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U.S. MARINE CORPS TECHNICAL MANUAL

INSTALLATION AND OPERATION

MARINE CORPS TACTICAL FUEL SYSTEMS

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APRIL 1995

PCN 182 036200 00

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APRIL 1995

PCN 182 036200 00

DEPARTMENT OF THE NAVY
Headquarters, U.S. Marine Corps
Washington, D.C. 20380-0001

28 April 1995

1. This Technical Manual for the Marine Corps Tactical Fuel Systems provides information on the installation, operation and management of tactical fuel systems.

2. This Manual is effective upon receipt.

3. Notice of discrepancies and suggested changes should be submitted on NAVMC 10772 directly to the Commander, Marine Corps Systems Command (SSEA), Quantico, VA 22134-5080.

BY DIRECTION OF THE COMMANDANT OF THE MARINE CORPS

OFFICIAL:

D. R. BLOOMER
Colonel USMC
Director, Program Support
Marine Corps Systems Command

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Dates of issue for original and changed pages are:

Original.....0.....April 1995

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SAFETY SUMMARY

The following are general safety precautions related to fuel systems and fuel handling. They may not be explicitly set forth in this manual but are implied. These precautions should be understood and followed to prevent accidents, bodily injury, and damage to equipment.

Prohibit smoking except in designated areas. Prohibit matches and lighters in hazardous areas.

Never use fuel to wash hands.

Avoid getting fuel on skin; wash fuel from skin as soon as possible with soap and water.

If fuel gets into eyes or mouth, flush thoroughly with water (avoid swallowing), and get medical aid immediately.

If fuel gets on clothing, remove clothing promptly but carefully, wash skin, and replace clothes with clean items.

Do not wear shoes with any exposed metal.

Do not carry or wear exposed metal objects, such as knives, keys, or loose identification bracelets that could cause sparks if struck or dropped.

Wear nonstatic producing clothing, with shirt sleeves rolled down and buttoned, and shirttails tucked in,

Do not carry or wear loose articles of clothing.

Use ear protection devices near operating aircraft engines or other loud noise sources.

Wear goggles or protective helmet with visor for eye protection when fueling aircraft.

Never use liquid fuels as cleaning fluids for floors, equipment, clothing, etc.

Fuel vapors are heavier than air and will collect in low places such as pits and sumps; exercise extreme caution in such areas.

Open fuel drums or cans slowly, especially if they have been shaken or exposed to heat, to prevent a fuel-air mixture from spewing out.

Beware of empty (or apparently empty) cans, drums, tanks, and hoses that formerly held fuel. Vapor can remain long after the container has been emptied, and the fuel-air mixture is exceptionally volatile.

Dispose of oily waste or rags immediately after use in a self-closing metal container.

Avoid spilling fuel, clean up spills at once. Wipe up small spills or cover with dirt. Follow local emergency procedures for large spills. Treat the area as dangerous until vapors dissipate.

Keep all fuel containers, whether full or empty, tightly closed when not in use.

Report leaks to the proper authorities. Do not operate leaky equipment.

Do not conduct fuel operations in a hanger, shop, or other confined area.

Allow a safe distance between bulk tank outlets and fuel dispensing points for fire safety.

Use only flashlights, drop lights, or lanterns approved for hazardous locations.

Use only explosion-proof electrical equipment and fixtures in hazardous areas; inspect often and correct any condition that could cause sparking, arcing, or overheating.

Open switches and pull fuses before performing essential work on electrical equipment.

Equipment requiring welding or cutting operations must be clean and vapor-free; heater, welding torches, or blowtorches must not be used within 50 feet of fuel handling operations.

Stop all fuel handling operations during electrical storms.

Bonds and grounds should be tested frequently to ensure conductivity; repair or replace defective parts. Bonds and grounds must be made before fuel flow begins, and must not be broken until fuel flow ends.

Vehicles carrying fuel as cargo and those operating within 50 feet of fuel handling operations must be equipped with a spark-arresting exhaust system.

Berm walls surrounding collapsible tanks must be built to contain one and a half (1 1/2) times the volume of fuel stored. Top of berm walls should be designed to give the least possible exposed fuel surface in case of fire and/or tank rupture.

Splash filling is prohibited. If top-loading is necessary, start filling at a slow rate with the filling hose laying on or near the bottom of the tank. Once the hose is submerged in fuel, loading can proceed at the required flow rate.

Do not filter fuel through anything other than properly grounded filter-separators and monitors.

After filling large tanks, allow sufficient relaxation time to allow the static charge on the fuel surface to equalize with the tank before inserting gauges or any objects into the fuel.

Do not throw or drag hose or nozzles; avoid kinking hoses.

Turn off aircraft radio and radar equipment during fueling or defueling.

Do not conduct fueling operation within 300 feet of active ground radar.

Aircraft to be refueled or defueled must not have hot brakes.

Do not clip ground wires to antennas, rotor blades, or propeller blades.

Keep clear of rotor blades, propeller blades, and their paths.

Keep the refueling area clear of loose material that could be blown about by prop wash, jet blast, or rotor wash.

Tankers used to accept fuel from vehicles or aircraft will be plainly marked DEFUELER. A vehicle

marked REFUELER will not be used to remove fuel from a using vehicle unless it is specifically authorized, nor will a vehicle marked DEFUELER be used to fuel vehicles.

At least two persons are required in defueling operations.

Refueling/defueling areas must be free of all ignition sources.

In defueling, the defueler operator must check with the unloader (crew chief, plane captain, lineman, etc.) to be sure the correct aircraft is being unloaded, that all electrical equipment is off, and no repair work is being done.

Firefighting equipment, including protective clothing, must be in good condition and readily available.

Water alone should not be used on fuel fires since it tends to spread the fire.

Fire extinguishing equipment must be in place and ready during refueling/defueling, including crash crew standby assistance if available.

The following definitions apply to the listed associated words when used throughout this manual:

WARNING: an operation procedure, practice, or condition, etc., which may result in injury or death if not carefully observed or followed.

CAUTION: an operating procedure, practice, or condition, etc., which, if not strictly observed, may damage equipment.

NOTE: an operating procedure, practice, or condition, etc., which is essential to emphasize.

The following warnings appear in this manual:

WARNING

Filter-separators generate static electricity; to reduce the threat of fire, implementation of approved bonding and grounding procedures and other safety considerations are mandatory, (Page 1-18)

WARNING

Exercise extreme caution using compressed air to purge hose lines of residual fuel or fumes. Serious injury or death could occur if compressed air is directed at the skin. (Page 2-52)

WARNING

Dry cleaning solvent is a safety and health hazard. Avoid breathing vapors and avoid skin contact with the solvent. Do not use near ignition sources. The flash point of cleaning solvent P-D-680 is 100 to 138°F, (38 to 59°C). An adequate supply of fire extinguishers must be located in the vicinity of cleaning operations. Foamite type fire extinguishers are recommended for solvent fires. (Page 3-11)

WARNING

To avoid endangering personnel, do not use a lifting device with a capacity less than 4,000 pounds. (Page 3-24)

The following cautions appear in this manual:

CAUTION

Do not tie guy ropes to the tank handles; a failure will rupture the tank. (Page 3-8)

CAUTION

Do not use a wire brush or other sharp edged instrument to clean the basket screen. The resulting damage will render the screen unserviceable. (Page 3-10)

CAUTION

Automatic fuel nozzles can be used. However, lock-open or latch-open devices which allow unattended operation must be modified so that the dispensing nozzles must be held open by hand end attended while dispensing fuel. (Page 3-10)

CAUTION

An excessive application of torque will cause distortion of the meter housing and rotor. (Page 3-35)

CAUTION

Do not attempt to replace individual fuses. Fuses shall be replaced by complete sets, and new packing (O-rings) shall used with each change. (Page 3-41)

CHAPTER 1

OVERVIEW OF TACTICAL FUEL SYSTEMS

Section I. INTRODUCTION

1-1. GENERAL.

a. Purpose. The purpose of this manual is to provide information and guidance to petroleum personnel responsible for the installation, operation and management of Marine Corps tactical fuel systems. For maintenance procedures, refer to TM 3835-15/1.

b. Scope. This manual describes the general features, capabilities, and limitations of the Marine Corps' principal tactical fuel systems (TFS). It contains a general description of major system components, their theory of operation, and their relationship to other components of the system. The manual is oriented toward expeditionary fuel operations, and deals with the responsibilities of both operator and supervisory personnel. Material is presented with an emphasis on basic system concepts and capabilities which, once mastered, can be applied to specific tactical situations by on-site personnel. Systems covered include the Amphibious Assault Fuel System (AAFS), the Tactical Airfield Fuel Dispensing System (TAFDS), the Helicopter Expedient Refueling System (HERS), and the Expedient Refueler System (ERS). This manual is not meant to be a sole source of information on bulk fuel operations, but rather is intended as a point of departure. For more detailed information, the reader is directed to references cited in the text and in Appendix A.

c. Manual Plan. The manual is divided into three chapters. Chapter 1 provides a general systems overview to include a brief description of each individual system and major systems components. Chapter 2 deals with general operations and contains information on site selection, preparation for use, fuel handling and safety, quality surveillance, and bulk fuel transfers. Chapter 3 is devoted to individual system components, providing general operating guidelines and considerations and tabulated data information. The appendices provide detailed references and procedures which expand on information contained in the text. In addition, a components list for each system is included in the appendices.

d. Wording. "Shall" has been used only when application of a procedure is mandatory. "Should" has been used only when application of a procedure is recommended. "May" has been used only when application of a procedure is optional. "Will" has been used only to indicate futurity, never to indicate any degree of requirement for application of a procedure.

1-2. BACKGROUND.

In 1952, in an attempt to replace the antiquated methods of World War II and Korea, the Marine Corps adopted a new fuel delivery concept for the support of amphibious operations. As originally conceived, the new approach stressed the need for maximum flexibility and adaptability in meeting the Corps' ever-changing requirements. That basic concept has since evolved into the current AAFS, TAFDS, HERS, and ERS bulk fuel systems. Still, though numerous hardware changes have been made, the fundamental principle of flexibility remains. All current TFS are based on the same or similar components which can be quickly arrayed to meet a specific operational requirement.

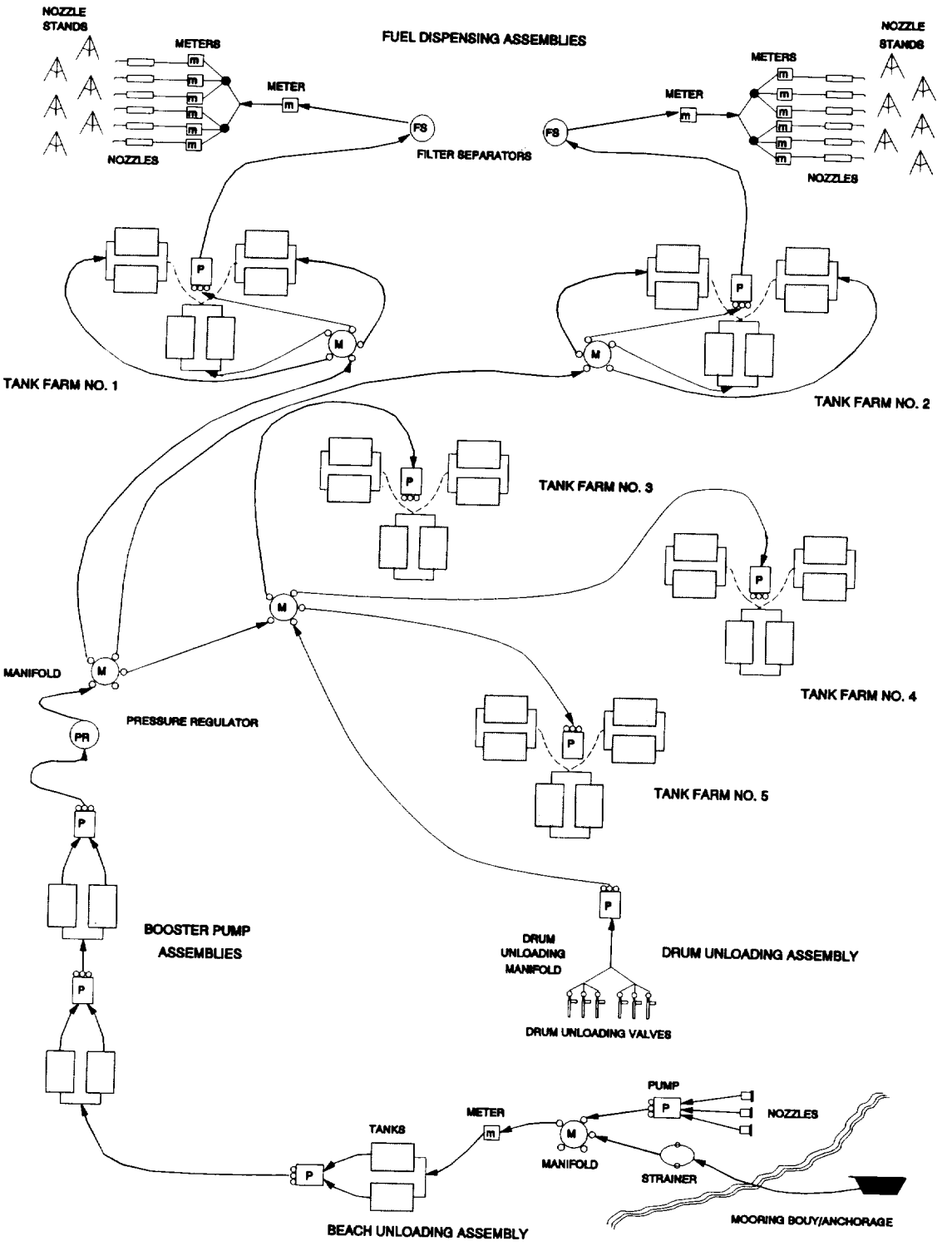


Figure 1-1. Amphibious Assault Fuel System

Section II. TACTICAL FUEL SYSTEMS

1-3. AMPHIBIOUS ASSAULT FUEL SYSTEM (AAFS).

a. General. The largest of the Marine Corps' tactical fuel systems, the AAFS is designed to receive, store, transfer, and dispense fuel in support of operations ashore. The AAFS is capable of receiving fuel from ship-to-shore operations from naval, MSC, or commercial shipping. In addition, the AAFS is capable of receiving fuel from navel landing craft, barges, railroad tank cars, tank trucks, pipelines/hoselines, fixed facility bulk tanks, and drums. The AAFS provides the majority or the MAGTF's storage capability and is utilized to store most of the MAGTF stockage objective for bulk fuel. The AAFS is capable of transferring fuel by hoseline to other storage areas, or airbases but not within airbases and dispense fuel to individual containers, tank trucks, and vehicles.

b. Description. The AAFS is a highly versatile system designed to meet a wide variety of operational or training requirements. It can be employed as a whole, in part, or in conjunction with another AAFS system. Figure 1-1 depicts one possible AAFS configuration. Each AAFS consists of several major subassemblies which help move petroleum products across the beach to tank farm sites inland. Major subassemblies are: one beach unloading assembly (figure 1-2); one drum unloading assembly (figure 1-3); two booster pump assemblies (figure 1-4); five tank farm assemblies (figure 1-5); two fuel adapting assemblies; and two fuel dispensing assemblies (figure 1-6). Subassemblies are comprised of a number of self-contained components that include collapsible fabric storage tanks, trailer mounted pumps, fuel filter-separator units, metering devices, hoses, valves, fittings, and associated hardware. Like components are interchangeable among assemblies, and all components are easily connected using the quick-disconnect couplers and adapters provided throughout AAFS. With the exception of the fabric tanks, all components are either wheeled, skid mounted, or light enough to be moved by hand. These features not only enhance the system's transportability, but also facilitate rapid changes in the system's configuration to meet specific tactical requirements.

c. Characteristics. The AAFS is capable of receiving and transferring fuels from offshore vessels and craft at rates up to 600 gallons per minute (gpm). Depending on the equipment employed, it can also receive and transfer product from bulk storage tanks, railroad tank cars, tank trucks, or fuel drums at rates varying from 100 to 600 gpm, It can dispense fuels from any of 12 outlets to individual containers, tank trucks, or vehicles at rates up to 350 gpm.

d. Capacity. The basic storage capacity of the AAFS is 600,000 gallons stored in five 120,000-gallon tank farms as depicted in figure 1-5. Each tank farm consists of six 20,000-gallon collapsible tanks. Any desired increase or decrease in storage capacity may be tailored to the situation by the addition or deletion of 20,000-gallon tanks. Each system can only contain one type of fuel. To receive other types of fuel simultaneously, additional system(s) must be installed with each having its own fuel supply line.

e. Installation and Operation. Each system component is designed for rapid installation or reconfiguration without the use of special tools. The time required to install a complete AAFS system will vary according to the tactical situation and terrain encountered. With proper care and maintenance, each system component is capable of continuous operation for extended periods of up to one year without replacement under normal conditions

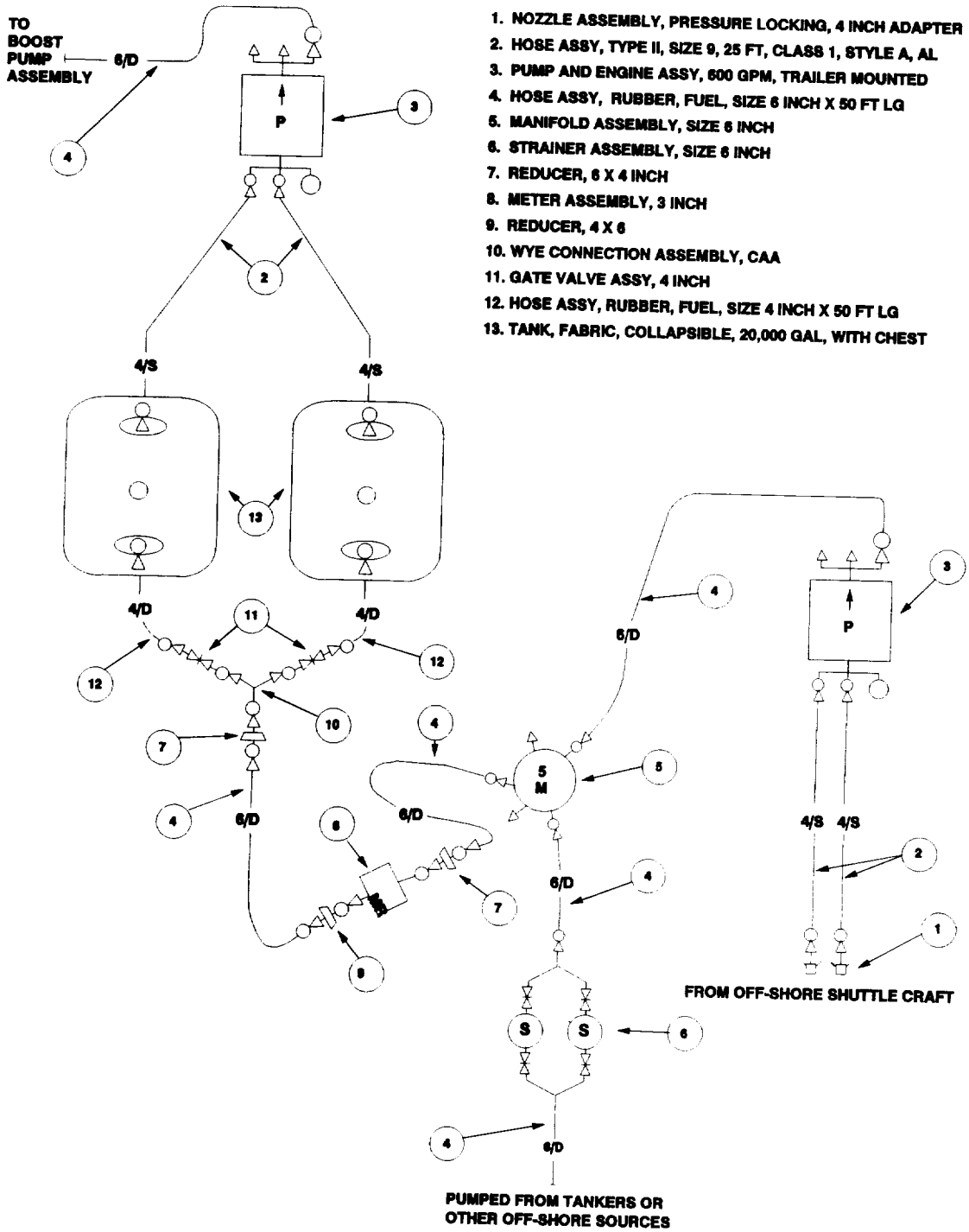
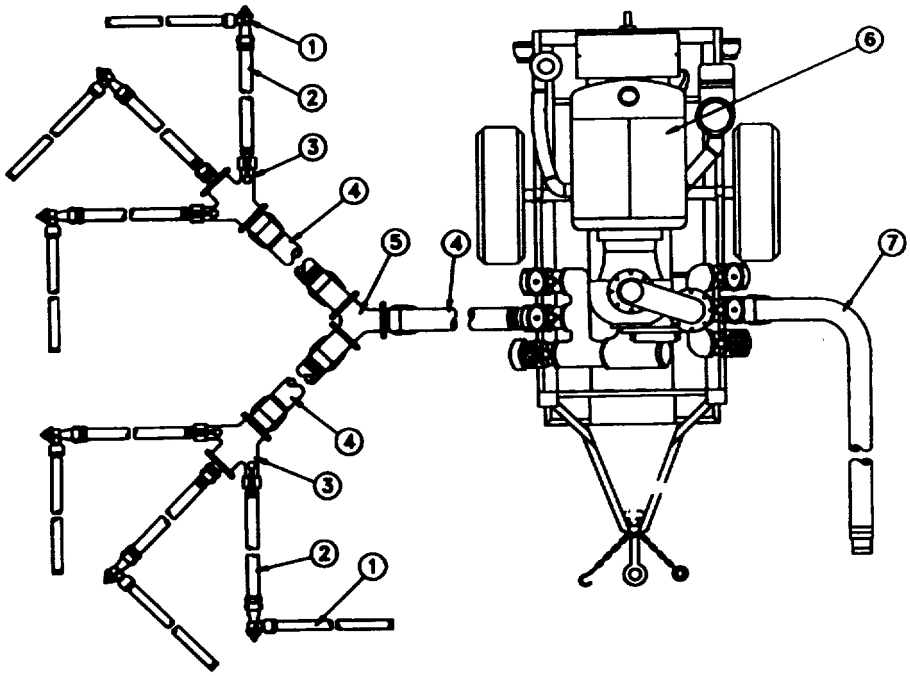


