess flow control is to trip, and go vertically along that line until it intersects the correct orifice bore size; then follow horizontally to read the differential pressure in PSI. Open valve (4) to vent the low pressure side of the diaphragm to atmosphere. Connect 0 to 15 psi gauge and air pump to shutoff valve (3), and apply pressure corresponding to the differential pressure (obtained from the flow chart) to the high pressure sensing connection and adjust the control until it shifts. After the control shifts, open valve (5) and bleed the pressure to (0) and reset the control. Repeat the above procedure several times to make sure the control shifts at the correct pressure.

(4) To put the system back in normal operation after the adjustments have been completed, close valves (3) and (4) and plug the open valves (1) and (2). Valve handles should be removed or safety wired to ensure proper positioning after test is complete.

b. Method 2:

(1) Obtain a manifold and gage assembly (NSN 4130-00-342-7336). The two refrigeration gages on this assembly will require replacement with two standard bourdon tube-type 0 to 30 psi gages for ease of reading.

(2) Obtain at least two tubing caps or plugs, whichever is needed, to cap or plug low and high pressure tubing when the tubing is disconnected from the pressure differential (excess flow) control.

(3) Coordinate with the appropriate aerospace ground personnel at your base to obtain (on loan basis) a portable air compressor (type and model MC2A) and an extra air hose. This hose may have to be purchased by your liquid fuels maintenance (LFM) shop if not available through aerospace ground equipment (AGE) channels. This extra hose is necessary to position the gasoline driven air compressor at least 50 feet from the control pit.

(4) It will be necessary to determine the orifice plate opening size and the GPM flow through the orifice. This may require the removal and measuring of one orifice plate located in the active fuel system, if this information is not available in your technical catalogs. Determining the GPM flow rate can be accomplished as follows:

(a) First, determine the restricted (normal max) GPM flow rate by viewing an actual refueling operation of an aircraft or refueling truck through the hose cart. The rate can be measured by timing the meter used on the hose cart.

(b) Second, determine the unrestricted flow rate by using a straight hose (in place of the hose cart) connected to a master meter, then connected to the bottom loading portion of the refueling line. This rate can also be determined by timing the meter on the master meter unit.

(c) When the two flow rates and the size of the orifice plate opening are known, then refer to the orifice bore chart (figure A-2) to determine the differential pressure across the orifice.

NOTE: If figure A-2 Orifice Bore Chart is not sufficiently legible, a new chart can be obtained from CLA-VAL CO., 17th and Placentia, Newport Beach, CA 92660. The proper psi setting for the CDHS-3 control would be the differential pressure reading, obtained using the hose cart or restricted rate, plus one-half of the difference in pressure between the restricted and unrestricted conditions.

Example: (See Orifice Bore Chart, figure A-2). Assume: (1) Orifice plate opening is 4.5 inches. (2) Hose cart or restricted (normal max) flow rate is 550 GPM (which equals 4.6 psi differential across the orifice). (3) Unrestricted flow is 700 GPM (which equals 7.6 psi differential across the orifice). Solution: (1) 7.6 psi minus 4.6 psi equals 3 psi. (2) Take one-half of the 3 psi which is 1.5 psi. (3) Add the restricted differential pressure 4.6 psi to 1.5 psi which equals (6.1 psi) across the orifice which will be the proper setting of the CDHS-3 control. After this has been determined, the actual setting or adjustment of the control can be accomplished.

(d) Disconnect the tubing lines from the low and high pressure side of the CDHS-3 and cap or plug all removed tubing.

(e) Connect the hose from the air compressor to the pressure inlet of the manifold and gage assembly and start compressor.