Figure 1-2. Beach Unloading Assembly



1 VALVE, DRUM UNLOADING

2 HOSE ASSY, TYPE II, SIZE 6, 25 FT, CLASS I, STYLE A, AL

3 MANIFOLD, DRUM UNLOADING

4 HOSE ASSY, TYPE II, SIZE 9, 25 FT, CLASS I, STYLE A, AL

5 WYE CONNECTION ASSEMBLY, 600 GPM, TRAILER-MOUNTED

7 HOSE ASSY, RUBBER FUEL, SIZE 4 INCH X 50 FT LG

Figure 1-3. Drum Unloading Assembly

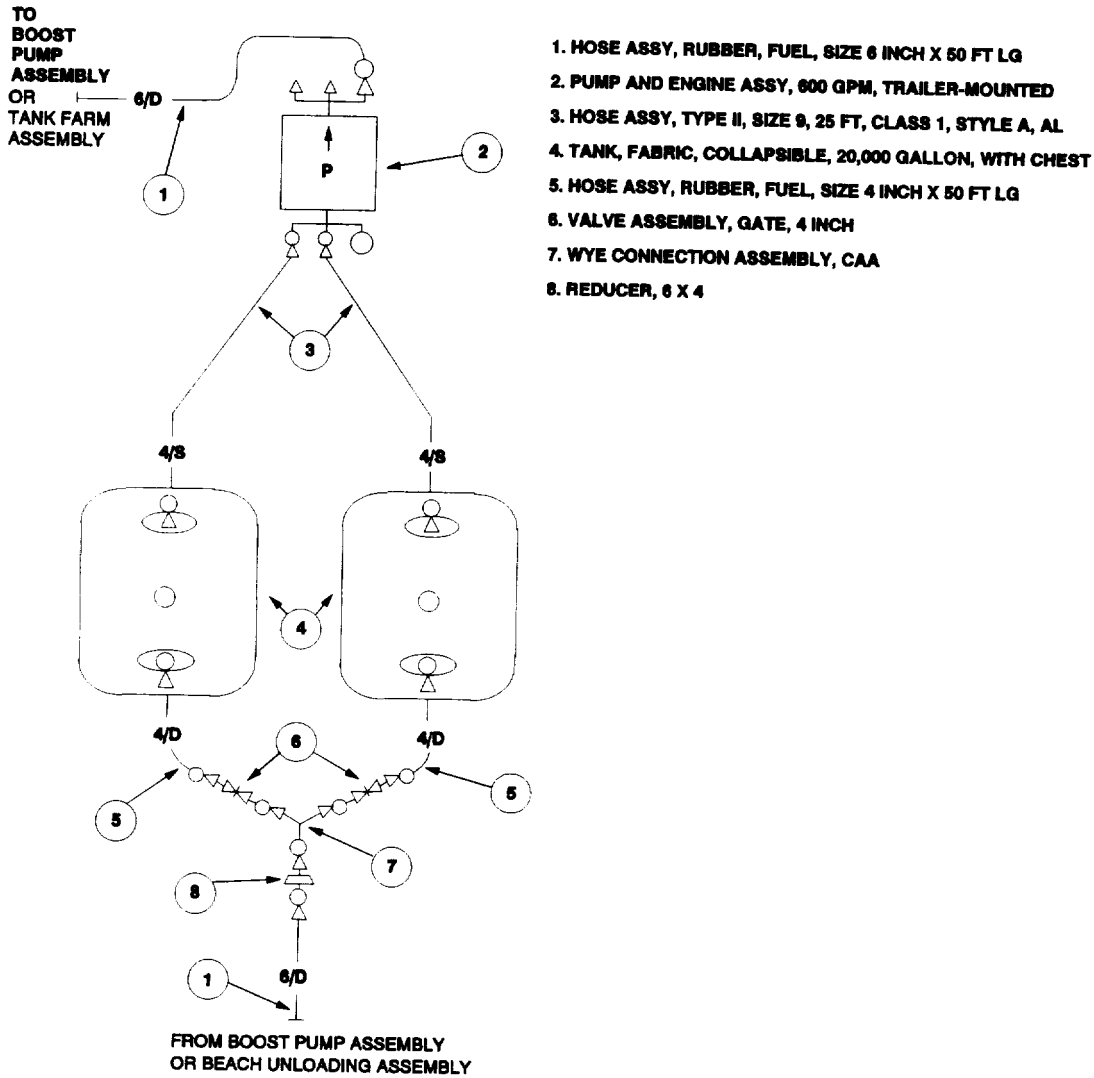
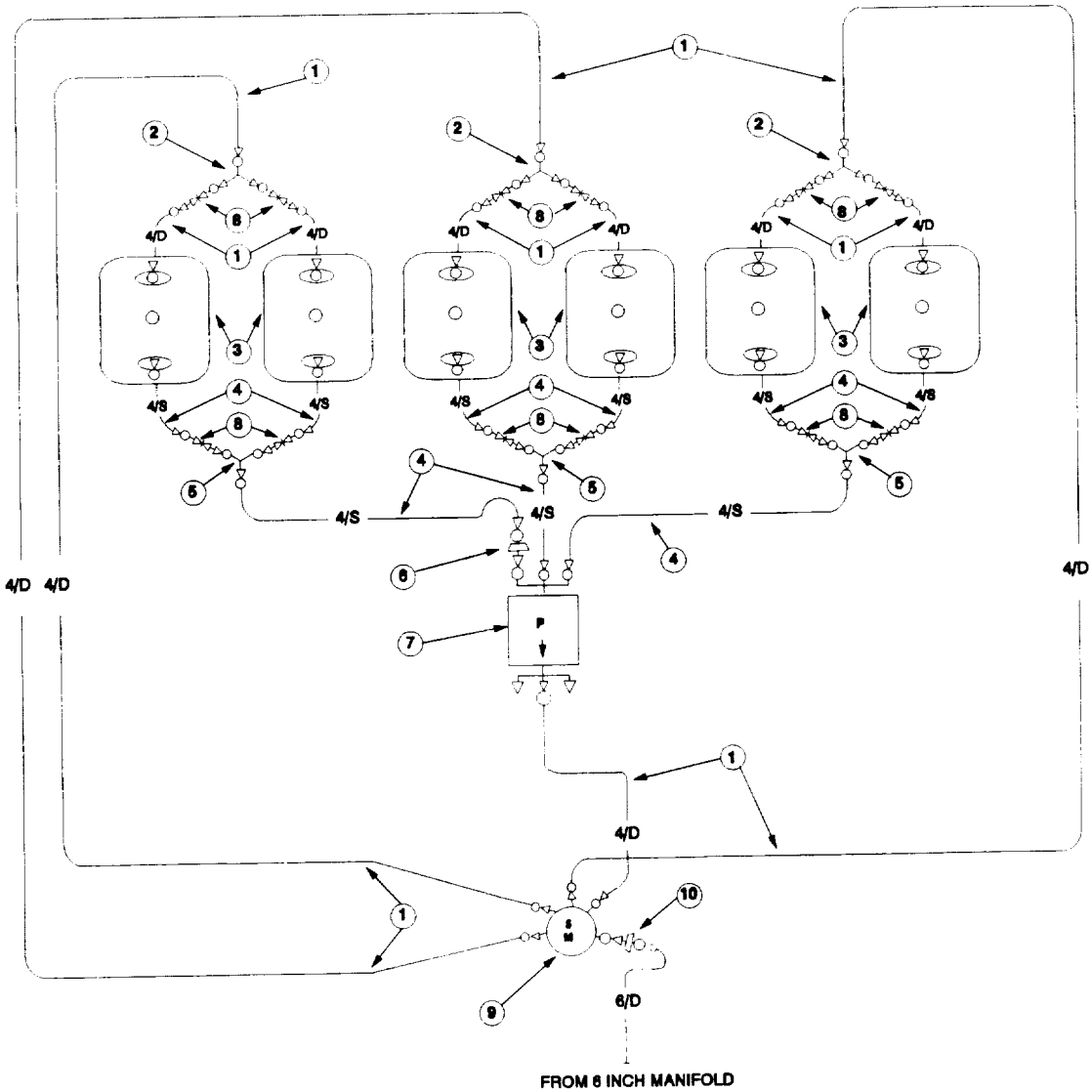
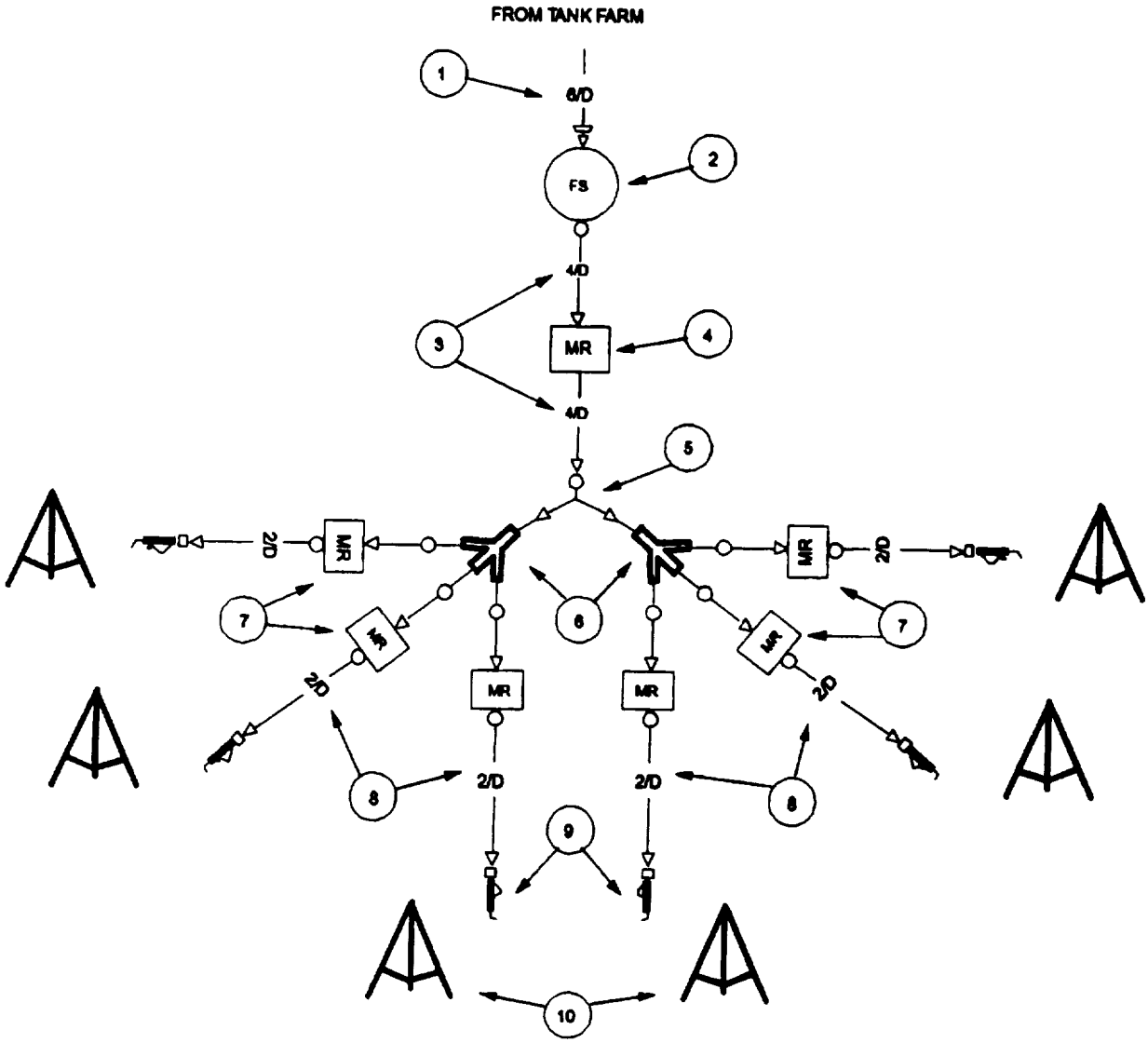


Figure 1-4. Booster Pump Assembly



1. HOSE ASSY, RUBBER, FUEL, SIZE 4 INCH X 50 FT LG
2. WYE CONNECTION ASSEMBLY, CAA
3. TANK, FABRIC, COLLAPSIBLE, 20,000 GALLON, WITH CHEST
4. HOSE ASSY, TYPE II, SIZE 9, 25 FT, CLASS 1, STYLE A, AL
5. WYE CONNECTION ASSEMBLY, ACC
6. REDUCER, 4 X 6, INCL. GASKET
7. PUMP AND ENGINE ASSY, 600 GPM, TRAILER-MOUNTED
8. VALVE ASSEMBLY, GATE, 4 INCH
9. MANIFOLD ASSEMBLY, SIZE 4 INCH
10. REDUCER, 6 X 4 INCL. GASKET

Figure 1-5. Tank Farm Assembly



1. HOSE ASSY, NONMETALLIC, SIZE 6 INCH X 50 FT LG
2. FILTER-SEPARATOR, LIQUID FUEL, 350 GPM
3. HOSE ASSY, NONMETALLIC, SIZE 4 INCH X 50 FT LG
4. METER ASSEMBLY, 3 INCH
5. WYE, QUICK DISCONNECT, TYPE CAA
6. MANIFOLD, DISPENSING
7. METER ASSEMBLY, 2 INCH
8. HOSE ASSY, NONMETALLIC, SIZE 2 INCH X 25 FT LG
9. NOZZLE, FUEL AND OIL SERVICING
10. STAND ASSEMBLY, FUEL

Figure 1-6. Fuel Dispensing Assembly

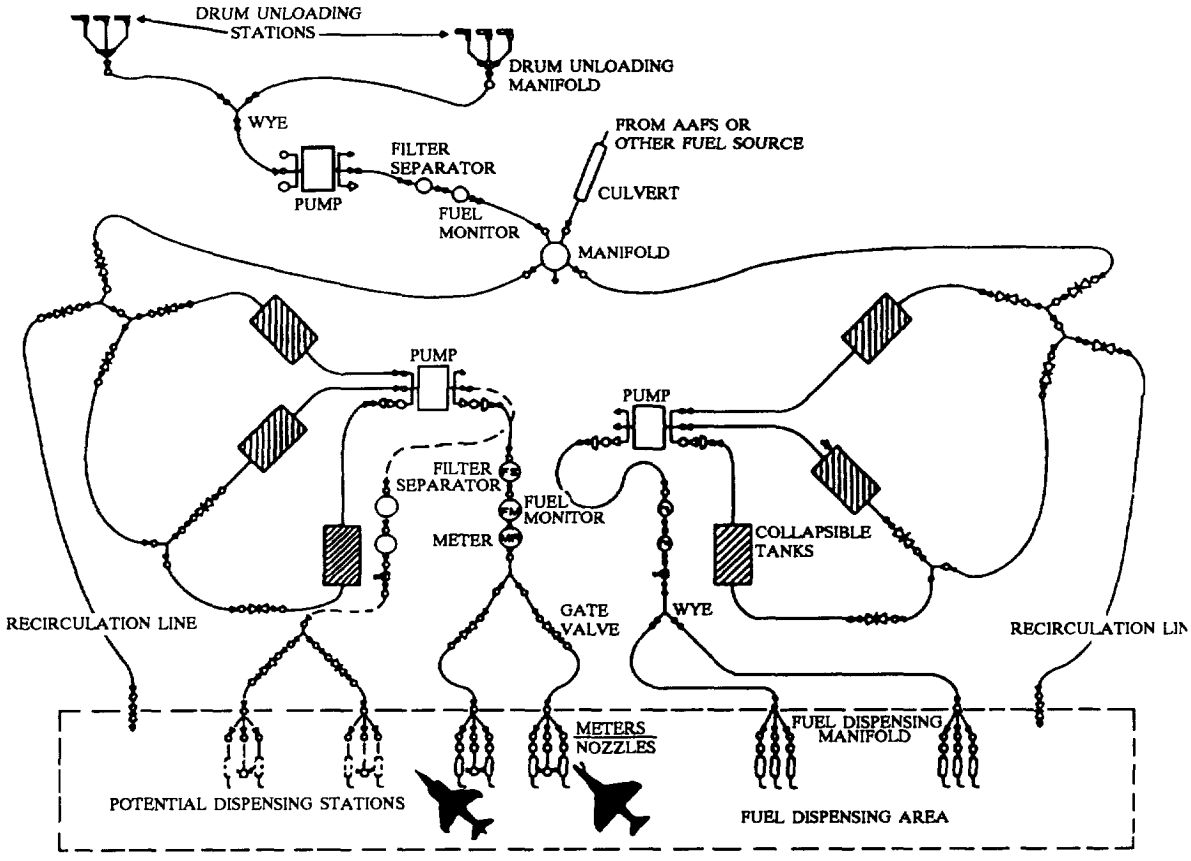


Figure 1-7. Tactical Airfield Fuel Dispensing System

1-4. TACTICAL AIRFIELD FUEL DISPENSING SYSTEM (TAFDS).

a. General. The TAFDS is a highly versatile system designed to receive, store, and dispense fuel in support of Marine Corps expeditionary airfields. It may receive fuel directly from an AAFS, or from virtually any other source within the theater of operations.

b. Description. The TAFDS closely resembles the AAFS, but on a somewhat smaller scale. Whereas the AAFS supports the overall requirements of the MAGTF, both air and ground, the TAFDS supports a specific tactical airfield requirement; hence its smaller size. Not withstanding these differences, however, the TAFDS is composed of the same basic components as the AAFS and therefore features the same flexibility of design. It can be employed as a whole, in part, or in conjunction with another TAFDS system, and it may be readily configured or reconfigured to meet a wide variety of aviation fuel dispensing requirements. Figure 1-7 depicts one possible TAFDS configuration.

c. Characteristics. The TAFDS is capable of receiving fuel directly from the AAFS or from other ground sources at rates up to 600 gpm. It is capable of simultaneously refueling up to 12 aircraft from separate refueling stations. Depending on the components assigned transfer rates will be from 350-600 gpm.

d. Capacity. The basic storage capacity of the TAFDS is 120,000 gallons stored in six 20,000-gallon tanks. Increased capacity may be obtained by the installation of an additional system or systems. As in the case of the AAFS, each system employed may contain only one type of fuel, and separate supply pipelines must be provided for each type.

e. Installation and Operation. Installation times will vary based upon local conditions and available support. Engineer site preparations will consume a majority of this time since component installation in prepared sites can be accomplished within hours of site completion. The time required to be operationally prepared to dispense fuel will be largely controlled by the Quality Surveillance Plan and will vary with the type product to be handled, the source of the product, etc.

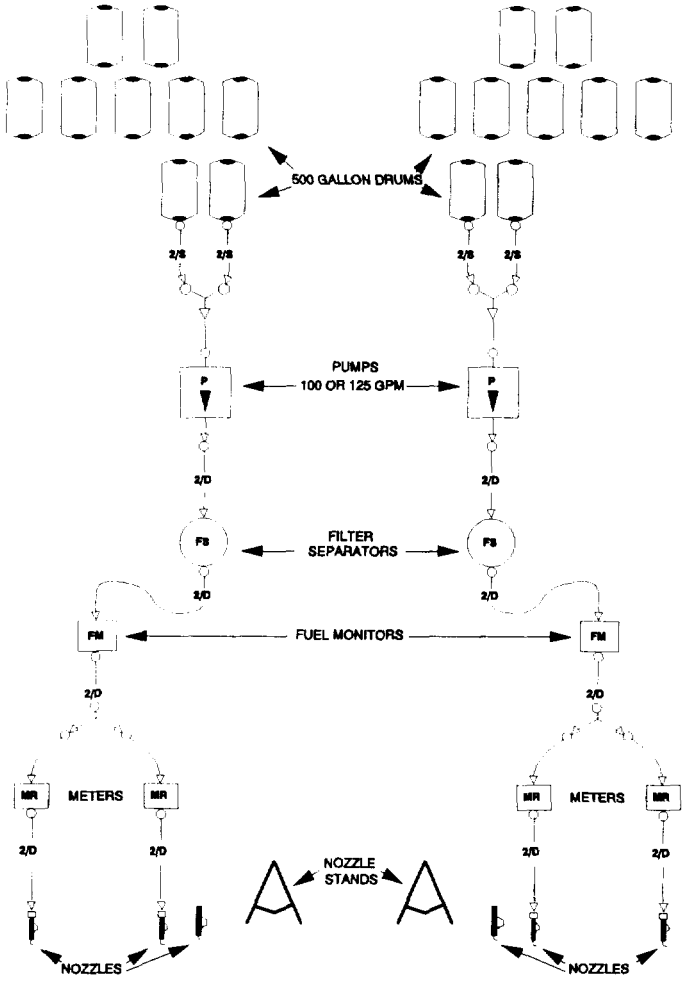


Figure 1-8. Helicopter Expedient Refueling System

1-5. HELICOPTER EXPEDIENT REFUELING SYSTEM (HERS).

a. General. The HERS is an expeditionary aircraft fuel dispensing system designed for use in forward areas, primarily for attack helicopters. The HERS is fully helicopter-transportable and can be inserted far forward in the battle area.

b. Description. To enhance its transportability, the HERS employs 500-gallon collapsible fuel drums and compact, skid-mounted pumps, filter-separators and monitors in place of the larger units used in AAFS and TAFDS. All other components, i.e., meters, hoses, fittings, etc., are essentially the same. Thus, the HERS can be rapidly installed, configured, or reconfigured to meet the specific tactical situation and requirement. Figure 1-8 depicts a typical HERS configuration.

c. Characteristics. The HERS is capable of receiving fuel from drums, tank trucks, or virtually any other ground source at rates up to 125 gpm. It is capable of simultaneously dispensing fuel to aircraft or containers from separate outlets at rates of 100 to 125 gpm depending on the equipment used.

d. Capacity. The HERS has a basic design capacity of 9,000 gallons stored in 18 collapsible 500-gallon drums.

e. Installation and Operation. Using common components with quick-disconnect cam-locking connectors and adapters, the HERS can be fully installed without special tools, enabling rapid setup upon insertion into the forward area.

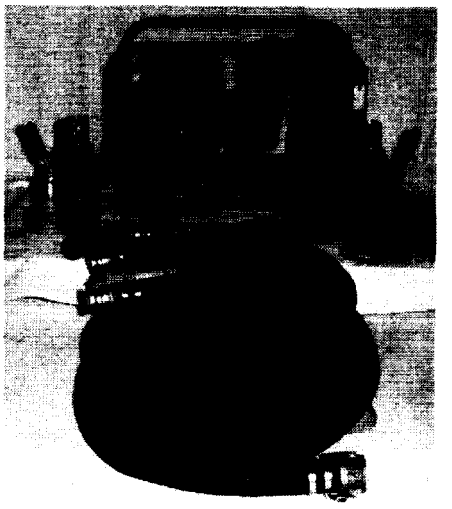


Figure 1-9. Expedient Refueler System

1-6. EXPEDIENT REFUELER SYSTEM (ERS).

a. General. The simplest of the Marine Corps bulk fuel dispensing systems, the ERS, figure 1-9, is a portable, compact, self-contained pump unit. It is used primarily for the expedient refueling of mechanized equipment in the field.

b. Description. The ERS is essentially a fuel transfer apparatus. It consists of a suction hose, a skid-mounted pump unit, and two discharge hoses with nozzles. All components are TFS common and are fitted with standard quick-disconnect cam-locking couplers. Depending on the model of pump employed, the ERS can deliver fuel continuously at rates of 100 to 125 gpm, dispensing from any source.

Section III. SYSTEM COMPONENTS

1-7. STORAGE CONTAINERS AND REPAIR KIT.

a. Collapsible Tanks. The AAFS and TAFDS employ 20,000-gallon capacity collapsible tanks, figure 1-10, as their primary fuel storage containers. Each tank is constructed of impregnated fabric and equipped with 4-inch elbow hose connections for receipt and issue, a vent assembly, and hand straps. A ground cloth fitted with hand straps is furnished with each tank; installed under the tank, it protects the tank from sharp rocks or other protrusions. An aluminum tank chest, figure 1-11, is provided to store and transport the collapsible tank, fittings, ground cloth, and an emergency repair kit. The chest is equipped with carrying handles, lifting hooks, towing eyes, and forklift cutouts.