SHEET 1 OF 2

CLA-VAL CO. NEWPORT BEACH, CALIFORNIA	CATALOG NO. CDHS3 CDHS3A	DRAWING NO. 86122	REV.
PROCEDURE FOR SETTING EXCESS FLOW PILOT ON AF VALVES		DESIGN	
		DRAWN 6-11-73	HWE
		CHK'D. 6-11-73	HJE
		APP'D. 6-11-73	Jm
		SCALE DIST CODE 000	

REVISION RECORD

LTR	DESCRIPTION	BY	DATE

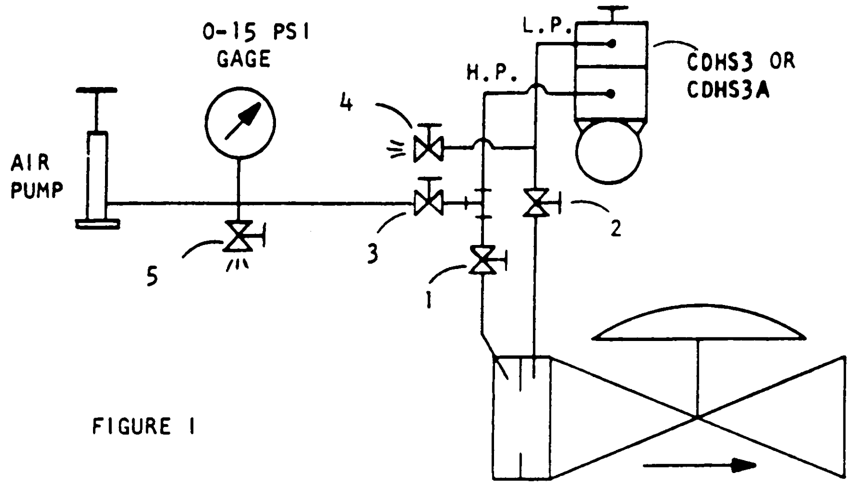
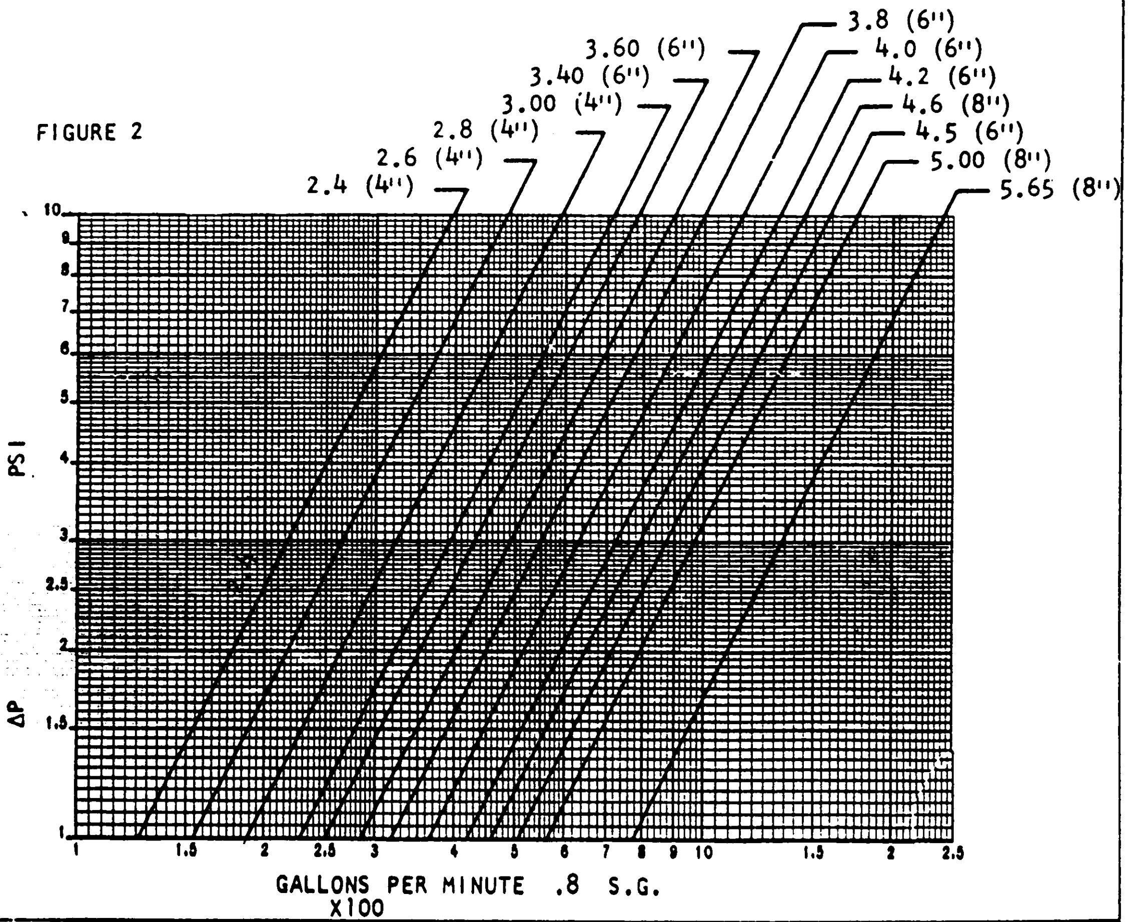