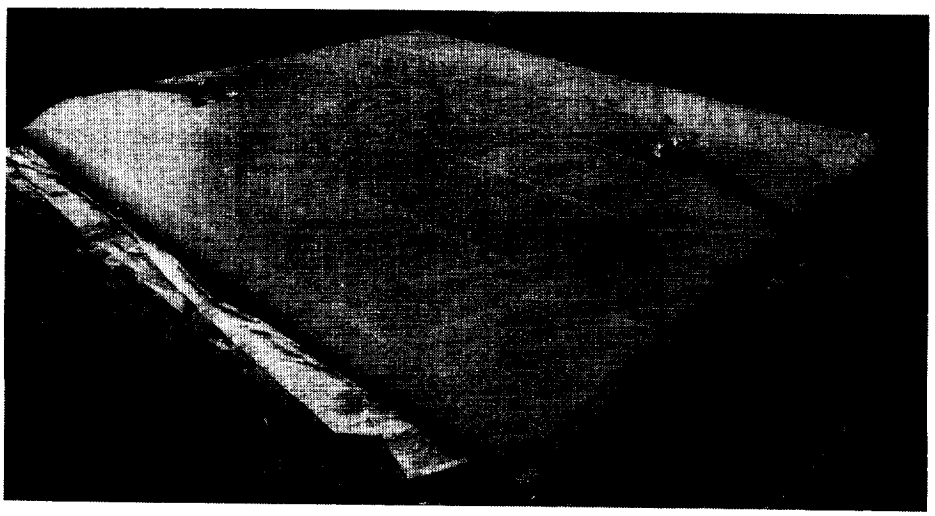


Figure 1-10. Collapsible Tank

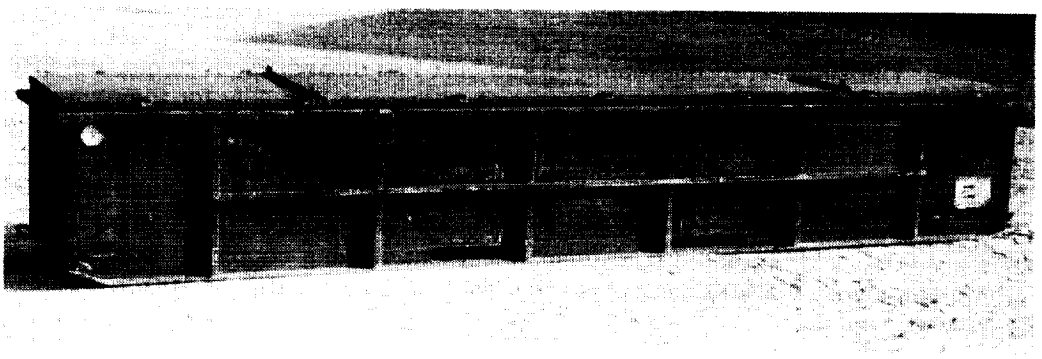


Figure 1-11. Tank Chest

b. Collapsible Fabric Drum. The 500-gallon capacity collapsible fabric drum, figure 1-12, is a durable, non-vented, hermetically sealed fuel storage container. It is a component of the HERS and normally used with the ERS. A towing and lifting yoke provides the means for towing the drum short distances. The 500-gallon drum has a TAMCN (B1570) when not a component of the HERS.

c. General Repair Kit. The general repair kit (GRK) contains spare parts, gaskets, gages and a limited number of tools for the routine maintenance, replacement and repair of individual components in the fuel systems. The kit is contained in three chests that are similar to, but smaller than, the tank chest. The kit also includes 4-inch and 6-inch hose evacuation kits.

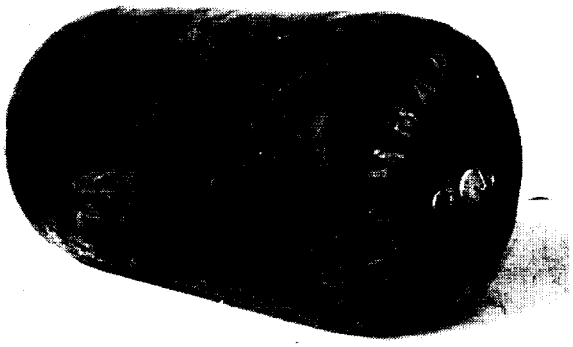


Figure 1-12. Collapsible Fabric Drum

1-8. PUMPS.

a. Description and Function. Self-priming, centrifugal pumps provide the means to move fuel within the fuel dispensing systems. The capacity of the system determines the size of the pump used: the AAFS utilizes a 600 gpm unit, figure 1-13; the TAFDS may use either a 600 or a 350 gpm pump, figure 1-14; the HERS is equipped with a 100 or a 125 gpm version, figures 1-15 and 1-16; and the ERS uses a 100 or 125 gpm pump. The two largest pumps are trailer-mounted.

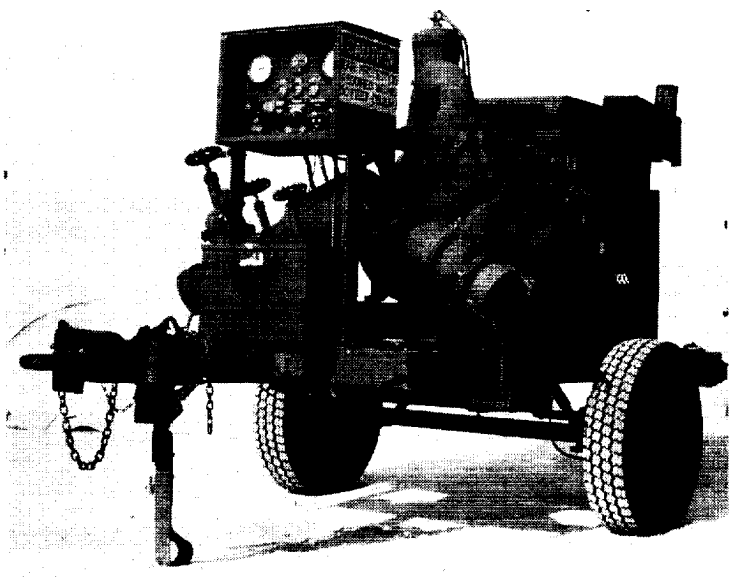


Figure 1-13. 600 gpm Pump

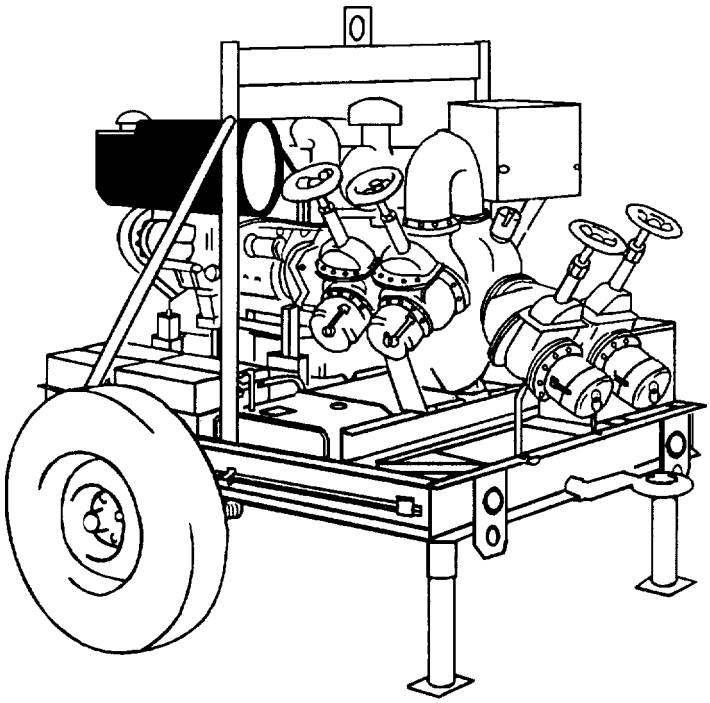


Figure 1-14. 350 gpm Pump

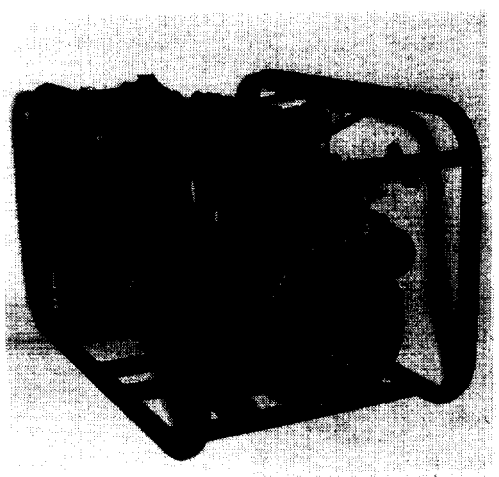


Figure 1-15. 100 gpm Pump

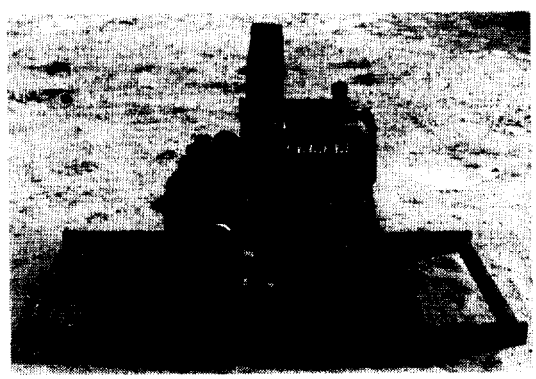


Figure 1-16. 125 gpm Pump

b. Theory of Operation. The central feature of a centrifugal pump is the impeller, a rotating disk with curved vanes which applies centrifugal force to the liquid being pumped. Liquid enters at the center of the impeller, called the eye, around the hub where the impeller is connected to the drive shaft. When the impeller rotates, the liquid is cast outward by centrifugal force and gains energy in the form of velocity. Liquid leaves the outer edge of the impeller and enters the volute, a spiral-shaped fixed casing. The cross-section of the volute increases as it approaches the discharge. As liquid passes into the larger portion of the cross-section, it loses speed, causing part of the energy of velocity to be converted to pressure. Concurrently, at the eye of the impeller, liquid has been displaced and an area of reduced pressure or vacuum is created so that new liquid continuously flows into the pump. The cycle continues as liquid is introduced into the suction port and expelled by centrifugal force through the discharge port. Typical sections showing the flow through the pump are shown in figure 1-17.

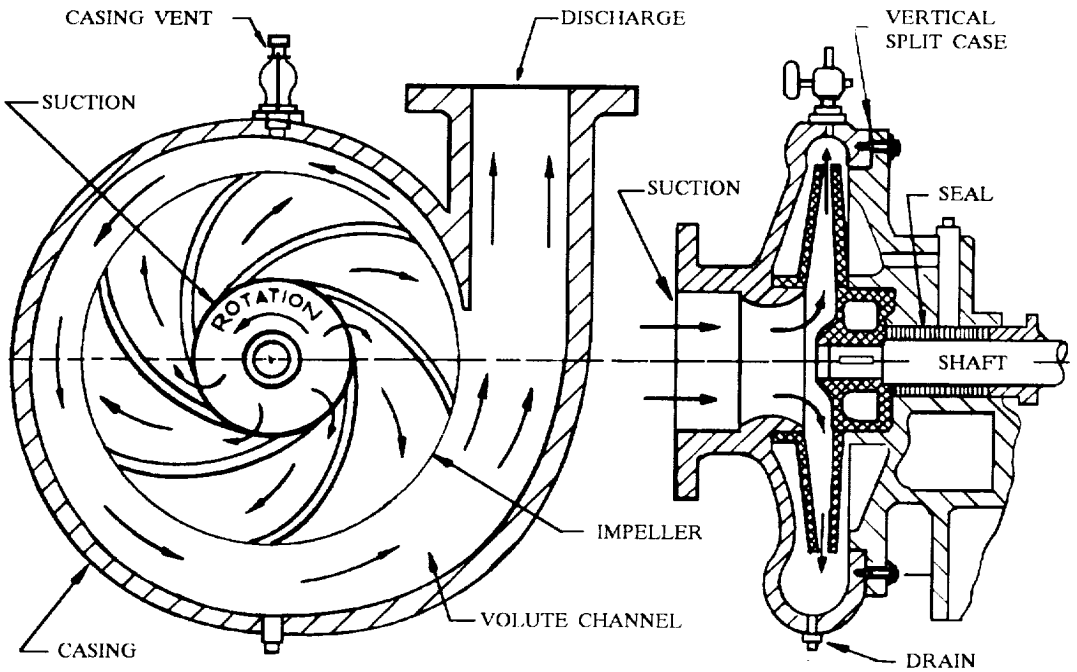


Figure 1-17. Schematic Flow Through Centrifugal Pump

(1) Three variables determine the height and distance that fuel may be pumped away from the unit: pump discharge pressure, the weight of the fuel per gallon, and the friction loss in the hose. The maximum height, or static head, and the maximum horizontal distance which fuel can be pumped must be computed to determine the appropriate placement of the pumps in the fuel delivery system. For further discussion of static head and friction loss, see paragraph 2-3.

(2) A centrifugal pump will not pump vapor, air, or other gases. For the pump to work properly, the impeller must be immersed in liquid. If the pump is drained dry or even partially dry, it must be primed and vented before it will start pumping again. This limits the use of centrifugal pumps to situations where there is always a wet suction. Some centrifugal pumps are equipped with automatic devices to make them self-priming.

(3) Each individual pump has its own performance curve similar to that shown in figure 1-18. The engine horsepower required to drive the pump varies with the weight of the liquid being pumped and the capacity or rate of pumping. To avoid overloading, the throttle control is adjusted

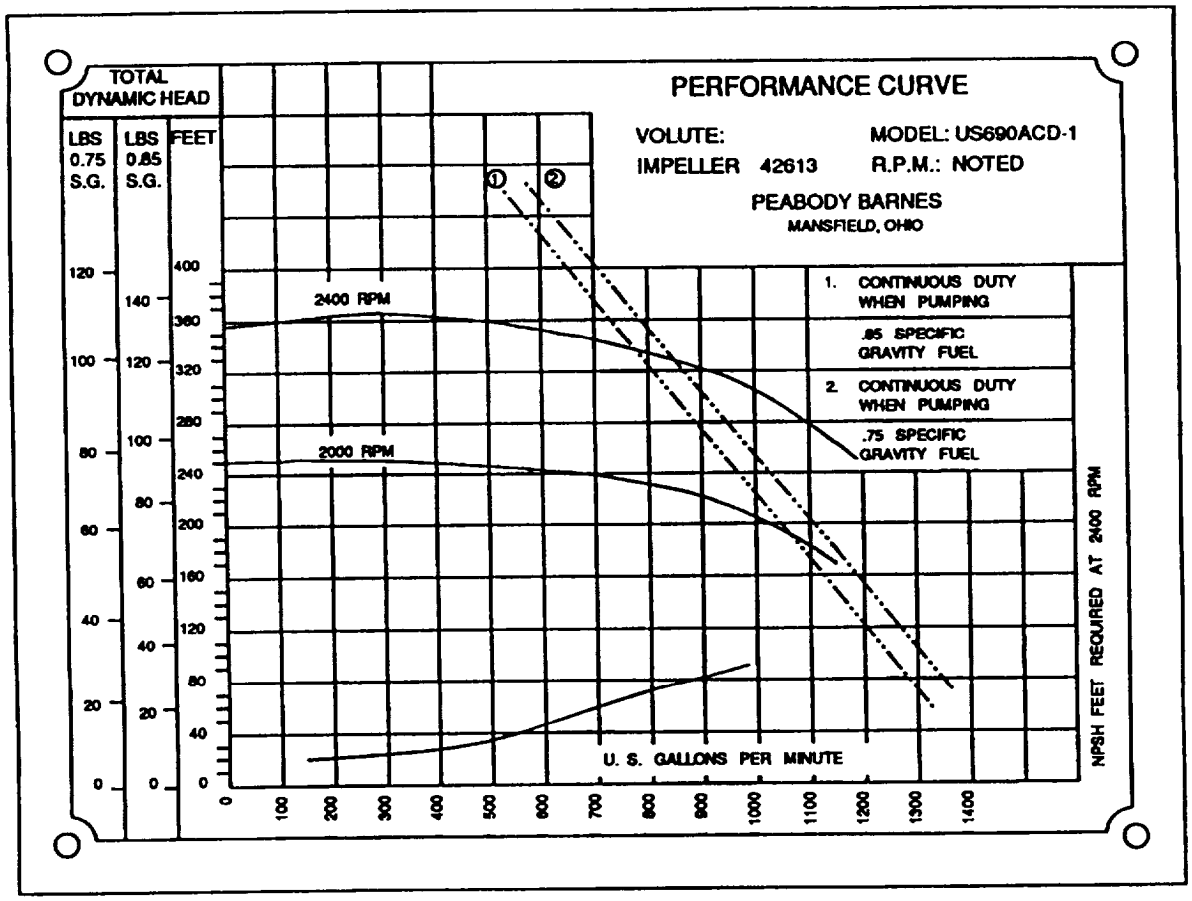


Figure 1-18. Pump Performance Curve, Model US690ACD-1

to maintain the desired flow rate determined from the pump performance curve. Pump capacities are shown in gpm. In the aforementioned illustration of the 600 gpm pump, discharge pressures are shown in pounds per square inch (psi) and feet of head for both 0.85 (DF-2) and 0.72 (JP-5) specific gravity fuels. Continuous duty limits (the ability of the pump to perform at maximum efficiency) are represented by lines 1 and 2 for these respective fuels, and the intermittent duty limit lying to the right and above line 2. Engine speed is presented in 200 revolutions per minute (rpm) increments from 1,400 rpm to 2,400 rpm (maximum governed speed). The pump and engine assembly will perform satisfactorily over a reasonable amount of time when operated within these limitations.

(4) Centrifugal pumps may be operated in parallel or in a series.

(a) When pumps are operated in parallel, discharge volume increases, but pressure remains the same. A parallel arrangement connects two pumps to the same discharge hoseline. When this done, the discharge capacity (volume) of the two pumps is twice that of one alone but the discharge head (pressure) is the same as one. If three pumps were used, the volume would triple, but the pressure would still remain the same. Figure 1-19 illustrates pumps operated in parallel. In order for this arrangement to work satisfactorily, the discharge heads of the pumps, as reflected in their performance curves, must be almost identical. If one has a higher discharge head than the other at a given capacity, the lower head pump will not deliver any product. This is

because the speed of the higher pressure fluid creates a wall-like barrier to the lower pressure stream at the point where the hoselines converge. A parallel configuration of pumps provides rapid refueling capability.

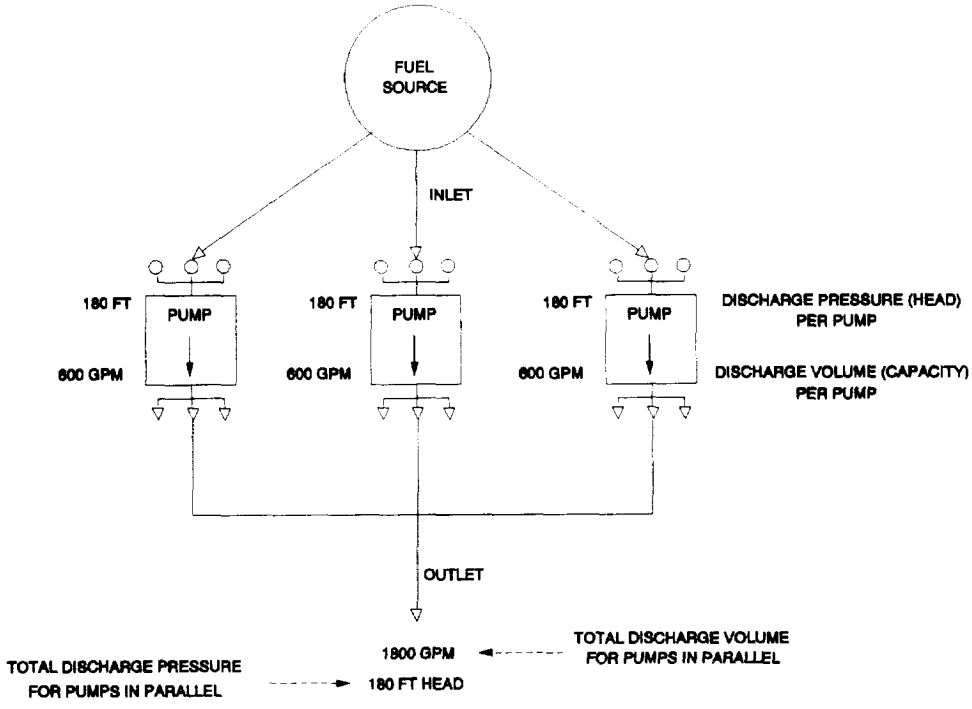


Figure 1-19. Pumps in Parallel

(b) When pumps are operated in a series, discharge pressure increases, but volume remains the same. In this arrangement, the discharge of the first pump is connected to the suction of the second as shown in figure 1-20. The discharge capacity is the same as one, but the discharge head is twice that of the first. This increased pressure may be employed to overcome an uphill grade. Pumps arranged in a serial configuration need not have identical discharge pressures as required in a parallel arrangement.

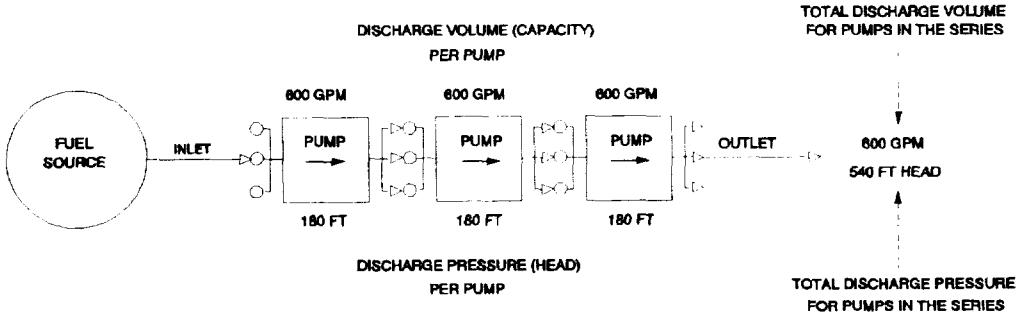


Figure 1-20. Pumps in a Series

1-9. FILTER-SEPARATORS.

a. Description and Function. The filter-separator, figure 1-21, is a skid-mounted, cylindrical, aluminum pressure vessel designed to remove solid contaminants and undissolved water from light petroleum products. The unit contains teflon coated screen-lined canisters. Fuel passes easily through the screen, but since teflon is water-repelling, it prevents small drops of water from escaping with the clean fuel. The canister surrounds an expendable filter coalescer element. An inner core of treated paper is often used for solids retention. Around this is wrapped layers of molded or loose mat form fiberglass. Another type of construction utilizes a perforated metal tube as an inner core wrapped with layers of fiberglass mats. A fabric sock covers the outer surface. Figure 1-22 shows a canister and a filter element.

WARNING

Filter-separators generate static electricity; to reduce the threat of fire, implementation of approved bonding and grounding procedures and other safety considerations is mandatory.