FIGURE 1

FIGURE 2



FORM F-4 REV 1-62 PRINTED IN U.S.A.

Figure A–1. Diagram and Graph, Procedure for Setting Excess Flow Pilot on AF Valves.

CAUTION: Be sure to locate gasoline driven air compressor at a safe distance from the control pit.

(f) Connect low pressure hose on manifold and gage assembly to low pressure side of CDHS-3 control. Control high pressure hose in the same manner on the high pressure side of the CDHS-3 control.

(g) Close pit inlet valve and energize the fuel system. (This is necessary to activate the refueling valves).

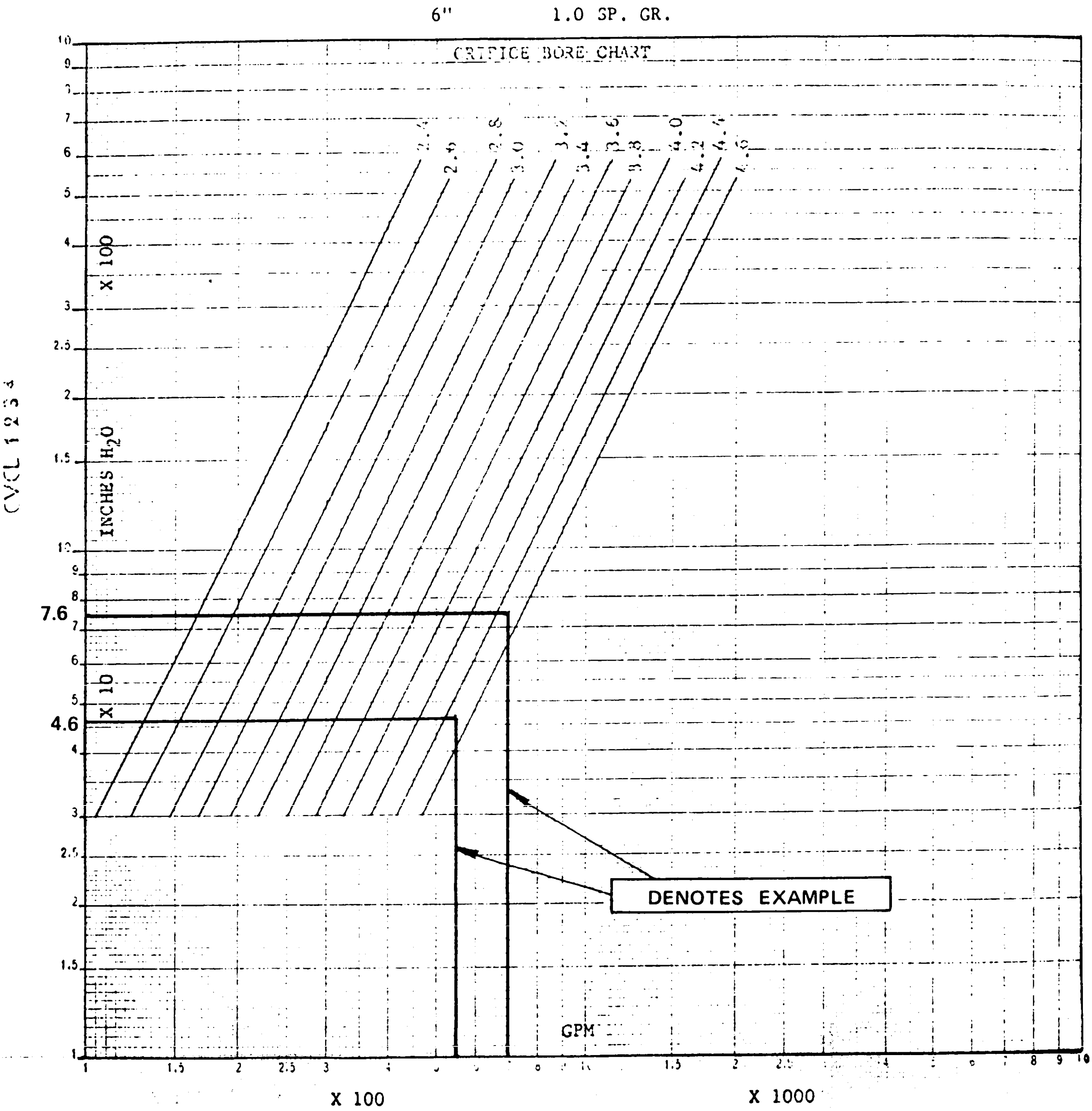
(h) Apply equal pressure to both the high and low sides (chambers) of the CDHS-3 control through the manifold and gage assembly. (Figure A-3 shows approximately 28 psi on high pressure side.)