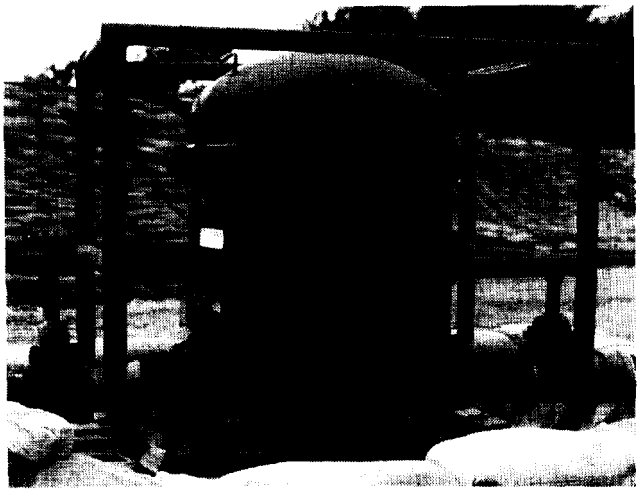


Figure 1-21. Filter-Separator

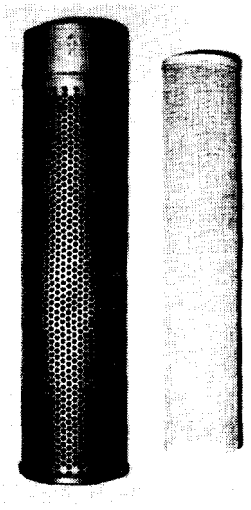


Figure 1-22. Canister and Filter Element

b. Theory of Operation. Emulsified water or solid contaminants present in the fuel are dispersed into finely divided particles by the sheering action of the high speed centrifugal pumps. The decontamination process of the filter-separator involves subjecting these particles to the physical and mechanical forces of coalescence and agglomeration. Coalescence means the merging of two water drops into a single larger drop. Physical details of the coalescence process are obscure, but the relative velocity of impact, the relative and absolute sizes of the colliding drops, electric charge of the drops, and external electric fields are believed to impact the process. Agglomeration is the process through which particles grow by collision with and assimilation of other particles. The filter coalescer element is the critical component of the filter-separator. It filters out all solid contaminants and coalesces and agglomerates finely dispersed water droplets into large drops which form on the exterior surface of the element and fall to the bottom of the vessel. Figure 1-23 provides a schematic view of fuel flow through the filter-separator.

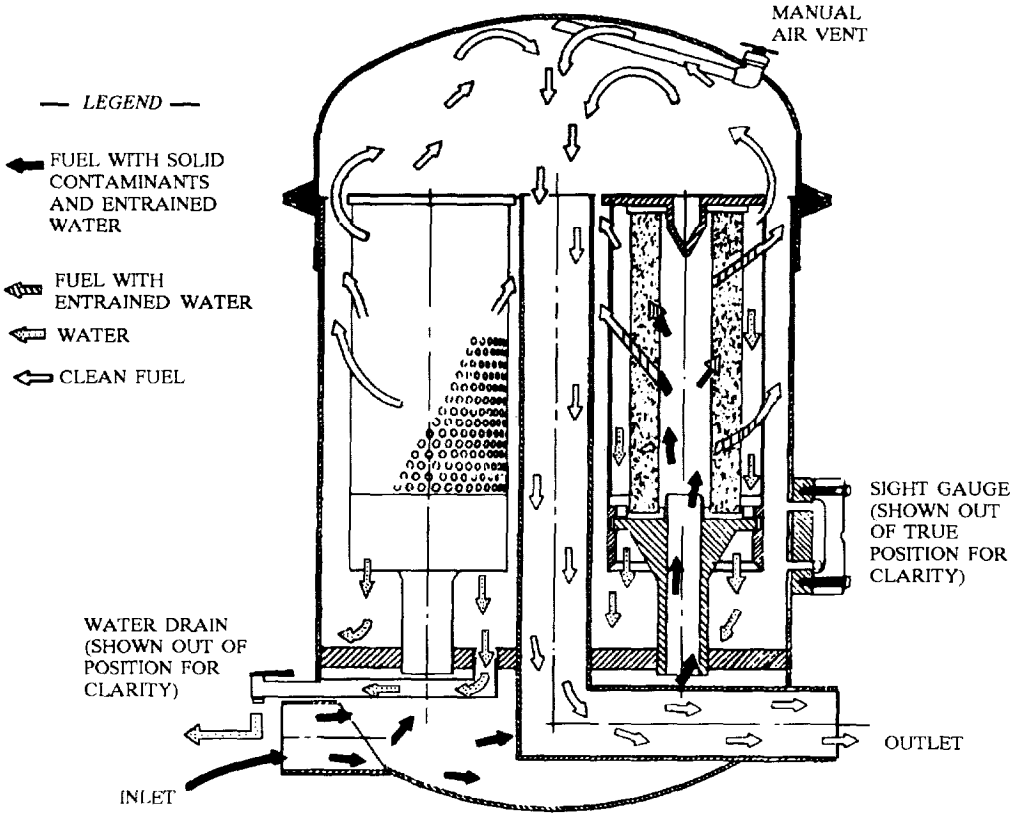


Figure 1-23. Schematic Flow Through the Filter-Separator

Fuel enters the vessel through the bottom inlet pipe and flows into the center tube of the expendable element. The fine particles of solids tend to agglomerate and are trapped in pores of pleated paper or fiberglass layers. The finely dispersed drops of water impinge on the glass fibers where they grow in size as other drops coalesce with them. These large drops are finally emitted at the downstream surface of the element, fall by gravity to the bottom of the vessel, and are removed through the drain. The number and size of the elements determine the design flow rate and pressure drop of the unit. As contaminants accumulate, the filter-separator responds to a pressure differential by reducing the flow rate. Additionally, a red button on the pressure differential indicator will pop up indicating the need to replace filter elements. A sudden, significant drop in pressure may indicate a filter rupture. Water coalesced in the decontamination process is drained by manually opening the drain valve at the bottom of the vessel.

1-10. FUEL MONITORS.

a. Description and Function. The fuel monitor, figure 1-24, is a portable unit containing filters, known as fuses, with special elements designed to reduce and eventually stop the flow of fuel when the amount of contaminants, either solids or water, exceed acceptable limits. It is installed downstream of the filter-separator.

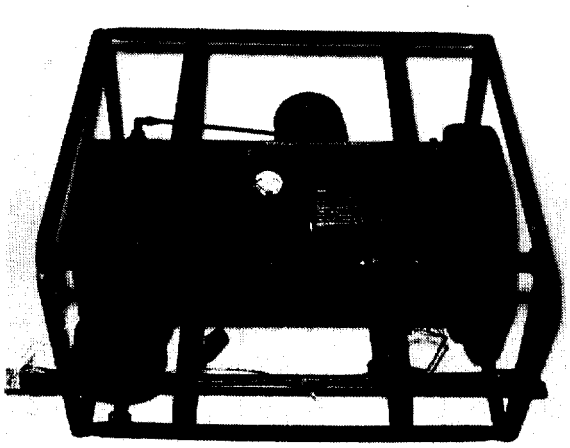


Figure 1-24. Fuel Monitor

b. Theory of Operation. In addition to warning the operator of excessive contamination by impeding the flow, the fuel monitor removes excessive contaminants from the fuel passed through it. Refer to the schematic drawing, figure 1-25. Two basic designs of fuses are manufactured for the fuel monitor: the absorbent type and the expansion type.

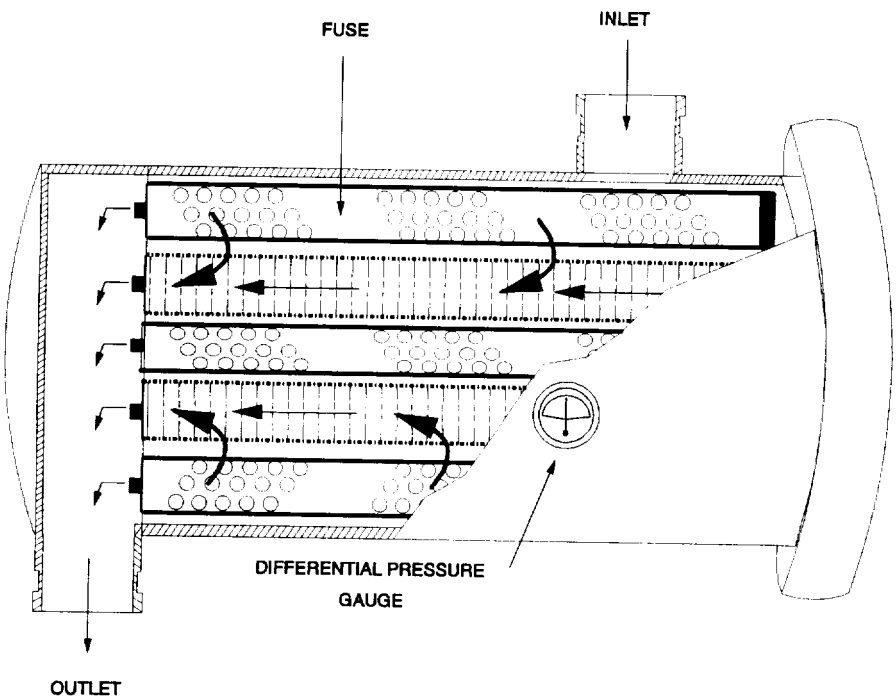


Figure 1-25. Schematic Flow Through the Fuel Monitor

(1) Absorbent Type. The absorbent type, the newest design, is composed of a cellulose media combined with cornstarch. This media is hydrophobic (has an affinity for water); it absorbs water and particulate but allows fuel to pass through. As water is absorbed and particulate are trapped, the media is transformed into a gelatinous type material which, when saturated, thickens and stops the flow of fuel.

(2) Expansion Type. A cylindrical stack of disks (wafers) with small clearances between them comprise the expansion type of filter elements. They function in one of two ways: rapid-closing or slow-closing. As solid and water contaminants expand the wafers in the rapid-closing design, a pressure differential is created, actuating a piston which immediately stops the flow of fuel, This design is the least acceptable due to the cavitation and stress created in the system by the sudden shutdown. The preferred type of expansion filter element is a slow-acting design. As the wafers collect water and particulate, they gradually expand, slowly closing off the flow of fuel.

1-11. METER ASSEMBLIES.

a. Description and Function. The meter assembly, a self-contained, skid-mounted unit, measures the amount of fuel delivered. The AAFS and TAFDS have 3-inch meter assemblies, figure 1-26, which register flow rates up to 650 gpm at 400 psi. The meter assembly is equipped with a visible register which has two seven-digit mechanical counters; one registers single operations and the other holds a cumulative total. The 2-inch meter assembly, figure 1-27, found in the AAFS, TAFDS, and HERS, registers to a maximum of 250 gpm at 225 psi. The 2-inch meter has one five-digit counter. Quick disconnect coupling halves allow 3-inch meters to accept 4-inch hose and 2-inch meters to accept 2-inch hose. A ground rod and wire are attached to the meter's skid.

b. Theory of Operation. The meter consists of a short section of pipe with a chamber housing a rotor. The rotor is driven by the flow of fuel; rotor speed is directly proportional to the total flow through the meter. A permanent magnet on the rotor shaft triggers the register's magnetic coupling, activating the digital counter. The meter is precalibrated. Meter calibration is discussed in chapter 3.

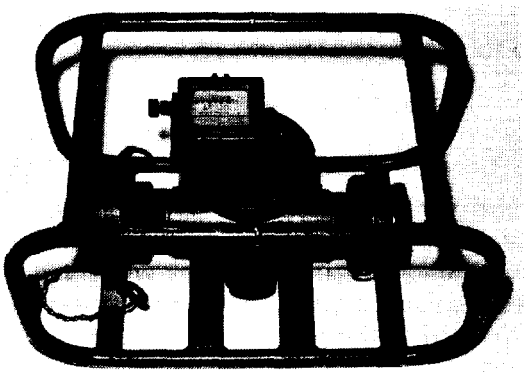


Figure 1-26. 3-inch Meter

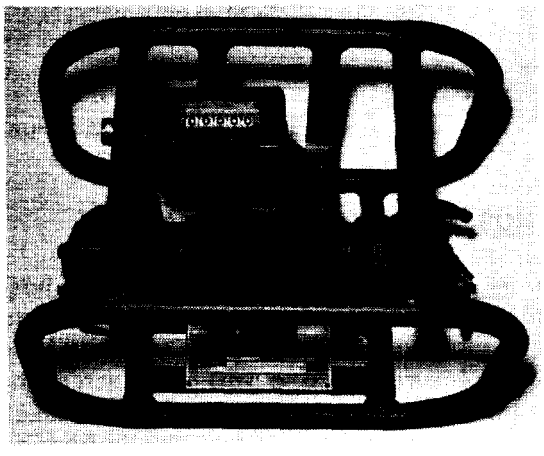


Figure 1-27. 2-inch Meter

1-12. FUEL PRESSURE REGULATOR.

a. Description and Function. The fuel pressure regulator, figure 1-28, is unique to the AAFS. This regulator consists of a diaphragm-activated hydraulic regulating valve equipped with quick disconnect fittings. Regulator units are employed to reduce fuel pressure to acceptable limits. Positioning of the pressure regulators within the system is discussed in detail in paragraph 2-3, d. When fuel lines must cross elevated terrain, the combination of pump pressure and gravity can cause excessive pressure buildup on a downhill slope. Even when the pumping operation stops, enough pressure is exerted by the fuel remaining in the line to warrant protective measures for the hose lines. This protection is provided by the pressure regulator. Its purpose is to limit fuel pressures within hose lines on downhill grades. The regulator has three controls and a pressure gauge.

b. Theory of Operation. Downstream pressure acts on the diaphragm in the reducing valve causing the flow through the ejector to vary in response to slight downstream pressure changes. This, in turn, causes the pressure in the regulating valve cover to vary, resulting in the corrective action of the valve to hold a constant downstream pressure. A flow control is placed between the reducing valve and the regulating valve to eliminate the pulsating effect caused by low pressure in the system.

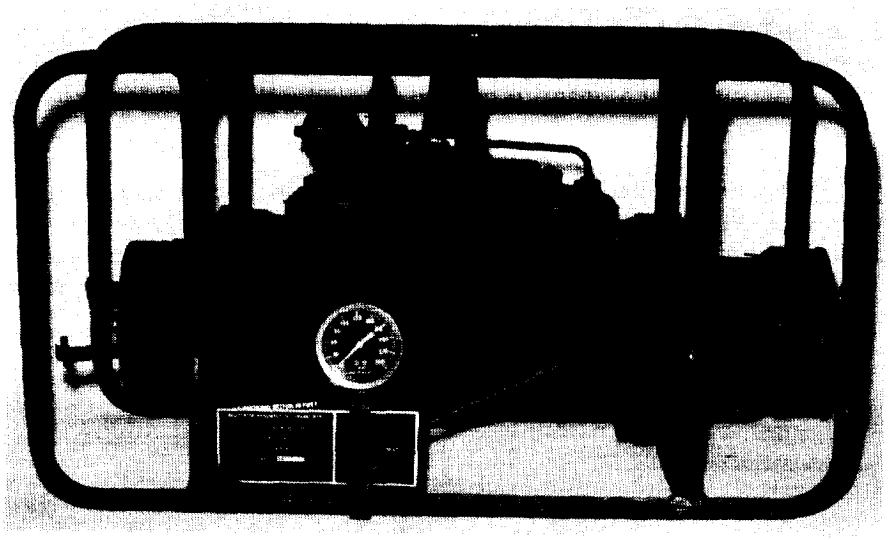


Figure 1-28. Fuel Pressure Regulator

1-13. HOSES, VALVES, AND STRAINER.

a. Hoses. Two types of hose, suction hose and discharge hose, are found in the system. Suction hose is wire reinforced to prevent collapse under high vacuum, and is not intended to withstand high positive pressure. Discharge hose will collapse under vacuum, but will withstand operating pressures of up to 150 psi. Each section of hose is equipped with a quick-disconnect adapter (male) at one end and a quick-disconnect coupler (female) at the other end. Refer to figure 1-29. The direction of fuel flow is from coupler to adapter. Each fitting is secured to the hose with stainless steel bands The adapter is inserted into the coupler and cam arm handles are

moved to a position flush with the hose. The cam action forces the adapter and coupler together against a gasket, forming a leakproof seal.

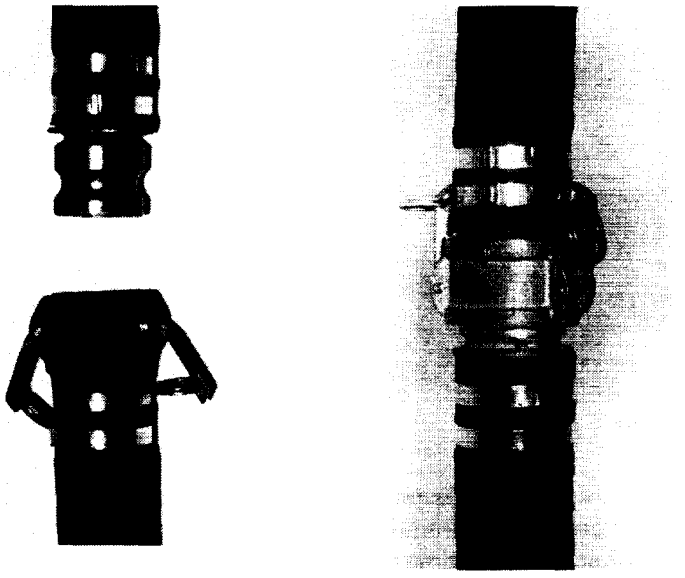


Figure 1-29. Hose With Quick-Disconnect Cam-Lock Fittings

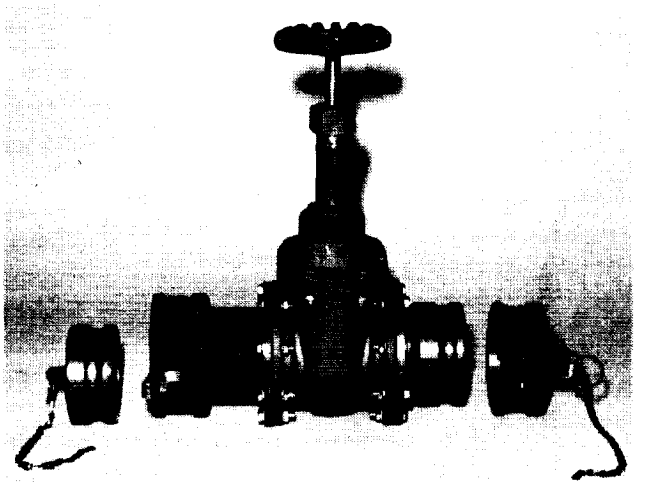


Figure 1-30. Gate Valve

Suction and discharge hoses are furnished in 2-inch and 4-inch sizes in both AAFS and TAFDS. In addition, the AAFS is furnished with 6-inch discharge hose. Table 1-1 provides hose specification data.

b. Valves. The hand-operated valves found throughout the system, figure 1-30, are of a standard rising-stem design and are made from anodized aluminum alloy. Four-inch gate valves with couplers and adapters are furnished with AAFS and TAFDS. The HERS is equipped with a 2-inch angle valve. These valves control the flow of fuel through the systems.

Table 1-1. Hose Specification Data

TYPE	MILITARY SPECIFICATION	SIZE (Inside Dimension) inches nom.	WORKING PRESSURE psi	BURST PRESSURE psi
Discharge	MIL-H-82127-08	2	100	400
	MIL-H-82127-11	4	150	600
	MIL-H-82127-32	6	150	600
Suction	MIL-H-370-B06	2	125	400
	MIL-H-370-B09	4	100	300

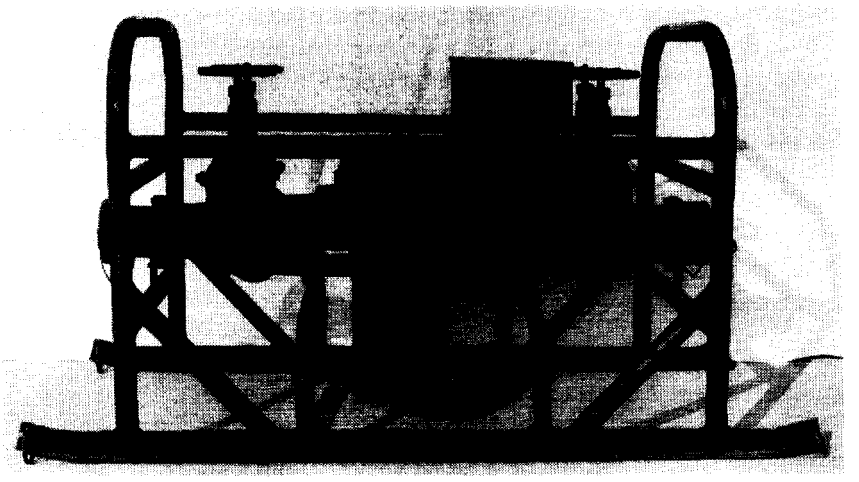


Figure 1-31. Strainer

c. Strainer. The 6-inch strainer, figure 1-31, is supplied as part of the beach unloading assembly of the AAFS. It consists of a steel outer case with a removable cover, a removable inner wire mesh strainer basket, and a bottom drain connection. Strainers remove large particles of foreign matter from fuels as they are pumped ashore. The design permits cleaning one side of the strainer while fuel continues to flow at a reduced rate on the other side.

1-14. MANIFOLDS AND FITTINGS.

a. General. Manifolds and fittings serve to redirect the flow of fuel and interconnect system parts directly with each other or through an adapter. The wide variety of manifolds supplied in the AAFS and TAFDS permits the systems to adapt to most situations and terrains.

b. Drum Unloading Manifold. The drum unloading manifold, figure 1-32, is used with the drum unloading valve, figure 1-33, to empty 55-gallon drums or 5-gallon cans into collapsible tanks. The drum unloading manifold has one 4-inch male adapter and three 2-inch female couplers.

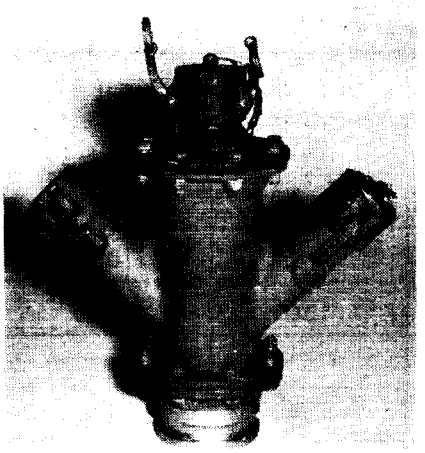


Figure 1-32 Drum Unloading Manifold

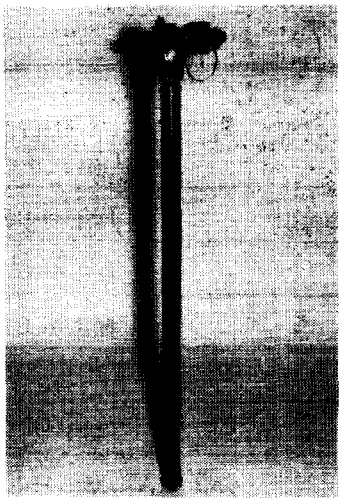


Figure 1-33. Drum Unloading Valve

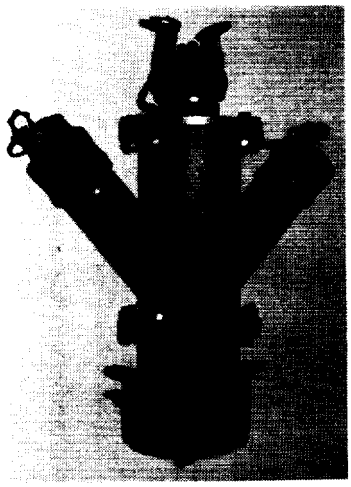


Figure 1-34. Fuel Dispensing Manifold

c. Fuel Dispensing Manifold. The fuel dispensing manifold, figure 1-34, connects a 4-inch discharge hose to three 2-inch discharge hoses. The fuel dispensing manifold thus has one 4-inch female coupler fitting and three 2-inch male adapter fittings.