(i) Slowly dispel pressure from the low pressure side. This can be done by slowly unscrewing the hose connection by hand on the low pressure side of the manifold and gage assembly. (Figure A-3 shows approximately 20 psi on low pressure side when the CDHS-3 has tripped.)

(j) The CDHS-3 control should then trip when the set differential pressure is obtained. If not properly set, adjust to desired differential pressure for your orifice plate size and system flow rate. This adjustment in setting will require the use of the trial and error method.

(k) Repeat the above procedures several times to make sure the control shifts at correct pressure.

(l) Put system back in normal operating condition after the adjustments have been completed.



NOTE: Use the proper fuel conversion factors for this chart (JP-4.775 × inches of H_2O and GPM/$\sqrt{.775}$

Figure A-2. Orifice Bore Chart, CDHS-3 Test Procedure.

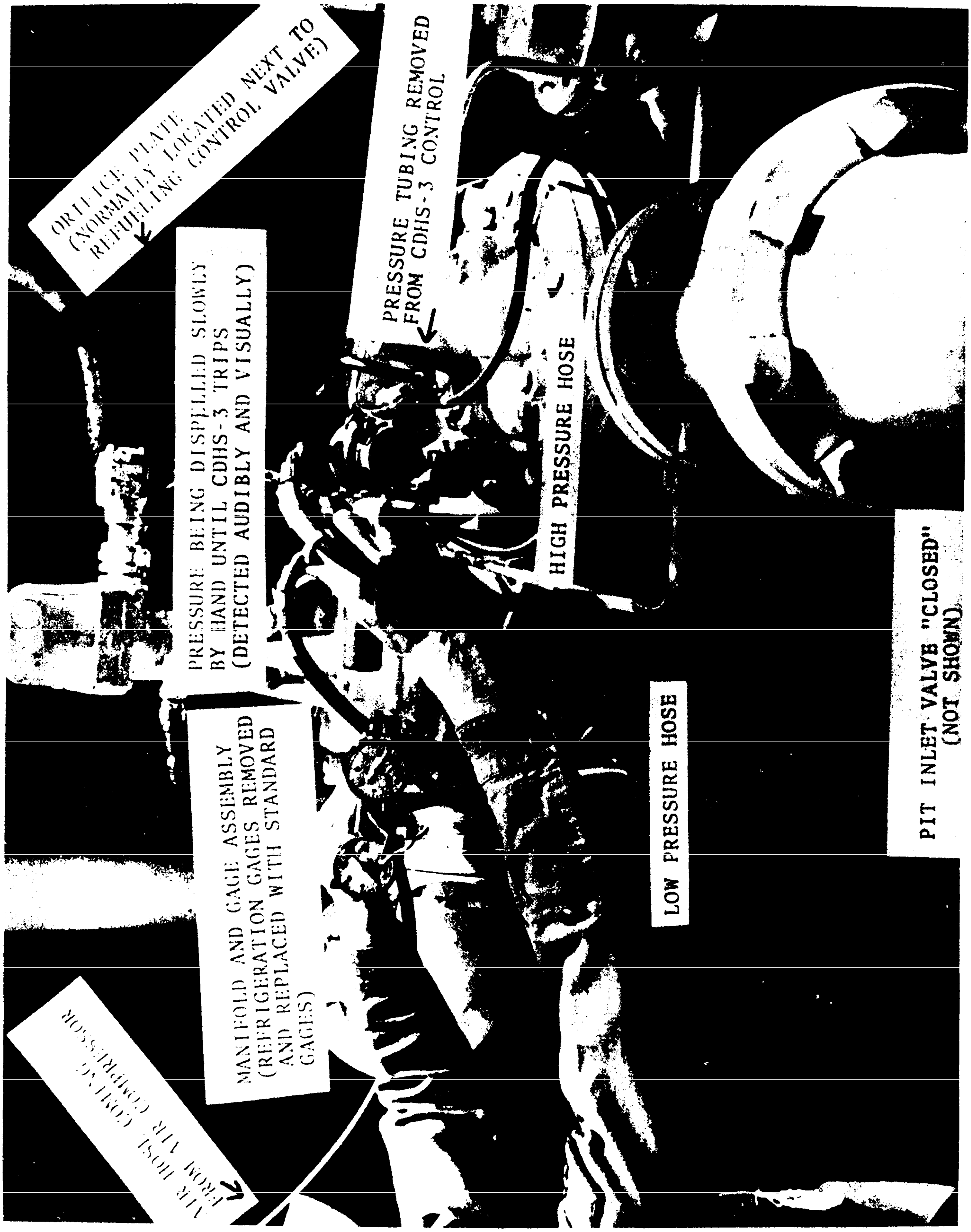


Figure A-3. CDHS-3 Control.

Proposed Memorandum of Agreement Format
(Optional—for Guidance Only)

From: Base Civil Engineering

Subject: Memorandum of Agreement Pertaining to Draining of Floating Roof Tanks and Interior Dike Basins.

To: Base Fuels Management Officer

1. The following will constitute a memorandum of agreement between base civil engineering and base fuels management officer pertaining to checking and draining during inclement weather, the floating roofs and interior dike basins associated with storage tanks in fuels bulk storage area.

2. The base fuels management branch usually operates the fuels bulk storage tank area on a schedule of 24-hours a day, seven days a week; whereas the authorized manning of the BCE Liquid Fuels Maintenance (LFM) shop provides for an 8-hour day, 5-days a week. According to paragraph 10-9b(4), certain responsibilities may be delegated to system operators when it is considered advantageous to the Air Force.

3. Due to the difference in working schedules between BCE and fuels management personnel, the draining of floating roofs and interior dike basins is delegated from the BCE to the FMO. Specific responsibilities delegated are:

a. During or immediately after a rain, fuels operating personnel will drain all water from the floating roof and interior dike basins. Operating personnel will continue onsite surveillance. The roof and the dike drain valves must never be open at the same time. Upon completion of drainage, fuels operating personnel will close and secure floating roof and dike drain valves which will remain closed except for exact period of time required for future drainage. Keys for locks on both the roof and dike drain valves will be maintained by fuels operating personnel. When the temperature of the product or the ambient air temperature drops to freezing or below, fuels operating personnel will secure the drip tight plug in top center of the floating roof(s).

b. BCE and LFM personnel will instruct fuels operating personnel on the correct procedure and method of installing the drip tight floating roof draining plug immediately before each winter season.

c. During freezing weather conditions, antifreeze solution or deicing fluid will be used in all roof drain lines. Responsibilities in connection with winterization follows:

(1) BCE and LFM will accomplish the initial fill of floating roof drain lines with antifreeze solution or deicing fluid prior to permanent freezing conditions or 1 November each year, which ever occurs first, and record as applicable. The roof drain valve will be secured and have a metal sign on it stating: "CAUTION. WINTERIZED. NOTIFY LFM BEFORE DRAINING."

(2) BCE and LFM personnel will perform monthly tests of antifreeze solution for proper composition and record results.

(3) BCE will supply all necessary items and equipment required to remove or melt snow from floating roof. (Pump, shovels, brooms, isopropyl alcohol, hoses, and empty drums).

d. The following procedures will be implemented when problems are encountered removing snow from floating roof tanks. These procedures are to facilitate removal of snow from floating roof fuel tanks when other methods of snow removal are impractical (that is, resupply to maintain floating roof in high position may not always be possible).