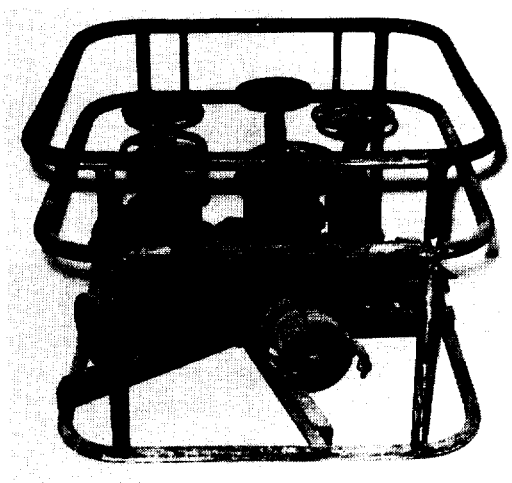


Figure 1-35. Skid-Mounted Manifold, 6-inch

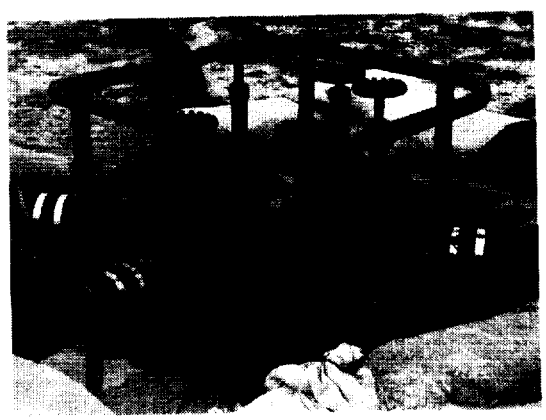


Figure 1-36. Skid-Mounted Manifold, 4-inch

d. Skid-Mounted Manifolds. The manifolds, figures 1-35 and 1-36, are the crossroads through which fuel is received and distributed in the tank farm. Two sizes of manifolds, 4-inch and 6-inch, are provided in AAFS, while only the 4-inch is used in TAFDS. The 6-inch manifold is equipped with two inlet and three discharge ports while the 4-inch unit has three inlet and three discharge ports. Flow through the ports is controlled by gate valves.

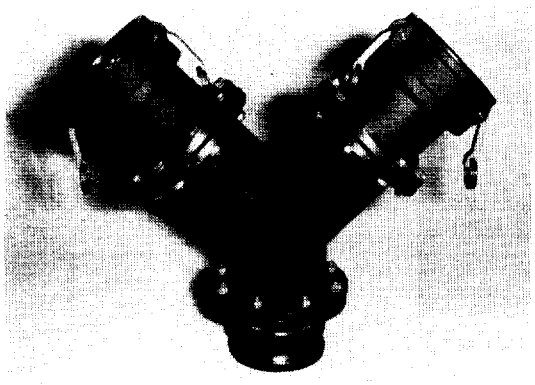


Figure 1-37. Wye ACC

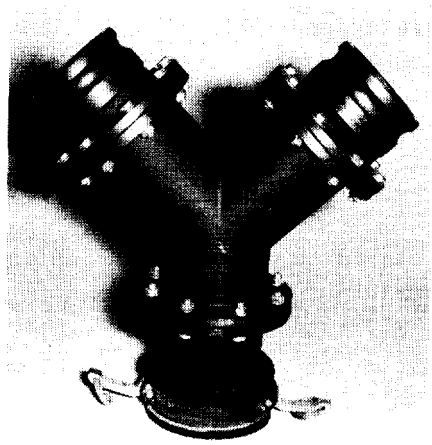


Figure 1-38. Wye, CAA

e. Wye Fittings. Wye fittings facilitate branching of the suction or discharge hose assemblies. Two types of wye fittings are provided to redirect fuel in the AAFS and TAFDS. One type has one 4-inch adapter and two 4-inch couplers (ACC), figure 1-37, and the other has one 4-inch coupler and two 4-inch adapters (CAA), figure 1-38.

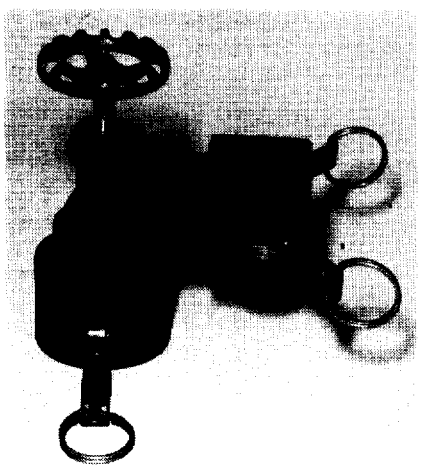


Figure 1-39. Elbow

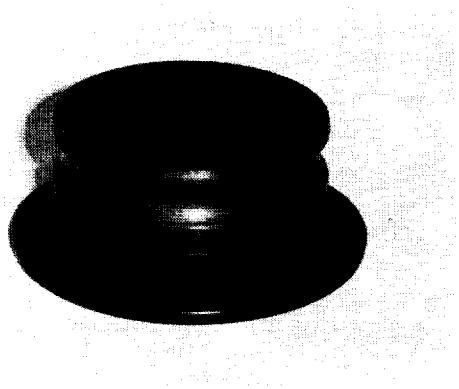


Figure 1-40. Flanged Adapter

f. Elbow. The AAFS has 2-inch 90-degree elbows, figure 1-39, with a coupler on one arm and an adapter on the other. An integral cast ring is on the outboard side of the angle. The elbow is designed to connect hoses used to fuel and defuel shuttle craft. When properly secured, it will prevent chafing and pinching of the hose.

g. Flaged Adapters. The AAFS is furnished with 4-inch and 6-inch quick-disconnect flanged adapters for connection to offshore fuel sources, figure 1-40.

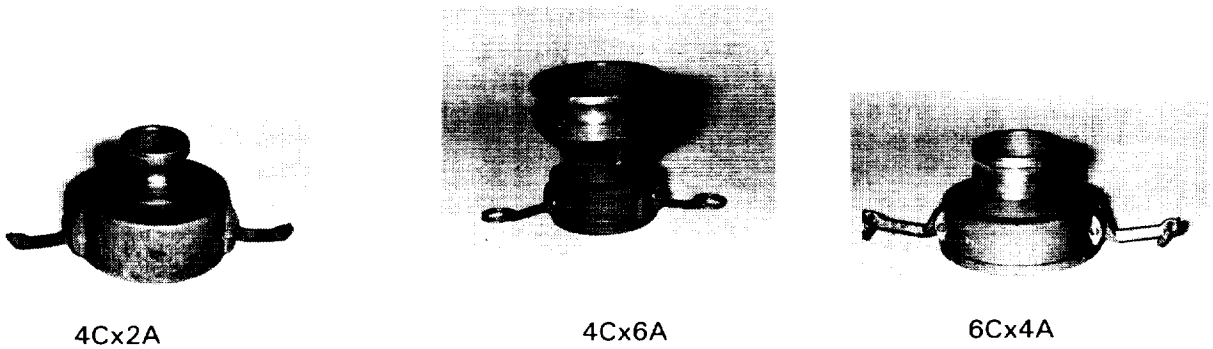


Figure 1-41. Reducers

h. Reducers. Reducers are used to connect hoses of different size. A 6Cx4A has a 6-inch coupler with a 4-inch adapter. A 4Cx6A has a 4-inch coupler with a 6-inch adapter. Another type, 4Cx2A, has a 4-inch coupler with a 2-inch adapter. Figure 1-41 illustrates these various reducers.

1-15. NOZZLES.

a. Pressure Fuel Servicing Nozzle, Locking. The 2-inch pressure fuel servicing nozzle, locking, figure 1-42, has a 2-inch male adapter quick-disconnect fitting for attachment to the hose. It is used in pressure-fueling (under wing) aircraft and in defueling. The 4-inch pressure-locking nozzle is used in defueling fuel-ferry craft and aircraft. It has a 4-inch male adapter quick-disconnect fitting for hose attachment. Specifications are found in MIL-N-5877.

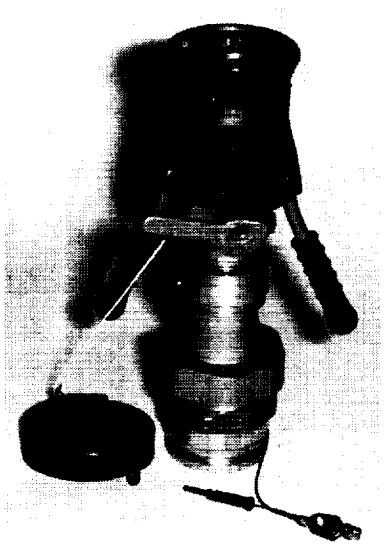


Figure 1-42. Pressure-Locking Nozzle

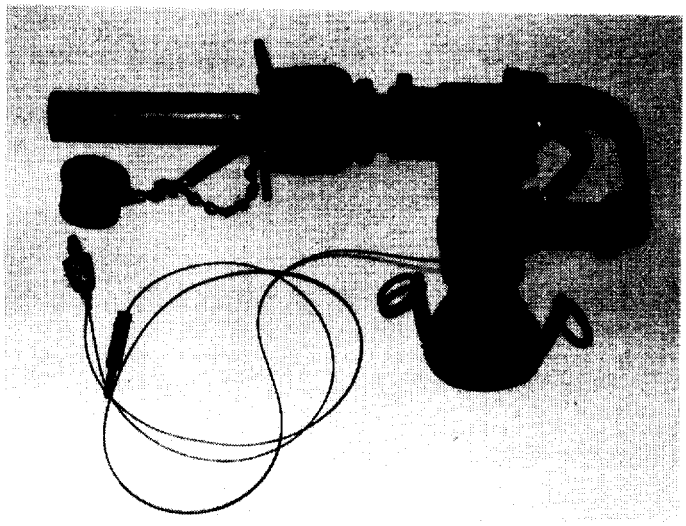


Figure 1-43. Fuel Servicing (Gravity) Nozzle

b. Fuel Servicing (Gravity) Nozzle. The fuel servicing nozzle, figure 1-43, is used to dispense fuel to vehicles, aircraft (overwing or gravity), and individual containers.

c. Nozzle Stand. The tripod nozzle stand is used at dispensing points to support the nozzle when not in use, figure 1-44.

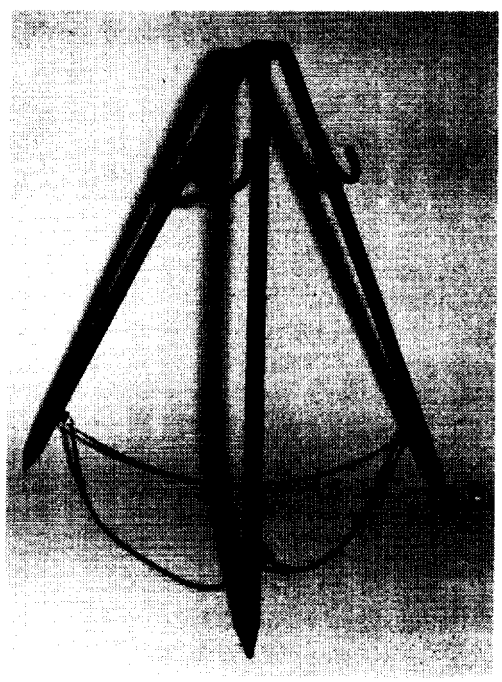


Figure 1-44. Nozzle Stand

CHAPTER 2

BULK FUEL OPERATIONS

Section I. PREPARATION FOR USE

2-1. PLANNING.

a. General. As with any other aspect of an amphibious operation, careful pre-D-day study and preparation are essential to the conduct of successful fuel operations. The key elements to be considered in fuel planning are fuel requirements, fuel procurement and source, fuel transportation, fuel storage requirements, fuel distribution, and quality surveillance. The information is general in nature and is meant to establish minimum requirements for any expeditionary fuel operation. Unless otherwise noted, these guidelines apply equally to all Tactical Fuel Systems (TFS). More detailed instructions on installation and operation are provided in succeeding chapters and in the references listed in Appendix A.

b. Planning Aids. A thorough study of the terrain to be occupied by the bulk fuel system must be made prior to installation. Since an actual ground reconnaissance will seldom be feasible until immediately before installation, planners will initially have to rely on contour maps, aerial photographs, detailed charts, and such intelligence studies as may be available on the area of operations. From contour maps and charts, planners will be able to determine the general trace of the TFS hose line; basic equipment requirements in terms of the amount of hose and number of booster stations needed; and the approximate location of beach unloading stations, booster stations, tank farms, and dispensing points. Aerial photographs will assist planners in refining map based estimates, and are particularly useful in the identification of routes and sites which will afford maximum concealment from enemy observation. With careful pre-landing planning, a ground reconnaissance immediately prior to installation will allow fuel handling personnel to quickly fix exact locations and routes.

c. Planning Considerations. In addition to selecting the most level and accessible routes available, planners should seek to take full advantage of natural cover and concealment such as bushes or trees. Where possible, hose lines should be located near and parallel to existing/planned roads or trails to facilitate transportation, assembly, inspection and maintenance of equipment. Routes along stream banks should generally be avoided because of the danger that localized flooding might disrupt the line. Similarly, hose lines should not be laid through ponds or marshes, but should pass over or around them on elevated routes to prevent added maintenance difficulties and fire hazards in the event of hose leaks. Finally, sufficient pipe culvert, sourced from Combat Engineers, should be available to bury hose segments that must cross roads or might otherwise be exposed to vehicle traffic. Consult FM 10-69 for additional information on hose line crossings of streams, gaps, and roads.

2-2. SITE SELECTION AND PREPARATION.

a. General. Of the numerous factors influencing the selection of a TFS site, the driving factor is mission requirements. That is, will the system be storing, transferring, and/or dispensing fuel; will it be operating as a complete assembly or as several geographically separated elements; and for what length of time will the system be in operation?

Other key factors include:

(1) Distance and elevation differences from the beach unloading unit or other fuel source to tank farms and dispensing points.

(2) Physical characteristics of the system that may require special terrain, space, or storage conditions.

(3) Construction work requirements.

b. Location. Ideally, sites for all fuel system components/assemblies should be selected so that minimum construction is required.

(1) Sea Unloading Area. Since the bulk of fuel and fuel handling equipment will initially be seaborne in an amphibious operation, prime consideration must be given to the location of the sea unloading area. If possible, a sheltered cove or beach area should be chosen so that fueling ships and craft may be clear of heavy seas. This will facilitate both the unloading of tankers and the movement of fueling system components during the ship-to-shore phase. Areas with heavy surf or dangerous reefs should obviously be avoided.

(2) Beach Unloading Area. This area should be located in a relatively clear section of the beach so that amphibious shuttle craft may unload at the beach unloading station with ease. Terrain must allow LST-type craft to beach/land with minimum hazard for fuel unloading and supply operations. Rough beaches should be avoided to preclude difficulties in maneuvering fuel vehicles. Finally, the site should be located on the downwind, downstream flank of the main landing area in order to:

(a) Decrease the threat to the overall operation in the event of a major fuel leak or spill.

(b) Minimize traffic congestion at the unloading point which could hamper either the main landing or general fueling operations.

(c) Take advantage of the reduced danger of accidental ignition and the greater concealment possible in a flank area.

(3) Transfer Lines. Hose transfer lines should be laid out along a course that provides the maximum possible concealment. This benefit will be lost unless a minimum disturbance of natural cover is effected. Hose must be laid around large obstructions such as boulders, trees, and heavy brush. Major obstacles such as steep cliffs or deep ravines should be avoided whenever possible. Flowing streams should be crossed using existing bridges. If none is available, simple suspension devices should be constructed. If hillside or valley locations are possible, the hose line route will be less obvious. Adjacent woody areas and hilly sections will provide a natural background reducing the possibility of successful air attack. If lines must cross barren or desert areas, the hose may be covered with a thin layer of sand or dirt as long as the surrounding color and contour of the ground are not obviously disturbed.

(4) Storage Tanks. Speed is essential in the construction of storage tank facilities and thus every effort has been made to provide easily and quickly assembled equipment and material. In keeping with this objective, grading for a station area should be kept to a minimum. The area selected should be as level as possible and of sufficient size to accommodate all of the station's equipment on the same plane. In cases where selection of a hillside location is necessary, a pocket

or bench area of sufficient size to accommodate all equipment is most desirable. This area should be graded so that all equipment may be installed on the same plane.

2-3. SYSTEM DESIGN AND LAYOUT.

a. General. Figure 2-1 depicts a typical fuel system as plotted on a contour map. Point A represents the fuel source, in this case a beach unloading site. Point B represents the final storage/dispensing site. The requirement for intermediate booster station site C in this example, is largely a function of the distance between A and B, and the exact nature or relief of the intervening terrain.

b. Static Head and Friction Loss. Three variables determine the height and distance that fuel may be pumped in a tactical fuel system. These are pump discharge pressure; the weight of the product; and the friction loss in the hoseline.

(1) Static Head. For a particular fuel at a given pump discharge pressure, there is a maximum height to which product can be pumped. This is known as the "static head". Static head is computed using the following formula:

$$\text{Static Head (ft)} = \frac{2.31 \text{ X Pump Pressure (PSI)}}{\text{Specific gravity of product}}$$

OR

$$\text{Static Head (ft)} = \frac{\text{pump pressure (psi) x 19.25}}{\text{weight of product (lb/gal)}}$$

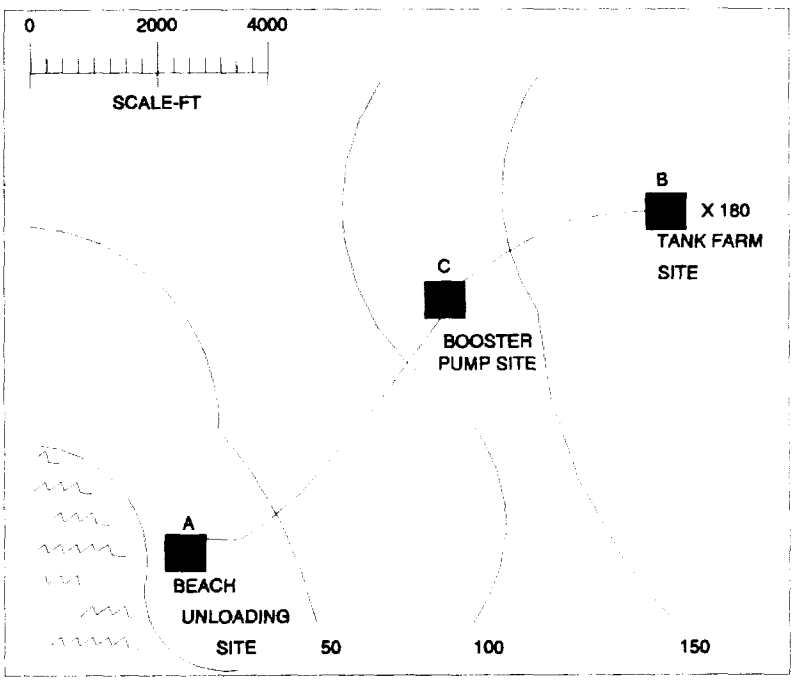


Figure 2-1. Hose Line Plot on Contour Map

If the elevation differential between points A and B exceeds the static head for the particular fuel and pump type being used, then one or more booster stations will be required to move the product from the fuel source to the storage/dispensing point.

(2) Friction Loss. The maximum horizontal distance that fuel can be pumped is a function of pump discharge pressure (psi) and the hoseline internal resistance to fuel flow. This internal resistance factor is known as "friction loss." To calculate maximum horizontal pumping distance, use the following formula:

$$\text{Distance (thousands of ft)} = \frac{\text{pump pressure (psi)}}{\text{friction loss (psi per 1000 ft)}}$$

Friction loss per thousand feet is a function of hose size, internal hose linear roughness, viscosity of the product being pumped, and the velocity of the product in the hose. However, utilizing a standard design criteria of 6 inch, 600 gallons per minute, DF-2 fuel with a specific gravity of .8496 and a friction factor of .22, will provide a useable, conservative estimate for planning purposes. Using the above factors results in a friction loss of 32 ft/head or 12 psi per 1000 ft of hose. For more detail on determining friction loss refer to Department of the Army TM 5-343.

(3) Static Head vs. Friction Loss. Since static head and friction loss impact a system's ability to pump product, their combined impact must be calculated. This is most easily accomplished by constructing a Static Head/Friction Loss graph. Utilizing the specific gravity of the fuel being pumped (e.g., DF-2; .8496 SG) and the static head formula, compute static head values for common pump pressures. Next, using a friction loss value of .012 and the distance formula provided, find the maximum horizontal distances for each common pump pressure. Record the results as in table 2-1.

Table 2-1. Static Head and Horizontal Distance at Varying Pump Discharge Pressure: DF-2 at .8496 SG

Pump Pressure (psi)	Static Head (feet)	Horizontal Distance (feet)
125	340	10,416
120	326	10,000
110	299	9,167
100	272	8,333
90	245	7,500
80	218	6,667
70	190	5,833
60	163	5,000

Using any convenient scale, construct a graph with static head values recorded on the vertical scale (ordinate) and distance values on the horizontal scale (abscissa). Connect the corresponding points for each value of pump discharge pressure and label accordingly. The result will be a graph similar to figure 2-2. A dual scale of pressure (inner scale) may be added to the vertical static head scale to make interpolation easier.

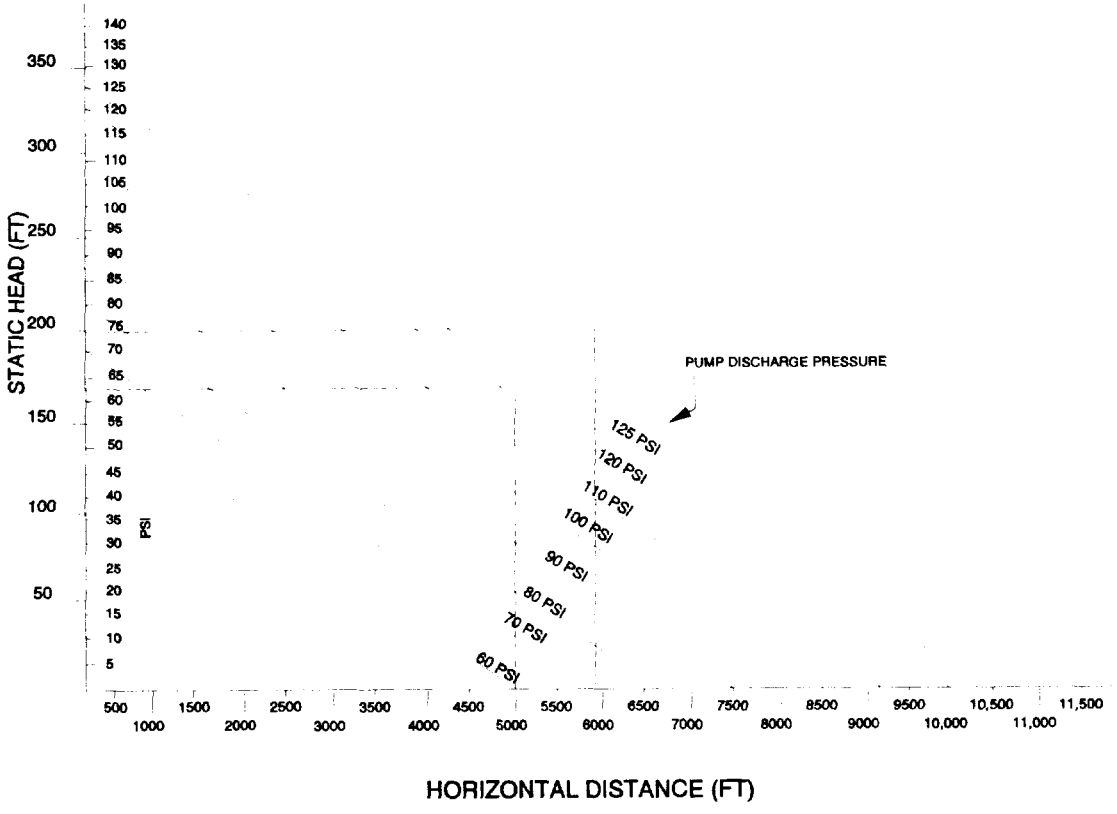


Figure 2-2. Static Head and Horizontal Distance at Varying Pump Pressures; DF-2 at .8496 sq. 12 PSI or 32 FT of l-lead Loss per 1000 FT Horizontal Distance.