(1) During daylight hours after a snow storm, fuels operating personnel will drain antifreeze or deicing fluid from the roof drain piping into partially buried, empty 55 gallon drum(s) which has been provided and installed by BCE or LFM personnel.

(2) Fuels operating personnel will then shovel snow from the outer periphery of the roof toward the center roof drain.

(3) After the snow has been shoveled to the center roof drain, BCE or LFM personnel will start and operate pumping apparatus so that fuels operating personnel can apply alcohol solution to the snow so that it can be melted and drained from the floating roof.

(4) Once the snow has been melted and all liquid has been drained from the floating roof and drain piping, the roof drain piping will then have antifreeze or deicing fluid reinstalled by BCE or LFM personnel. Fuels operating per-

sonnel will ensure the roof drain valve is closed and secured. They will also ensure the roof drip tight drain lug is reinstalled and inspected for tightness. The warning sign will be redisplayed on the drain valve.

CAUTION: If a heavy snow storm occurs during other than normal duty hours and possible floating roof damage is foreseen, the fuels operating personnel will notify the BCE service call section of the potential hazard. Service call personnel will in turn notify the BCE or LFM personnel on standby recall. The LFM standby personnel will report to duty, and a combined effort between fuels operating and BCE or LFM personnel to melt and remove snow from the tank roof will be initiated.

Base Civil Engineer

Base Fuels Management Officer

INDEX

DEPARTMENT OF THE AIR FORCE
Headquarters US Air Force
Washington DC 20330-5000

CHANGE 3
AFM 85-16
16 September 1988

Civil Engineer—General

MAINTENANCE OF PETROLEUM SYSTEMS

AFM 85-16, 18 August 1981, is changed as follows:

Page-Insert Changes. New or revised material is indicated by a ★.

Remove	Date	Insert
v thru viii	18 Apr 86	v thru viii
1-3, 1-4	18 Apr 86	1-3, 1-4
1-10.1	18 Apr 86	
1-10.1	28 Jan 83	1-10.1
1-11, 1-12	18 Aug 81	1-11, 1-12
1-15 thru 1-18	28 Jan 83	1-15 thru 1-18
2-7, 2-8	18 Apr 86	2-7, 2-8
2-15, 2-16	28 Jan 83	2-15 thru 2-16
2-35, 2-36	18 Aug 81	2-35, 2-36, 2-36.1
3-11 thru 3-14	18 Apr 86	3-11 thru 3-14
8-11, 8-12	18 Apr 86	8-11, 8-12
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10-9, 10-10	18 Apr 86	10-9, 10-10
11-1, 11-2	18 Apr 86	11-1, 11-2
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12-1 thru 12-6	23 Jan 83	12-1 thru 12-6
A6-1 thru A6-4	18 Apr 86	A6-1 thru A6-4
A7-1 thru A7-4	28 Jan 83	

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

LARRY D. WELCH, General, USAF
Chief of Staff

WILLIAM O. NATIONS, Colonel, USAF
Director of Information Management
and Administration

No. of Printed Pages: 46
Distribution: F

DEPARTMENT OF THE AIR FORCE
Headquarters US Air Force
Washington DC 20330-5000

MASTER REFERENCE

01 MAY 1986

CHANGE 2
AFM 85-16
18 April 1986

Civil Engineer—General

MAINTENANCE OF PETROLEUM SYSTEMS

AFM 85-16, 18 August 1981, is changed as follows:

1. **Explanation of Change.** This change incorporates all the write-in changes shown in paragraph 2 on the transmittal page of change 1, 28 January 1983.

2. **Page-Insert Changes.** New or revised material is indicated by a ★.