The data in table 2-1 and the graph, figure 2-2, are correct only if the fuel being pumped has a specific gravity of .8496 pounds per gallon. Graphs may be constructed for fuels of various specific gravities with the only difference being the slope of the pump pressure lines. Using these

lines, the pump pressure required to reach any given elevation can be determined. Similarly, for a given elevation, the maximum hose length for a given pressure can be determined.

(4) The most important element in the actual design of a military hoseline system is that of pumping station spacing. Basically, the spacing is determined by the hydraulic design, that is, by the head loss in the hoseline for reasons of friction and elevation when the hoseline is operating at the normal capacity are spaced closer. On level terrain, spacing is wider. Where the lines runs downhill, the spacing is widest. That the distance between stations are not equal is of no consequence. The important factor is that all stations are in balance hydraulically. That is to say that each station in the system must have the same workload to perform.

a. Positioning Booster Pump Stations. In determining the number and location of booster pump stations required in any scenario, use the largest scale contour map available to plot the location of the beach unloading station, the tank farm(s), and the hose line route between them. Note the elevation of the tank farm(s) in relation to the fuel source, and determine the length of the hose line required by measuring the horizontal map distance. Figure 2-1 depicts a typical fuel system as plotted on a contour map. Point A represents the fuel source, in this case a beach unloading site. Point B represents the final storage or dispensing site. Note that approximately 10,000 feet of hose will be required to reach from the beach, point A, elevation 0 feet, to the tank farm, point B, elevation 180 feet. By entering the graph, Figure 2-2, at 180 feet on the vertical scale and moving horizontally to 125 PSI line, then moving down to the horizontal distance scale, shows that the fuel can be pumped approximately 5,900 feet horizontally while being lifted 180 feet. Therefore, one or more booster stations will be required. Using trial and error and the contour map determine the maximum distance the fuel can be pumped and overcome the elevation. Using Figure 2-2, the fuel can be pumped to an elevation of 125 feet with a horizontal distance of approximately 7,300 feet. The contour map, figure 2-1, shows that at an elevation of 125 feet, the horizontal distance is approximately 6,000 feet. This area, point C, is the best location to place the first booster station. The extra head or psi available allows some flexibility in the exact placing of the booster station so you can select the best terrain in the area. It also allows for the required head or psi to be available at the suction port of the booster station. The lift of 55 feet from the first booster station to the tank farm requires 4,000 feet of travel through the hose. From the graph, you can see that the pump can easily handle this distance and lift. The graph can also be used to show at what PSI the booster station needs to operate in order to overcome the elevation and distance required. In this case 60 psi will overcome the 55 feet elevation and the 4,000 feet distance.

b. Positioning Pressure Regulators. When hose lines must follow a downhill path, static pressures can exceed friction loss when fuel is flowing, or can even become excessive under no-flow conditions. In these situations, pressure regulators are used to protect the hose. They can be positioned by again using the relationship between static head and friction loss as was done with the booster stations. Regulators are normally positioned at a pressure differential of 85 psi, and are adjusted to reduce the pressure on the downstream side to 20 psi. To find the pressure at any given point in the hose line, use the following equation:

$$P_x = P_p - (P_e + P_f) + P_d$$

Where:

P_x = pressure at any point (x)
P_p = pump discharge pressure
P_e = pressure reduction due to increase in elevation (static head pressure)
P_f = pressure reduction due to friction loss
P_d = pressure increase due to decrease in elevation

Pp is self-explanatory. The sum of Pe plus Pf can be found by entering the graph (figure 2-2) with the elevation and hose length, and interpolating as necessary to find the corresponding pressure. For example, to find the pressure corresponding to an elevation of 150 feet and a hose length of 1,200 feet, find 150 feet static head on the vertical scale and move to the right until this value intersects a vertical line drawn through the hose length of 1,200 feet on the horizontal scale. The intersection (x) represents a pressure of 90 psi. The value of Pd can be found by interpolating along the vertical scale of the pressure resulting from a static head equal to the decrease in elevation. In practice, however, it may be easier and more practical to adjust the pump discharge pressure so that hose pressure at the start of the downhill slope is nearly zero. Then, since Pp and Pe are zero for all practical purposes, the pressure at any given downhill point can be computed using the simplified equation:

$$P_x = P_d - P_f$$

2-4. INSTALLATION.

a. General. While site preparation is under way, components should be moved to their approximate final locations, uncrated, and checked for readiness. The TFS offers potentially unlimited design configurations; installation requirements are tailored to match terrain features and operational needs. The following paragraphs provide a theoretical guide to the installation of the TFS subsystems. Keep in mind that the ideal arrangement of components will ensure the prudent management of assets, take into consideration the available layout, and follow basic safety and quality surveillance procedures.

b. Beach Unloading Site. The beach unloading site begins at the beach end of the offshore line from tankers, or where tanker craft are beached, The area must be large enough to accommodate a variety of amphibious vehicles, and should be downwind and downcurrent of the main landing area. Since the initial load or purge of product from each new source or through each new hose line is likely to contain a high concentration of contaminants, the beach unloading site should contain a special sump or storage tank designated for this purpose. Fuel is channeled into this sump until it runs clean and can be rechanneled to general storage. Using an extra storage tank to receive the initial surge is the safer, more economical method since it allows fuel to be returned to the system after the contaminants have settled out. Figure 2-3 shows one method of installing a sump at the beach unloading station.

c. Storage Tank. Collapsible storage tanks should be located on relatively level ground with good drainage, and away from depressed or low-lying areas where fuel vapors can collect to create a fire hazard. Each tank must be installed within its own protective berm or firewall. These berms are designed to: (1) contain the product in the event of a tank rupture or failure; (2) isolate/insulate the tank in the event of a fire in an adjacent container; and (3) provide a measure of Protection from direct small arms fire.

(1) The tank berm, figure 2-4, must be of sufficient size to contain a minimum of 150 percent of the contents of a completely filled container. Generally, the berm is formed by removing enough earth from an area to accommodate the size of the tank and by using the removed earth to build up the surrounding walls to a recommended height of at least 5 feet when possible. The type of construction depends upon site conditions and available materials. To provide an effective repose slope, the height of the berm and the thickness at the base will vary with the construction material used. The inside walls and floor of the berm should be smooth to prevent damage to the tank. Additionally, impervious construction may be required due the proximity of an encampment or for environmental considerations, When using a berm liner due to environmental requirements, berms should be constructed to accommodate the specific berm liner dimensions to be utilized.

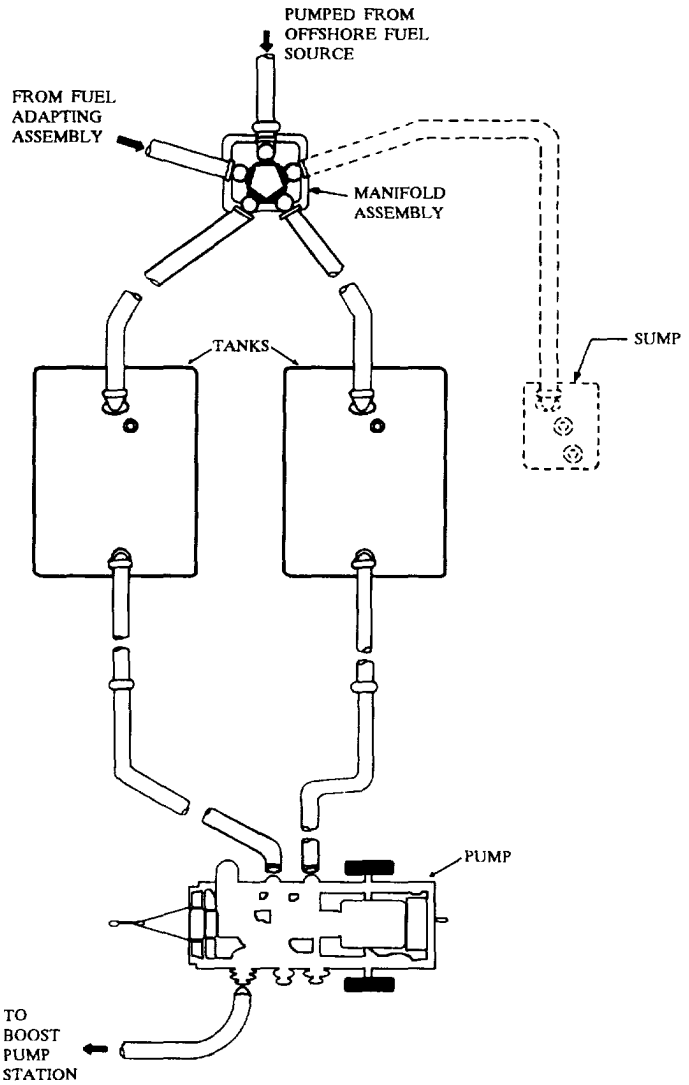


Figure 2-3. Beach Unloading Station with Sump

(2) If the soil does not drain well or the berm is impervious, a drain should be installed to remove surface water. One method is to use a length of noncollapsible suction hose to run under the berm and into an outside sump or drainage ditch as shown in figure 2-5. The buried portion of the drain must be below the level of the berm floor, and the outlet end of the drain hose should have a valve installed. This will permit the flow of fuel or other products to be shut off in the event of a tank rupture. If impervious construction is employed, alternative methods of drainage may provide a variety of water/fuel/mix recovery methods. One such method would provide recovery to an adjacent tank.

(3) A common method of construction is depicted in figure 2-4. An area approximating the size of a filled storage tank plus a footpath width is staked off, Engineers tape is strung an additional 5 feet outside the perimeter of this area, marking the berm's base. The sides of the berm are formed by either pushing earth with a bulldozer, as illustrated in figure 2-4, or hauling in

earth with a scoop loader. Various configurations are possible. Although commonly pictured as rectangular in shape, the general outline of a berm may take on any form. For example, an irregular shape or design may be dictated by available space considerations. Likewise, existing terrain conditions may alter the means of construction such as when soil and/or other materials must be brought in to permit berm construction in bedrock areas. Engineer support may employ a variety of solutions tailored to a given situation; expediency is of primary importance in a tactical situation. Precise configurations and methods of construction are immaterial, as long as the resulting structure provides the essential functions of containment and protection.

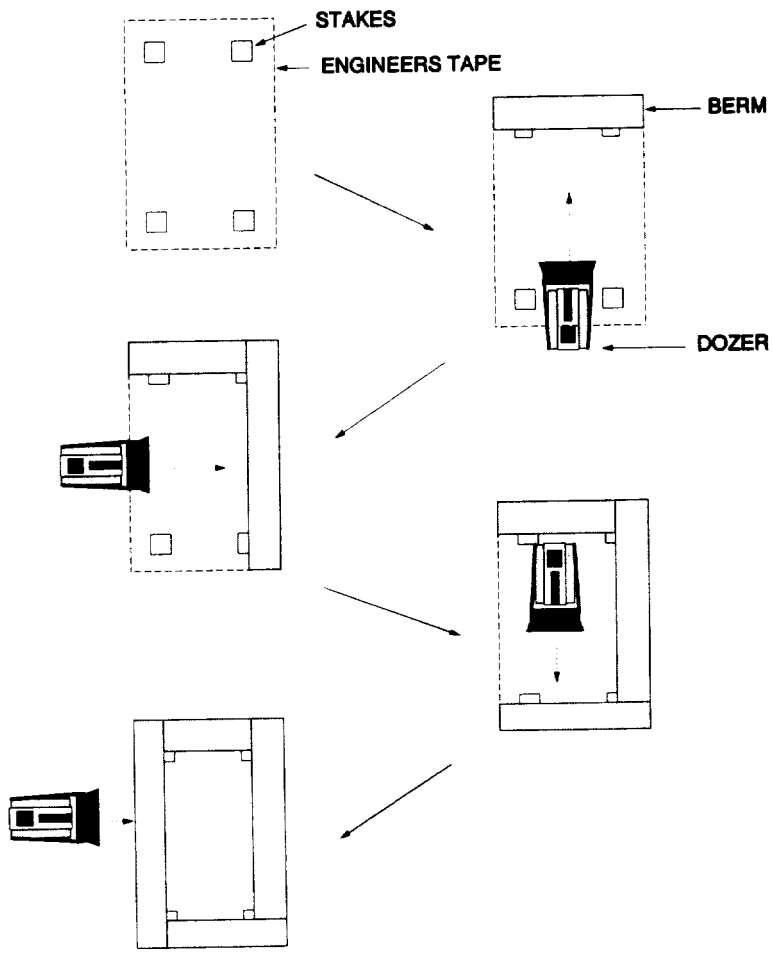


Figure 2-4. Berm Construction

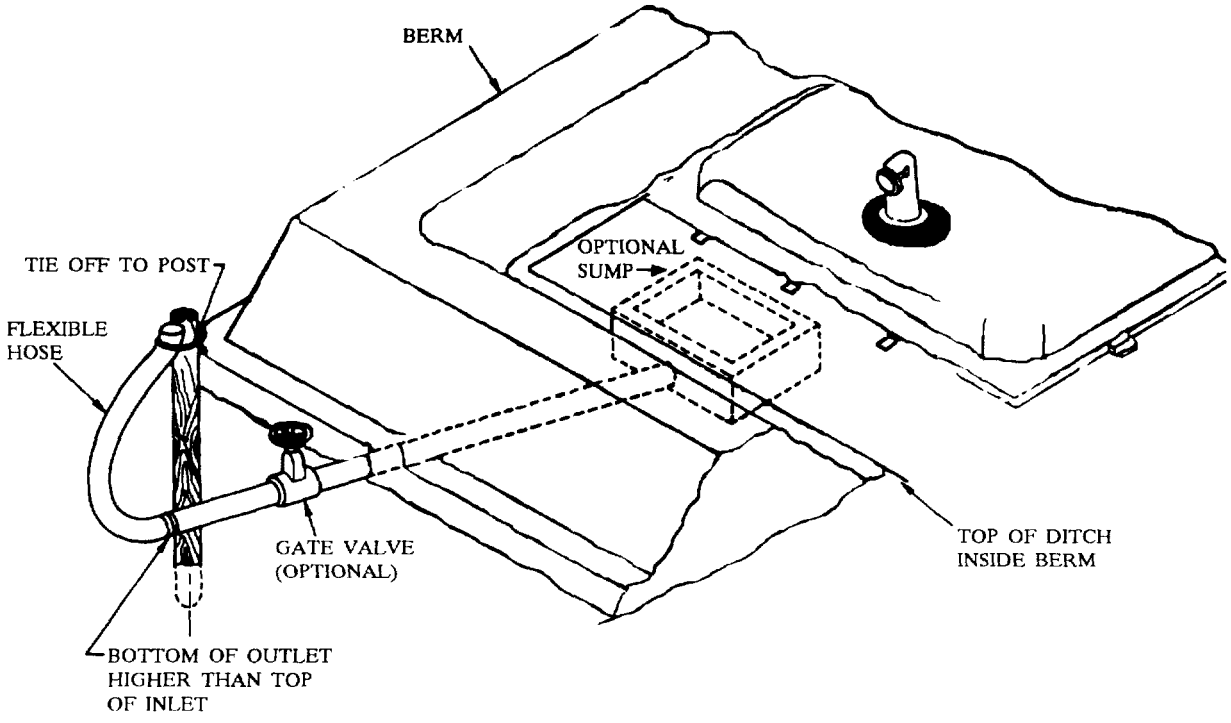


Figure 2-5. Berm Drain Installation

(4) To install the tank in the berm:

(a) Inspect the floor and walls of the berm. Remove all sharp objects that might damage the container.

(b) Spread the ground cloth over the floor of the berm.

(c) Remove the tank from the tank chest and unroll within the berm enclosure.

(d) Install the vent standpipe, figure 2-6. Place the gasket provided between the pressure ring and the closure plate. Turn the pipe down tight into the adapter plate.

(e) Check both the inlet and outlet closures. With the torque wrench provided from the GRK, torque all bolts to 20-30 inch-pounds.

(f) Install the inlet and outlet fittings with the quick coupling adapter facing the location of the transfer pump and the coupler facing the source of supply. If the berm is on an incline, install the tank with the outlet fitting (adapter) on the low side.

(g) Connect the inlet and discharge hoses.

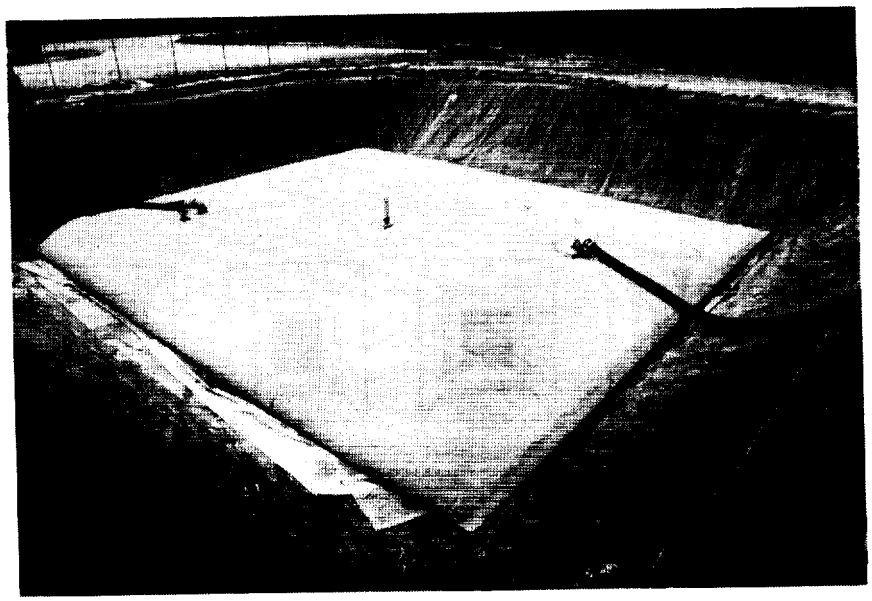


Figure 2-6. Collapsible Tank in Berm

d. Tank Farms. Individual storage tanks are grouped into farms with up to six collapsible tanks per farm. Tank farms should be located on reasonably level ground with sufficient space to permit the proper dispersal of tanks for protection from fire and enemy attack. Many arrangements of the tanks in a farm are possible. The radial type farm, figure 2-7, arranges tanks like the spokes of a wheel. This design takes up the least area and uses a minimum amount of hose. It is, however, more concentrated and therefore more susceptible to attack. Also with the radial design, one or more storage tanks will be downwind of a fire in an upwind tank.

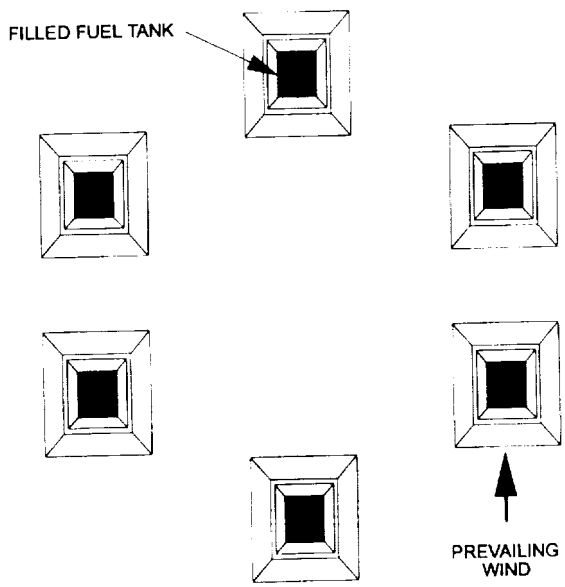


Figure 2-7. Radial Tank Farm Layout

A linear design, figure 2-8, places all tanks abreast to provide more dispersion. This design is safer than the radial arrangement, especially if the long axis is perpendicular to the prevailing wind. However, this design uses significantly more hose and spreads out available firefighting equipment.

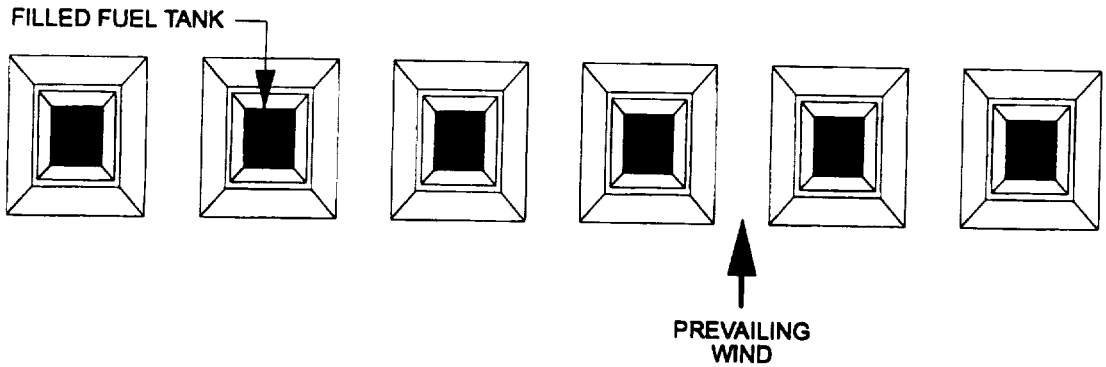


Figure 2-8. Linear Tank Farm Layout

The recommended arrangement, figure 2-9, represents a compromise between the radial and linear designs. In this design, two parallel rows of three tanks each are arranged with their long axes perpendicular to the prevailing winds. In all arrangements, the distances separating the tanks are based on maximum fire safety and minimum ground use, and will often need to be tailored to fit the local situation.

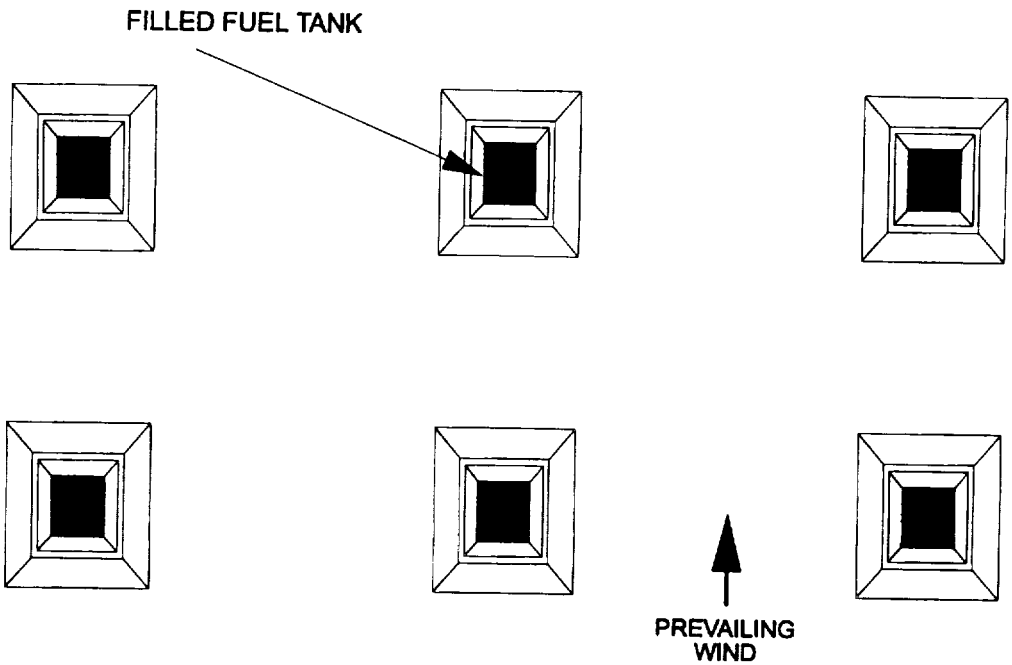


Figure 2-9. Parallel Tank Farm Layout

e. Pumps. Fuel transfer pumps must be placed on firm, level ground with the inlet manifold facing and nearly level with the source of supply in order to avoid suction lifts which reduce the pump's capacity. Suction lifts (vertical lift by suction) in excess of 10 feet must be avoided to prevent cavitation, particularly in hot climates. To install the pump, extend the chassis support and set the hand brakes. Blocking of the wheels will provide additional stability. Remove the ground rod from the chassis and drive it into the ground to within 3 to 6 inches of the end. Connect the ground wire from the pump to the ground rod ensuring positive, metal-to-metal contact. The pump should be installed as close to the storage tanks as safety permits, usually not more than 75 feet from the most distant tank outlet fitting.

f. Quick Disconnect Fittings. Connections throughout the fuel systems are made with quick-disconnect cam-locking type coupling units. The quick-disconnect adapter (male or external fitting) is fitted into the quick-disconnect coupler (female or internal fitting), and the joint is locked by depressing the cam arms on the coupler. This forces the adapter against the gasket in the coupler and makes a liquid-tight seal. The direction of flow, in a single hose, is from the coupler to the adapter. This flow direction is maintained throughout the system so that stations may be added or two systems connected without difficulty. Also, it has been standardized because the characteristics of some components will not permit reversal of this coupler-to-adapter flow direction.

g. Hose. Each section of hose has a quick-disconnect cam-locking coupler attached to one end and an adapter at the other end. The inlet side of all components is equipped with a coupler to receive the adapter end of the hose, and the outlet side has an adapter for attaching the coupler end of the next hose section. Prior to mounting out for an operation, the hose is normally removed from commercial packaging and trailer-loaded. Hose sections may be loaded separately or connected. When laying out hose between stations, the operation should start at the source of supply. Remove the coupler end of the hose first, so that the terminal end will have an adapter for connecting to the equipment. When it is necessary for hoses to cross, the collapsible discharge hose should cross over the rigid suction hose to prevent hose collapse. Hose should be laid out of the paths of vehicles, but culvert pipe may be used where necessary to protect the hose.

h. Pressure Regulator. The pressure regulator unit is connected into the hose line as desired, by using the integral quick-disconnect coupler and adapter. Determination of the location of this unit is discussed in paragraph 2-3, d.

i. Strainer. The 6-inch strainer assembly is usually installed as a part of the over-the-beach fuel receiving installation. Its purpose is to remove gross contamination such as sand and scale that may be pumped ashore from ships' tanks.

j. Filter-Separator. The filter-separator requires a reasonably level location with adequate drainage to allow removal of water filtered out of the fuel. The unit is self-contained and skid-mounted, and is equipped with quick-disconnect coupler and adapter fittings. The ground rod and wire assembly furnished should be installed prior to the start of fuel flow. Drive the rod into the ground to within 6 inches of the end. Connect the ground wire to a bare metal portion of the filter-separator or make sure the alligator clamp bites through the paint to make a metal-to-metal contact.

k. Meter Assembly Skid-mounted meter assemblies are coupled into the dispensing line between the pump unit and the dispensing point. They are also used in the beach unloading area. The meters measure fuel received or dispensed. Meters are positioned downstream of the filter-separator and fuel monitor (if used). Meters require a reasonably level and stable area and should not be placed in a spot likely to flood. Quick-disconnect fittings allow easy insertion into the system. The ground rod and wire should be installed as soon as the unit is sited properly.

l. Fuel Monitor. Fuel monitors can be installed on any reasonably flat surface capable of supporting their weight. Monitors are inserted in the system downstream of the filter-separator and usually upstream of the meter by using the quick-disconnect fittings provided. The ground rod and wire should be installed as soon as the unit is in place.

m. Valves, Manifolds, Fittings, and Accessories. All valves, manifolds, fittings, and accessories can be connected into the system at the desired points either directly or with adapters. Their use is largely self-evident from their nomenclature. These units may be placed anywhere in the system in order to perform the desired functions. Skid-mounted manifolds which control fuel distribution have individual gate valves on each port, and should be grounded when the units are in place. All hardware, except nozzles, can be placed on the ground for easy leak detection. Hardware should not be placed so that leaking fuel can form puddles.

n. Auxiliary Equipment. Certain pieces of equipment are not part of the basic tactical fuel systems, but are furnished in a using unit's authorized allowance as necessary for safe and proper operation. The major items in this category are fire extinguishers and quality surveillance testing equipment. The fire extinguishers may be vehicle-mounted, wheeled, or hand-carried, They do not require special installation instructions, but they must be placed where they are readily available in accordance with the local firefighting plan. The types and uses of fire extinguishers are discussed in paragraph 2-7. Testing kits and equipment commonly used are the Combined Contaminated Fuel Detector, the Contaminated Fuel Detector (AEL MK Ill), the Free Water Detector (AEL MK II), the Aviation Fuel Contamination Test Kit, the Petroleum Sampling and Gaging Kit, the B2 Anti-icing Additive Refractometer and Test Kit, and the Fuel Sampling Kit. These kits are discussed in paragraph 2-16,

Section II. FUEL HANDLING AND SAFETY

2-5. PERSONNEL QUALIFICATIONS AND TRAINING.

It is essential to the safety of fuel handling operations that the personnel involved be properly trained. Historical records disclose that the instinctive reactions of experienced fuel operators during emergency situations have minimized personnel injuries, fuel losses, and the destruction of Government property, Accordingly, only those personnel who are MOS qualified or OJT certified by a senior supervisor shall conduct petroleum operations.

2-6. FUEL HANDLING HAZARDS AND CONTROL MEASURES.

a. General. Human and environmental hazards are inherent in any fuel handling operation. Fuel handling personnel must minimize the risk of fire, explosion, injury, illness and environmental contamination. To attain this goal, personnel must have a thorough knowledge of the hazards involved, must strictly observe fire and safety precautions, and must closely follow spill control and containment measures. Although the hazard level is high, operations can be safely performed if simple procedures and precautions are carefully observed. More detailed treatments of fuel hazards are provided in U.S. Army FM 10-68, Aircraft Refueling; NAVAIR 00-80R-14, Aircraft Firefighting and Rescue; and the NATOPS 00-80T-109, Aircraft Refueling Manual. Two of the major hazards in handling fuel are fire/explosion and risk to personal health. Both hazards are created primarily by the vapors from the petroleum products.

b. Fire and Explosion. Liquid fuels must vaporize easily and burn rapidly to provide energy to do useful work in powering piston and turbine engines. Fuel vapors, caused by evaporation, form

explosive mixtures when they are mixed with the proper amount of air. If the amount of fuel vapor is less than about 1 percent by volume of the fuel-air mixture, it is too lean to ignite. If the fuel vapor is more than about 8 percent of the mixture, it will not ignite because it is too rich. These points are called the lower and upper explosive limits. If the fuel-air mixture is within the explosive limits, it will ignite instantaneously when a spark or flame is introduced. If ignition takes place in a confined area, the mixture burns so fast that the expanding hot gases produce extreme pressures. This process is called an explosion. If the mixture burns in an open space where hot gases have room to expand or be carried away by air currents, no explosion occurs. Although the formation of vapors in the fuel handling process cannot be eliminated, every effort must be made to control vapors and to control ignition sources. The following paragraphs present the most common vapor and ignition sources and control measures.

(1) Control of Vapors

(a) Avoid fuel spills through positive preventive maintenance programs and awareness training. Use drip pans and catch basins when appropriate. If leaks or spills do occur, clean up the area immediately using locally approved techniques and procedures; treat the area as hazardous until vapors dissipate.

(b) Inspect all equipment frequently for leaks; take immediate action to repair any leaks that are found.

(c) Be wary of vapors in empty hoses, pipes, cans, or tanks. A container that previously contained fuel can be more dangerous than a full one. The fuel-air mixture in the “empty” container is more explosive than the liquid alone.

(d) Inspect cans, drums, or other containers before filling to make sure they are liquid-tight.

(e) Keep fuel containers tightly closed, whether full or empty.

(f) When drums have been shaken or exposed to heat, open the bungs slowly to prevent sudden release of the pressure and vapor-air mixture.

(g) Be wary of confined or unventilated spaces where vapors can accumulate. Vapors are heavier than air and can collect in pits or depressions.

(h) Never use gasoline or other fuel as a cleaning fluid.

(i) Coordinate tank-cleaning and vapor-freeing operations with any other activities nearby that could be hazardous in combination.

(2) Control of Ignition

(a) prohibit smoking within fuel storage, transfer, or dispensing areas. “NO SMOKING” signs must be displayed prominently. Prohibit open fires, matches, lighters, oil lanterns or similar open flames within 100 feet of fuel handling operations.

(b) Suspend fuel loading and unloading operations during electrical storms or when storms are nearby.

(c) Inspect electrical fixtures and apparatus often. Immediately correct any condition likely to cause sparking, arcing, or overheating.

(d) Oily and paint-soaked rags can be sources of spontaneous combustion. Use only self-closing metal containers for these items and dispose of the collections daily.

(e) Practice good housekeeping; dispose of any trash/waste that could be ignited by small heat sources; clear grass and weeds from fuel handling areas.

(f) Coordinate all welding and cutting near fuel installations with other operations such as tank cleaning that could be potentially hazardous in combination,

(g) Guard against sparks caused by metal to metal contacts.

(h) Do not conduct fuel handling operations in close proximity to ground radar equipment until safe distances are coordinated based on the type of equipmant being used (generally 300-500 feet). Be certain that aircraft radars and all unnecessary radio equipment are switched off before refueling or defueling is begun. If it is necessary that equipment remain on for warmup purposes prior to immediate launch, be sure that it is not transmitting. The only exception to this rule occurs during hot refueling. During such refueling operations the pilot must keep in radio contact with the tower at all times.

c. Static Electricity. Static electricity is a potential ignition source that requires special treatment due to its importance in fuel handling. Static electricity is produced by various forms of friction, such as air moving over an aircraft, fluid flowing in a pipe or hose, or two pieces of material rubbing together. The human body builds an electric charge during normal movement; a parson can build and hold a charge of several thousand volts when walking over rugs or working in certain manufacturing operations. Static is always produced when fluids flow or are agitated, and fuels are particularly effective static producers. Although static itself is not a hazard, if an object charged by static is positioned near an object of a different charge level, the attraction between the two bodies may become strong enough to generate a spark to equalize the charge. Static generation cannot be eliminated, but sparking can be prevented in two ways: the charges on different materials can be equalized by connecting them with a conductor (bonding), or a path can be provided for the charges to dissipate harmlessly (grounding).

(1) Bonding. Bonding is the process through which two conductive objects are connected together to minimize their potential differences. Bonding does not dissipate static electricity; it equalizes the charge on two unlike objects to prevent sparking, in the presence of vapor, as the two objects are joined. For this reason, it is imperative to bond the objects before fuel flow operations commence. For example, a nozzle-aircraft bond is required when refueling aircraft. This bond is made prior to removing the nozzle dust cap or gas tank cap so that if a spark is generated, it will occur before fuel vapor is present. The bond remains connected until refueling is complete and the caps have been replaced.

(2) Grounding. Grounding is the process of providing a conductive path into the earth so that static charge will not be trapped on the surface where it may produce a spark. Grounding actually dissipates the static charge. The path is made by connecting a conductive cable from the object to be grounded to a conductive metal rod. The rod is driven far enough into the earth to reach the level of permanent ground moisture, a level which varies according to climate and soil type. The connection to the equipment involved must be made to a clean, unpainted, non-oxidized metal surface. An effective ground may prove difficult to attain due to terrain and climate. In these instances, the following are possible alternatives to accessing the level of permanent ground moisture:

(a) When frozen soil is encountered, several approaches may be taken. Multiple ground rods may be driven in at different locations to as great a depth as possible. Alternately,

locate the grounding system near a heat source or connect it to nearby metal buildings or underground pipes.

(b) In some warm regions, rocky or sandy soils provide a poor ground due to their low conductivity. In such cases, chemicals may be used to condition the soil and to increase its conductivity. Magnesium sulfate (Epsom salts), copper sulfate (blue vitriol), calcium chloride, sodium chloride (common table salt), and potassium nitrate (saltpeter) are used for soil conditioning. Common table salt will likely be the most readily available conditioning agent. To prepare the ground with salt, first dig a hole approximately 1 foot deep and 3 feet across. Pour a mixture of 5 pounds of salt and 5 gallons of water into the hole; allow it to seep in. Install the ground rod and wire, and keep the soil around the rod moist.

(3) Control of Static Electricity.

(a) All applicable equipment must be bonded and grounded prior to the start of fuel flow. Such connections must not be broken until fuel flow has stopped.

(b) Inspect and test bonding and grounding devices for conductivity at regular intervals. Repair or replace defective items before resuming operations.

(c) Do not splash-fill tank trucks, cars, or sixcon units. Place the hose near the bottom of the tank when filling begins and pump at a slow rate, thus reducing turbulence. When the hose end is submerged, loading can proceed at the full flow rate. Top loading should be done only if its absolutely the only way.

(d) After filling a large steel tank, allow a minimum of 30 minutes relaxation time for the static charge of the fuel surface to equalize with the tank before performing closing gage procedures.

(e) Do not filter fuel through anything other than properly grounded filter-separators and fuel monitors.

(f) Before dispensing fuel to any container (e.g. aircraft fuel port), personnel shall bond themselves to the container by taking hold of it. If it is a piece of metal equipment, take hold of a bare metal part with both hands for a few seconds.

(g) Fuel dispensing equipment must be bonded to the receiving vehicle. The NATOPS Aircraft Refueling Manual (NATOPS 00-80T-109) outlines specific aviation requirements.

(h) Outer clothing, especially clothing made from wool, silk, or synthetic fiber, is an active static generator; cotton is the preferred clothing material.

(i) If clothing becomes fuel-soaked, leave the refueling area as soon as possible and wet the clothing down with water before removal. If an adequate water supply is not available, personnel may ground themselves by placing both hands on a piece of grounded equipment before removing fuel-soaked clothing.

d. Health Hazards.

(1) Vapor's Toxic Effect. The principle health hazard of petroleum products lies in the vapor's toxic effects. Vapors released by fuel cause an anesthetic effect when inhaled. Petroleum vapors in a concentration of 0.1 percent by volume may cause slight vertigo at the end of 6 minutes; 0.5 percent concentrations can cause vertigo, to the extent of inability to walk straight, in

four minutes. Longer exposure or greater concentration may cause unconsciousness or death. The first symptoms of exposure to toxic vapors are headache, nausea, and dizziness; removing the victim to fresh air will normally prompt recovery. However, longer exposure requires immediate medical attention. Jet fuels contain more toxic aromatics than aviation gasolines, so special care should be exercised in their presence.

(2) Lead Poisoning. The toxicity of heavy concentrations of vapors from gasoline is increased if the gasoline contains lead for antiknock purposes. Lead additives are poisonous; they may be inhaled with the fumes or may enter the body by ingestion or absorption into the skin. Lead poisoning may occur from repeated exposure to gasoline vapors in an enclosed or inadequately ventilated area where spills have occurred or where stoves or other gasoline powered equipment is used. Adequate ventilation should be maintained. If personnel are persistently exposed to leaded gasoline, a rotation schedule should be established to minimize the cumulative effects of exposure.

(3) Injury to Skin and Eyes. Volatile fuel products may cause skin irritation if allowed to remain in contact with the skin, particularly under soaked clothing or gloves. Fuel-soaked apparel should be removed immediately, following precautions noted in paragraph 2-6c(3). Never use fuel as a cleaning agent. Fuel should be washed from the skin with soap and water. Repeated contact removes the protective oils from the skin, leaving it cracked, dry, and exposed to infection. Oil-resistant rubber or leather gloves, all-leather rubber-soled boots, and goggles or a protective helmet with visor provide protection from contact with fuels. If fuel is splashed into the eyes, administer first aid immediately. Flush with large amounts of water; then, sterile castor oil, olive oil, or mineral oil may be applied. Seek medical attention immediately.

(4) Swallowing Petroleum Products. If fuel is splashed into the mouth, flush repeatedly and thoroughly with water. Avoid swallowing the water. Generally, if fuel is swallowed, do not induce vomiting; an exception would be made if the fuel contains particularly toxic additives. Seek medical attention immediately.

e. Environmental Hazards. Air and water pollution are the two primary environmental threats involved in petroleum operations.

(1) Air Pollution. Because of their strong tendency to evaporate, petroleum products which have a vapor pressure of/above 1.5 pounds per square inch absolute (psia) at actual operating temperatures are considered potentially harmful to air quality during storage and transfer operations. Motor and aviation gasolines are typical examples. The vapor pressure of JP-4 may also exceed 1.5 pounds psia when the product temperature is 72°F or above. In addition to the evaporation of petroleum fuel, air pollution also results from the combustion process.

(2) Water pollution. Water pollution frequently occurs during storage and transportation of fuels. Accidental discharge of petroleum caused by defective or deficient facilities and equipment, improper operating procedure, and human error contribute to water contamination. Some water polluting discharges are made intentionally to dispose of unwanted tank washings, polluted bilge water, bottom sludge, and contaminated products. In most cases the environmental damage caused by these practices is irreversible,

f. Environmental Protection. Laws and regulations have been enacted by Federal, State, and local governments which are intended to protect the environment by limiting the types and amounts of polluting materials which may be discharged upon land, into the water, or into the air. Elimination of accidental or intentional discharge of petroleum products is the focus of these laws.

(1) Protection of the Air. The laws pertaining to air pollution vary in detail from one geographic location to another, depending on the degree of pollution that currently exists. In general, the law establishes a standard for the maximum allowable amount of hydrocarbon vapor that can be present in the atmosphere for a given period of time. The law requires corrective measures when these limits are exceeded. Due to the variety of regulations, plans and procedures for bulk fuel operations must be developed at the unit level.

(2) Protection of the Water. Federal laws, implemented and enforced by the United States Environmental Protection Agency (USEPA) and the United States Coast Guard, protect against water pollution. In addition, many states have their own regulations and enforcement agencies. The keystone of the USEPA regulations is the Spill Prevention and Control Countermeasure (SPCC) Plan. The law requires that where the possibility exists for an accidental discharge of oil to reach navigable water, large oil storage facilities must have an operating plan and a commitment to maintain adequate physical facilities. The US EPA requirements and recommendations for the preparation of an acceptable plan are found in Appendix B.

2-7. FIREFIGHTING.

a. General. While every effort is made to reduce the risk of fire and explosion during fuel handling operations, it is necessary to plan for the possibility of a fuel fire. To this end, the following section provides information on fires and firefighting methods.

b. Principles of Combustion. In order for a petroleum fire to occur, three elements must be present at the same time and in the right amounts. These are:

(1) A flame, spark or arc with enough energy to ignite the fire, or enough heat to raise the temperature of the petroleum vapor to its ignition point.

(2) Oxygen to support combustion. When oxygen in purer form than air (such as liquid oxygen) comes in contact with petroleum vapor, spontaneous combustion results.

(3) Petroleum vapor in the right amount to mix with the air forming a vapor-air mixture that is within the explosive range.

c. Controlling the Elements of Combustion. The basic principle of firefighting is to eliminate one or more element of combustion (heat, oxygen, or fuel) so that a fire cannot be supported.

(1) Control of Fuel. The first effort in firefighting should be to stop the flow of fuel. This can be accomplished by shutting down a pump, closing a valve, or using a hose clamp.

(2) Control of Heat. Heat is usually controlled by spraying water on as a stream, fog, or mist. The cooling effect of water is used to reduce the temperature of a fire to below the ignition point and also to keep nearby flammables cool so that they will not ignite spontaneously. Since fuel is lighter than water, using large amounts of water may actually spread a petroleum fire; therefore extreme caution must be exercised. Carbon dioxide is also a cooling agent; when discharged from a fire extinguisher, 30 percent of it becomes dry ice.

(3) Control of Air. Since it is impossible to remove air from an outdoor site, the principle of cutting off oxygen supply is implemented by one of three methods: diluting the air, smothering, or chain breaking. Air can be diluted with carbon dioxide, with a fog or mist of water, or with steam until there is not enough oxygen left to support combustion. An air-diluting agent requires sustained application, continuing until the fire is put out. Smothering a fire will exclude all air at the burning surface. For a large fire, an effective smothering agent is foam, especially aqueous film

forming foam (AFFF). Small fires can be smothered with sand, wet burlap, or a blanket. Chain breaking is a process in which a chemical agent interferes with oxygen and other chemical components of fire in hydrocarbon combustion. This principle is employed by the Halon 1211 fire extinguisher, the preferred choice for hot refueling operations.

d. Classes of Fires. The National Fire Protection Association (NFPA) has standardized the classification of fires into four types: A, B, C, and D. All fire extinguishers now produced are clearly marked with the class of fire for which they are suitable. The types of fires are:

(1) Class A. Class A fires are those involving ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics. The cooling and quenching action of water is an effective extinguishing agent for Class A fires.

(2) Class B. Class B fires are those in flammable liquids, gases, greases, and similar substances that do not leave embers as residue after burning. A smothering or diluting effect is necessary to put out Class B fires.

(3) Class C. Class C fires are those that involve live electrical equipment where the extinguishing agent must be a nonconductor of electricity. A smothering effect is preferred for Class C fires, such as that produced by carbon dioxide. When electrical equipment is deenergized, extinguishers for Class A or B fires may be safely used.

(4) Class D. Class D fires are those involving combustible metals, such as magnesium, titanium, zirconium, sodium, and potassium. Normal fire extinguishing agents may speed up burning or cause an explosive reaction if applied to burning metals. Smothering with dirt or sand is usually the best way to contain a Class D fire until it burns out. Fogs and foams may be used to reduce temperatures in the immediate area and prevent fire from spreading to other combustibles.

e. Fire Extinguishers. The fire extinguishers used with the tactical fuel systems are not a part of the system, but are included in the unit's authorized allowance. Dry chemical and foam extinguishers are immediate response tools.

(1) Carbon Dioxide. The carbon dioxide (CO_2) extinguisher contains a charge of liquid CO_2 under high pressure. On release, the charge flows in a high-speed stream concentrated and directed by a horn or flaring nozzle. The expansion of the CO_2 in the horn chills the expelled charge and converts about one third of it to dry ice. $C0_2$ is valuable for dilution of air in Class B fires. It is the best choice for Class C fires since it is a nonconductor of electricity and leaves no residue.

(2) Dry Chemical. The dry chemical extinguisher's active agent is potassium bicarbonate, commonly called purple K, which acts by smothering the fire. Its primary use is Class B and C fires; however, it leaves a residue that must be cleaned up after use on Class C fires. It provides flame knock down capabilities and is effective in running fuel fires when used in conjunction with AFFF. Dry chemicals may also be effective on some Class A fires.