Remove	Date	Insert
i thru iv	18 Aug 81	
v thru vii	28 Jan 83	i thru vii
1-1 thru 1-4	18 Aug 81	1-1 thru 1-4.1
1-9, 1-10	28 Jan 83	1-9, 1-10.1
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4-11 thru 4-14	18 Aug 81	4-11 thru 4-14.1
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7-5	18 Aug 81	7-5
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8-11, 8-12	18 Aug 81	8-11, 8-12
10-1 thru 10-9	28 Jan 83	10-1 thru 10-10
11-1 thru 11-6.1	28 Jan 83	
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A6-1 thru A6-4	28 Jan 83	A6-1 thru A6-4

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

CHARLES A. GABRIEL, General, USAF
Chief of Staff

NORMAND G. LEZY, Colonel, USAF
Director of Administration

Supersedes IMCs 83-1, 6 Dec 83 and 84-1, 26 Nov 84.
No. of Printed Pages: 123
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DEPARTMENT OF THE AIR FORCE
Headquarters US Air Force
Washington DC 20330

CHANGE 1
AFM 85-16
28 January 1983

Civil Engineer—General

MAINTENANCE OF PETROLEUM SYSTEMS

4 FEB 1983

AFM 85-16, 18 August 1981, is changed as follows:

1. **Page Insert Changes.** New or revised material is indicated by a ★.

Remove	Date	Insert
v thru vii	18 Aug 81	v thru vii
1-9, 1-10	18 Aug 81	1-9 thru 1-10.1
1-15 thru 1-18	18 Aug 81	1-15 thru 1-18
2-15 thru 2-18	18 Aug 81	2-15 thru 2-18.1
3-9, 3-10	18 Aug 81	3-9 thru 3-10.1
4-1, 4-2	18 Aug 81	4-1, 4-2
9-1 thru 9-3	18 Aug 81	9-1 thru 9-3
10-1 thru 10-9	18 Aug 81	10-1 thru 10-9
11-1 thru 11-6	18 Aug 81	11-1 thru 11-6.1
11-11, 11-12	18 Aug 81	11-11, 11-12
		12-1 thru 12-6
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A6-1 thru A6-4	18 Aug 81	A6-1 thru A6-4
		A7-1 thru A7-4

2. **Write-In Changes:**

Page	Reference	Line	Action
i	Purpose Para	1	Change "(LEM)" to "(LFM)."
iv	Chapter 9, Section D	—	Delete "Coatings . . . 9-11, 9-3" and change paragraph "9-12" to "9-11."
1-1	Para 1-1d	3	Change "manuals and technical orders (TOs) for guidance" to "publications."
1-1	Para 1-2	8	Change "regardless of cost," to "estimated at more than $500."
1-4	Para 1-5f(4)	7	Change "AFR 127-101" to "AFOSH Standards."
1-14	Figure 1-4	—	Change "¾″ x 8′ Ground Rods" to "⅝″ minimum x 8′ Ground Rods."
1-19	Para 1-32	3	Change "of this technical manual are listed in TO 00-25-172" to "are available in the electrical shop and are listed in TA 486."
1-21	Figure 1-11	—	Change "¾″ x 8′ Grounding" to "⅝″ minimum x 8′ Grounding."
2-5	Para 2-4e(4)	8	Change "soft" to "shaft."
2-7	Para 2-6	29	Change "granted to HQ USAF/LEEMM" to "granted by HQ AFESC/DEMM."
2-8	Figure 2-8, Item 5, Source of Supply	—	Change "HQ SAC/DEMU" to "MAJCOM/DEM."
2-9	Para 2-8a(1)(a)	5	Change "AFM 88-15" to "AFM 85-3."
2-9	Para 2-8a(1)(a)	10	Change "AFM 88-15, attachment 9" to "AFM 85-3."
2-12	Para 2-8a(2)(a)	3	Change "AFM 91-23, chapter 15" to "chapter 12."
2-13	Figure 2-16	—	Add "13. Centrifugal Pump."
2-13	Para 2-8b(2)	7	Change "AFM 91-23, chapter 15" to "chapter 12."
2-20	Para 2-14l	—	Add "NOTE: Filter separator modification kit is not required on types III or IV systems."
2-20	Para 2-14l(1)	2	Change "HSF" to "HFS."
2-22	Figure 2-24, Item 14, Part No.	—	Change "11923" to "11923-1."

Supersedes IMC 82-1, 29 Jan 82.
No. of Printed Pages: 62
Distribution: F

Page	Reference	Line	Action
2-22	Para 2-16a	14	Change "KMU-16/F" to "KMU-416/F."
2-24	Para 2-16d	10	Change "5330" to "4330."
2-26	Para 2-17a	8	Change "4300" to "4330."
2-28	Table 2-2, Remedy or Action	19	Change "230 series in manufacturing" to "and manufacturer's."
2-29	Para 2-21a	6	Change "blind flange" to "orifice plate."
2-30	Para 2-23b	2	Change "filter seperator, all teflon coated screens must be agitated" to "teflon coated screens, agitate."
2-31	Para 2-26	3	Add "installed" before "meter."
2-31	Para 2-26e(1)	1	Change "SA-6 OR" to SA-60 R."
3-2	Para 3-4b(2)	2	Change "a high level control valve" to "the hydrol valve B."
3-3	Para 3-4b(5)(b)	2	Change "R" to "H."
3-6	Para 3-4h(3)(d)	3	Change "not" to "now."
3-6	Para 3-4j(2)(g)	3	Change "figure 50" to "figure 3-7."
3-7	Para 3-5b	5	Change "present" to "preset."
3-8	Para 3-6b	1	After "defueling" add "or wetline."
3-11	Para 3-8b	5	Delete "before and."
3-12	Para 3-8d(2)(c)	3	Replace paragraph with the following: "Shut off pump, the main valve closes completely."
3-12	Para 3-9d(2)(d)	3	Delete "CV."
3-14	Para 3-10a	22	Change "(paragraph 3-4(2))" to "figure 3-6)."
3-18	Para 3-13d(5)	5	Change "2-13c(5)" to "2-14c(5)."
3-18	Para 3-13d(14)	3	Change "if possible" to "if provided."
4-3	Para 4-7c(5)	8	Delete "push-button."
4-4	Para 4-7c(5)	3	Delete "NOTE: The .... be shown."
4-4	Para 4-7d(1)(f)	1	Change "(LRD)" to "(CRD)."
4-6	Para 4-9c	5	Change "checkvalve" to "check valve."
4-11	Para 4-14b(1)(c)	2	Change "loadded" to "loaded."
4-11	Para 4-14b(1)(c)	—	Add "NOTE: The spring loaded covers over the refueling and defueling switches may be removed with no adverse effect."
4-14	Para 4-16c(3)	—	Add "NOTE: A replacement poppet kit is available for the Cla Val 352AF hydrant adapter. This kit should be installed on all these adapters to preclude a sticking problem encountered with the original poppet. It will be stamped as MOD-1 on the poppet face."
5-1	Para 5-3	4	Change "(1 foot 6 inches)" to "(approximately 1 foot 6 inches)."
6-1	Para 6-1b	2	Change "type HAAR" to "piston type."
6-1	Para 6-1g	1	Change "air-operated" to "AIR-hydraulic operated."
6-1	Para 6-1g	2	Delete "and of the air pressure tanks."
7-1	Para 7-1i	1	Change "4-11" to "4-12 and 10-16i."
7-2	Para 7-5b	11	Change "fullstands" to "fill stands."
7-5	Para 7-9	2	Change "1-9" to "1-10."
8-1	Para 8-2a(2)	6	Change "front" to "frost."
8-2	Para 8-2b(1)	10	Delete "and D."
8-11	Para 8-9a	12	Add "existing galvanized ground fuels piping may remain in use."
8-12	Para 8-11d	4	Change "his" to "this."
11-9	Para 11-13c	1	Change "The preferred" to "A."
A3-1	Para 2c	1	Delete "(see AFR 127-101)."
A3-3	Para 4-b(3)(b)*1*	1	Delete "MSHA approved 1-inch, wire reinforced,."
A3-3	Para 4b(3)(b)7	1	Delete "voice powered."
A4-4	Figure A-2	—	Add "NOTE: Use the proper fuel conversion factors for this chart (JP-4.775 × inches of H_2O and GPM/$\sqrt{.775}$)."
A4-4	Figure A-2	Title	Change "CDMS-3" TO "CDHS-3."
A4-5	Figure A-2	Title	Change "CDMS-3" TO "CDHS-3."

BY ORDER OF THE SECRETARY OF THE AIR FORCE

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CHARLES A. GABRIEL, General, USAF
Chief of Staff

JAMES L. WYATT, JR., Colonel, USAF
Director of Administration