(3) Foam. The foam type of fire extinguisher mixes foam concentrate with water to form a film that spreads over the burning liquid. The blanket of foam excludes air and prevents the release of vapors from the fuel surface. Foam also provides a cooling effect to reduce heat. The most common concentrate in use is AFFF. Foam is especially effective in combating liquid fuel fires configured in large pools, since it can be floated over the surface to completely cover large areas.

(4) Twin-Agent Fire Extinguisher. The twin-agent fire extinguisher (figure 2-10) is used to protect bulk fuel systems. It is skid-mounted, with a tank of dry chemical and a tank of AFFF,

both charged with high-pressure nitrogen. The basic unit has a reel of 150 feet of twin hose ending in a separate but close-coupled nozzle for each agent. The remote hose cart has an additional 150 feet of twin hose. The operator moves the nozzles across the fire from left to right. The dry chemical hits the fire first and extinguishes the flame. The AFFF concentrate mixed with water then coats the extinguished area and prevents reignition. Operation and maintenance instructions for the unit are detailed in TM 07661B-14.

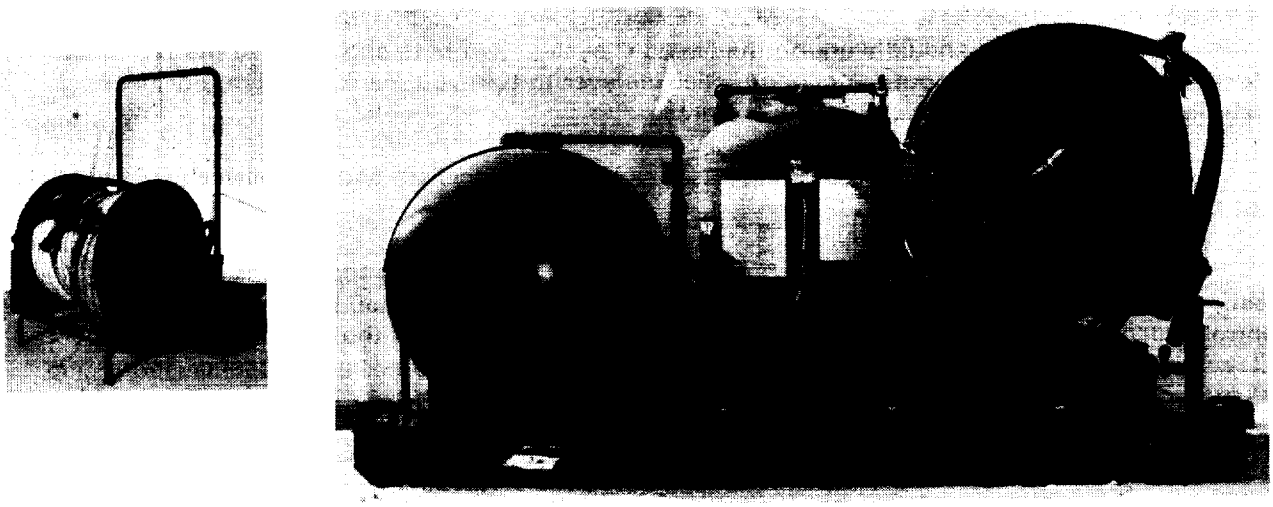


Figure 2-10. Twin-agent Fire Extinguisher with Remote Hose Cart

f. Firefighting Methods. Fires of varying degrees of severity are possible given the nature of petroleum operations in a tactical environment. They range from those involving small spills to a full-blown tank fire. An exhaustive treatment of firefighting is beyond the scope of this manual, but a short discussion will illustrate the principles involved.

(1) Portable fire extinguishers should be placed within easy reach of connecting points. All connecting points in the system are sources of potential leaks, usually due to loose, missing, or deformed gaskets. Constant inspection will reduce this hazard to a minimum. In systems of this type, connections are made and broken regularly in the normal course of operations, and some fuel spillage is inevitable.

(2) The danger of a pressure-fed fire is always present and will usually occur in the hose system. To control the pressure, shut down a pump, close a valve, or secure a hose clamp. If none of these options is available, the fire will be beyond the capability of the hand extinguishers and large equipment must be used.

(3) If the pressure cannot be shut off, concentrate on extinguishing the fire at the break. Work outward from that point to put out the rest of the fire. If the break is gravity-fed, attack the spill fire first, and then work back toward the break. Team-work, using two firefighters working

from different approach angles, can be very effective. This is especially true if there are obstacles that prevent one operator from reaching both sides of the fire.

(4) Before a fire reaches full-scale proportions, all available equipment and personnel should be called into action. A maximum coordinated effort, directed and controlled by one responsible supervisor, must be made to control the fire and protect surrounding equipment.

(5) Approach the fire from upwind and direct the fire fighting agent at the bottom front edge of the fire first. Sweep from side to side, extending just outside the edges of the fire to create a rolling effect of the agent into the fire.

(6) Flashback, or re-ignition of extinguished areas from radiant heat, is an ever present danger. Flashback can be prevented by keeping the stream of the extinguishing agent constantly in motion and not concentrating it on points in the fire.

(7) Firefighters should work on the “buddy” system and both should leave the fire when an extinguisher charge runs out. A good practice is never to turn your back on a fire, but back away, looking out for other firefighters in the area,

(8) Above all, firefighters should remain calm, take immediate and aggressive action to fight fires, and call for assistance.

g. Firefighting Training. Marines are instructed in basic firefighting techniques during the 12-week fuel handling training course at the U.S. Army Quartermaster School, Fort Lee, Virginia. Fire control is demonstrated and techniques are practiced using a burn pit at the school. Training follows those methods described in U.S. Army TM 10-68, Aircraft Refueling. Refresher firefighting training should be conducted annually under the control of and with Crash, Fire and Rescue facilities at MCAS.

Section III. QUALITY SURVEILLANCE

2-8. GENERAL.

a. Quality Surveillance. Quality surveillance is the aggregate of measures applied to determine and maintain the required quality of petroleum products. A vigilant quality surveillance program implemented by properly trained personnel is necessary to protect the original product quality. Fuel handling personnel are responsible for the delivery of high quality fuel to ground and air units. A thorough knowledge of the products dispensed by the systems is essential to understanding the procedures and precautions necessary to maintain their integrity.

b. Scope. An exhaustive description of petroleum products and quality surveillance procedures is beyond the scope of this manual. Included is a brief discussion of the fuels commonly dispensed by the TFS and general quality surveillance information and guidelines. MIL-HDBK-114, MIL-HDBK-200, AND NAVAIRINST 10340.3 are required references which contain detailed instructions, descriptions, and information on petroleum products and quality surveillance.

2-9. FUEL PRODUCTS, PROPERTIES, AND ADDITIVES.

a. General. The chemical composition of all petroleum products is based on various arrangements and combinations of hydrogen and carbon atoms to form hydrocarbons, each with its own unique, identifiable characteristics. These characteristics are established and published as

product specifications, quantitative measures of the physical and chemical properties of the product which make the product appropriate for its intended use. Hence, any change in the composition of the product may result in such marked changes in its properties that it becomes unsuitable for use. For this reason, knowledge of the products handled by the TFS is essential to an effective quality surveillance program. MIL-HDBK-114 provides information on fuels commonly used in ground mobility equipment. NAVAIRINST 10340.3B will provide information on aviation fuels.

b. Fuel Types. Three types of fuels are commonly dispensed by the TFS: gasoline, used to power spark ignition piston engines; diesel fuels, used to operate compression ignition piston engines; and turbine fuels which power aircraft turbine engines, turbine-powered equipment, and multifuel piston engines. To aid identification, dye is added to combat automotive gasoline (MOGAS) and aviation gasoline (AVGAS). MOGAS is dyed red. AVGAS is manufactured with either a blue (low lead grade) or green (high lead grade) dye. Diesel and turbine fuels are not dyed. Table 2-2 provides specification data.

c. Aviation Turbine Fuels.

(1) Types. Military jet fuels are designated by the letters JP (jet propulsion) followed by a number. Currently, three grades are in use: JP-4, JP-5, and JP-8. Specifications for each are found in MIL-HDBK-200 and NAVAIRINST 10340.36. JP-4 is a gasoline-kerosene blend, wide cut fuel used by military land-based aircraft. A high volatility product, JP-4 has a vapor pressure of 2-3 psi, JP-5 is a kerosene fuel with a significantly higher flashpoint, facilitating safety in shipboard operations. JP-8 is a kerosene fuel having significant advantages over JP-4 in terms of fuel handling and operational safety due to its higher flashpoint. However, since its flashpoint is not as high as JP-5, JP-8 cannot be used for shipboard operations. JP-8 has been studied by the Department of Defense as a replacement fuel for diesel fuel-consuming vehicles/equipment. The goal of this conversion program is to promote a single fuel requirement on the battlefield.

(2) Significance. Particular attention must be paid to quality surveillance procedures on aviation fuel. The complex fuel systems and high fuel consumption rates of modern aircraft magnify the effects of any deterioration or contamination of the fuel. NAVAIRINST 10340.36 provides guidelines for quality surveillance procedures on aviation fuel.

d. Additives. Additives are compounds which impart new physical properties to a product. Of particular significance to tactical bulk fuel quality surveillance are the additives used in jet fuels to counter the effects of water, microbiological growth and static electricity. Those are Fuel System Icing Inhibitor (FSII) and Static Dissipator Additive (SDA). NAVAIRINST 10340.3B and MIL-HDBK 114 contain more information on these and other common additives

(1) FSII. Certain aircraft require a minimum concentration of FSII in their fuel to prevent dissolved water from freezing at high altitudes causing airframe fuel system, engine filter, and/or engine fuel control icing. FSII also acts as a biostat to control microbiological growth in storage and aircraft tanks. There are currently two compounds being used as FSII. Di-ethylene-glycol-mono-methyl-ether (DiEGME) is the only approved FSII additive for use in JP-5 and JP-8 because of its high flashpoint. The second additive, ethylene-glycol-mono-methyl-ether (EGME), is approved for use in JP-4.

(2) SDA. Injecting JP-4 and JP-8 with SDA increases conductivity and helps relax static electric charges produced during pumping and filtering operations. If the fuel conductivity is sufficiently high, charges dissipate fast enough to prevent their accumulation and dangerously high potentials at fuel dispensing points. Tests reveal SDA, when added to JP-5, has adverse effects on

the performance of filter/separators; therefore, SDA is not added to JP-5. Two types of SDA are in use: ASA 3 and Stadis 450.

Table 2-2. Fuel Data (1 of 2)

FUEL	NATO CODE	UNITED KINGDOM INTERSERVICE DESIGNATION	AMERICAN PETROLEUM INSTITUTE GRAVITY RANGE (DEGREES)	SPECIFIC GRAVITY RANGE
Diesel:				
DF-A	N/A	N/A	51-64	0.72-0.78
DF-1	N/A	N/A	35-51	0.78-0.85
DF-2	F-54	N/A	35-51	0.78-0.85
Gasoline:				
AVGAS 80/87	F-12	N/A	64-79	0.67-0.72
AVGAS 100/130	F-18	N/A	64-79	0.67-0.72
AVGAS 115/145	F-22	N/A	64-79	0.67-0.72
MOGAS	F-46	N/A	51-64	0.72-0.78
Military Jet:				
JP-4	F-40	AVTAG/FSII	45-57	0.75-0.80
JP-5	F-44	AVCAT/48	36-48	0.79-0.85
JP-8	F-34	AVTUR/FSII	37-51	0.78-0.84
Commercial Jet:				
Jet A	N/A	N/A	36-48	0.79-0.85
Jet A-1	F-35	AVTUR/50	36-48	0.79-0.85
Jet B	F-45	AVTAG	45-57	0.75-0.80

Table 2-2. Fuel Data - Continued (2 of 2)

FUEL	POUNDS PER U.S. GALLON (AVERAGE)	FLASHPOINT IN °F (°C) (MINIMUM)	POOL RATE OF FLAME SPREAD (FT/MIN)	FEDERAL/ MILITARY/ COMMERCIAL SPECIFICATION
Diesel:				
DF-A	6.2	100 (38)	N/A	VV-F-800
DF-1	6.7	100 (38)	100+	VV-F-800
DF-2	6.7	125 (52)	100+	VV-F-800
Gasoline:				
AVGAS 80/87	6.0	-50 (-46)	700-800	MIL-C-5572
AVGAS 100/130	5.9	-50 (-46)	700-800	MIL-G-5572
AVGAS 115/145	5.8	-50 (-46)	700-800	MIL-C-5572
MOGAS	6.2	140 (60)	N/A	MIL-C-3056
Military Jet:				
JP-4	6.6	-10 to +30 (-24 to-2)	700-800	MIL-T-5624
JP-5	6.8	140 (60)	100	MIL-T-5624
JP-8	6.8	100 (38)	N/A	MIL-T-83133
Commercial Jet:				
Jet A	6.8	95 to 145 (35 - 63)	100	ASTM D 1655
Jet A-1	6.8	95 to 145 (35 - 63)	100	ASTM D 1655
Jet B	6.6	-10 to +30 (-24 to-2)	700-800	ASTM D 1655

N/A = Not available/applicable

2-10. DETERIORATION OF PRODUCTS.

a. General. Changes that occur while a product lies in storage become more marked as the product ages. The loss of essential fuel properties due to deterioration can produce critically damaging results to receiving units in addition to increased equipment maintenance problems. The most common forms of deterioration are: weathering; gum formation; and loss of additives, of tetraethyl lead, and of color. Consult MIL-HDBK-200 for deterioration limits and tolerances.

b. Weathering. Weathering refers to the loss of the more volatile components of motor and aviation gasolines. Volatility is the measure of the rate of evaporation; it increases markedly with rises in temperature and produces sufficiently high gas pressures to rupture a container. For this reason, all tanks are vented to the air. The vapors lost during storage are the components of the fuel which are required to provide easy engine starts and a plentiful fuel supply during warmup periods. Hence, the less volatile weathered fuel may cause considerable trouble if issued for use in cold weather.

c. Gum Formation. Gum formation is the most common and troublesome form of deterioration suffered by internal combustion engine fuels. Gum formation is caused by the presence of unsaturated hydrocarbons in the fuel which, in the presence of oxygen, tend to undergo chemical changes producing first gummy, and eventually resinous materials. The latter are insoluble and slowly settle out on the walls and bottoms of containers from which they are difficult to remove. The gummy substances remain dissolved but are difficult to vaporize. They can cause clogged carburetor jets and fuel lines, sticky deposits on rings and valves, and excessive carbon deposits in the chamber. The existence of gum in fuels, in greater than allowable amounts, will necessitate increased engine maintenance. Although gum or oxidation inhibitors are added to internal combustion engine fuels, these additives are effective for a limited time only and may not offer permanent protection.

d. Loss of Additives, of Tetraethyl Lead, and of 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. Loss of oxidation inhibitors decreases the safe storage time of the fuel due to the possible early formation and rapid development of gum. The loss of tetraethyl lead (TEL) decreases the power-producing characteristic of the fuel and is indicative of very serious deterioration, particularly in aviation fuels. The loss of color itself has no importance other than to promote distrust of the product; deterioration and contamination should be suspected.

e. Loss of Fuel System Icing Inhibitor (FSII). FSII provides jet aircraft with icing protection by lowering the freeze point of water present in jet fuel to a point as low as the fuel itself. Loss of FSII will occur throughout the distribution and storage systems since FSII is preferentially soluble in water versus fuel. The elimination of water in jet fuel systems is essential to minimize FSII losses.

2-11. CONTAMINATION OF PRODUCTS.

a. General. A contaminated product is one which contains some material not normally present, such as dirt, water, or another petroleum product. Such a mixture may modify the normal qualities of the fuel permanently or add undesirable characteristics. In either case, the contaminated fuel may be unsuitable for its intended use. Contamination may result from accident, failure to follow prescribed procedures, gross carelessness, or sabotage. Fuel contamination can generally be divided into two classifications: chemical and material.

b. Chemical Contamination. Chemical contamination usually results from the inadvertent mixing of petroleum products, known as commingling, resulting in a change in their chemical and physical properties. Commingling may result from inadequate cleansing of lines or containers; from

the use of unmarked or improperly marked containers, and from the mishandling of manifolds. In such cases, it can be minimized by supervision sufficient to ensure strict application of the prescribed petroleum handling procedures. Commingling may also result from leaks in tanks or valves aboard tankers, and from leaky valves or insufficient protective facilities in shore installations. These sources can be minimized by proper inspection and maintenance procedures. Commingling can be negligible or serious, depending upon the product contaminated, the contaminating agent, and the amount of contamination. Some serious effects are: loss of power in fuels, increase in volatility, increase in gum content, formation of heavy sludge, degradation of thermal stability, and increased water separation time. Commingling can generally only be detected by specific laboratory tests conducted at refineries, bulk terminals, and petroleum testing laboratories. Consult MIL-HDBK-200 for prescribed procedures for laboratory testing.

c. Material Contamination. Material contamination of fuel consists of the introduction of water, microbiological growth, or particulate matter.

(1) Water. Both fresh and salt water are encountered in fuel systems. It may be present as dissolved, entrained or free water. Dissolved water is fresh water absorbed in the fuel and is not visible. It cannot be separated out of the fuel by either filtration or mechanical means. A threat is posed when the temperature of the fuel drops, causing dissolved water to be liberated from solution to form free water. Free water, fresh or saline, may be in the form of a cloud, emulsion, entrained droplets, or in gross amounts in the bottom of a tank or container. Water can enter storage tanks during the receipt of the product, particularly from barges or tankers. In the case of packaged products, water may become a contaminant through the use of open or damaged containers, through improper storage and handling methods, and by the breathing which normally occurs in drums and cans. (Breathing is the reverse of vaporization; when temperatures fall, air is sucked into the storage tank through the vents.) Water contamination of packaged products can be avoided by application of prescribed methods of inspection, storage, and handling. The presence of water in fuel can have serious consequences, Free water may cause icing in fuel system components, malfunction of engines and components, and corrosion. Dissolved water presents a particularly hazardous situation when present in aviation fuels, because as the altitude of the aircraft increases and temperature drops, dissolved water changes to free water and freezes. Fuel contaminated by water can be improved by filtering methods, such as those found in use of filter-separators.

(2) Microbiological Growth. Microorganisms, including protozoa, bacteria and fungus, grow at the fuel-water interface. Fungus presents the major source of fuel contamination; it holds rust and water in suspension, produces hydrogen sulfides, acts as a stabilizing agent for fuel-water-sediment emulsion, and clings to glass and metal surfaces. Microbiological growth appears as black, brown, or gray strings, mats, globules or fibrous material. Microbiological growth is generally found wherever pockets of water exist in fuel tanks. Microbiological growth can be effectively controlled by removing water bottoms in storage tanks and by maintaining general cleanliness of handling equipment. FSII is an effective biocide, but is only present in military aviation turbine fuels and can actually deteriorate in the presence of water. Problems associated with microbiological growth include erroneous readings in meter devices, sluggish fuel control operation, and sticking of flow dividers.

(3) Particulate Matter. Particulate matter, or sediment, may be in the form of dust, powder, flakes, granules, fibers, sludge, or slime. Sediment may be organic or inorganic, and is classified by its size. Coarse sediment is 10 microns or greater and can be visually detected. Fine sediment, particles less than 10 microns, is not visible to the naked eye but does scatter light. This light-scattering property makes the particles show up as point flashes of light or as a slight haze in the fuel. The composition of the sediment will usually reveal its source. Metallic particles may be the result of an upstream mechanical failure; rust particles are usually from scrapings in tanks and

pipelines; fiberglass fibers may result from the breakdown of filter/coalescer elements; mill-scale is a magnetic product formed during the manufacturing process. Particulate contamination, generally the result of inadequate cleaning and inspection of tanks, containers, and hoses or the use of muddy water to flush them, can be minimized by thorough cleaning of storage containers and components. Adverse effects of solid contamination include clogged fuel lines and damaged fuel injector pumps, engine components, and metering equipment. Strainers and filter-separators aid in the removal of particulate contaminants.

2-12. QUALITY SURVEILLANCE PROCEDURES.

a. Settling Time. When tanks are filled for the first time, or after fresh stocks have been added, the maximum possible settling time should be allowed to permit water and solids to settle out. As a guide, the following minimum times are recommended; actual times should be determined through sampling and testing:

(1) Three hours per foot of fuel depth for JP-5 type fuels.

(2) One hour per foot of fuel depth for JP-4 type fuels, gasolines, and diesel fuels.

b. Recirculation. Recirculation is the process of transferring fuel from one part of the system through every other part into an empty or partially filled tank. Recirculation acts to reduce existent gum formation, resulting from the interaction between fuel and hose deterioration products, and allows the filtering mechanisms to remove contaminants after hose line maintenance. Contamination increases with the length of time fuel is idle in the system. Recirculation is the only known, practical way to dissipate existent gum formation buildup. Recirculation will reduce gum content to an acceptable level where the system has been idle for up to 24 hours. If a longer period of nonuse (i.e. months) is expected, fuel in hoses should be drained back into tanks and then recirculated prior to dispensing. Generally, pumping about twice the amount of fuel contained in the installed hoses through the system is sufficient. This guideline applies to dispensing points only prior to daily issue.

c. Changing Fuel Types. The tactical fuel systems are designed to store/transfer single, segregated products. The collapsible tanks shall remain dedicated to one fuel type until removed from service.

2-13. RECLAMATION.

a. General. Suspected deterioration or contamination must generally be confirmed by laboratory tests. Reclamation refers to the procedure required to restore or change the quality of a petroleum product to meet the desired specifications. The procedures for reclamation include: (1) identification; (2) downgrading; (3) blending; (4) filtering; (5) dehydrating; and (6) inhibiting.

b. Factors. Before definite action is taken to reclaim a product, the following factors must be fully considered:

(1) Contaminating agent or agents and source;

(2) Degrees of contamination or variation in specifications of contaminated product from required specifications;

(3) Probable end use of product in present condition;

(4) Probability of removing or nullifying undesirable effect of contaminating agent, or agents, so the product can be used for the purpose originally intended, or for another end use;

(5) Location and quantity of questionable product, probable need for unreclaimed or reclaimed product at its present or other location, and the estimated rate of consumption;

(6) Availability of time, materials, equipment, and labor necessary to reclaim the contaminated product.

c. Identification. Examination of an unknown product will sometimes yield clues to its identity; for example, gasolines are identifiable by color. Laboratory analysis, however, is the only reliable method of confirming identity.

d. Downgrading. Downgrading is the procedure of 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. For example, aviation gasolines that cannot be reclaimed for use in aircraft engines by prescribed procedures may be downgraded, blended with low TEL content motor fuel, and used as motor fuel provided that the final blend meets specified limits. Contaminated high grade motor fuel originally designed for use in combat vehicles may be downgraded, or blended, if preferred, and used in transport or administrative vehicles and stationary engines in accordance with prescribed limiting factors. The responsible command will determine the most efficient use or the most advantageous means of disposal in conformance with environmental regulations.

e. Blending. All blending must be rigidly controlled and the correct percentages to be blended determined by the laboratory. The actual field blending must be closely supervised and when the resulting blend is of sufficient volume to warrant additional inspection, the laboratory should run additional tests on the field blend to determine that the mixture meets required use specifications.

f. Filtering. Filter-separators are highly effective in removing water and solid materials from fuels. Quality checks for water and sediment, as provided by the fuel monitor, are required downstream of the filter-separator to ensure proper functioning. Three potential problem areas encountered are: improper installation of the filtering elements, faulty elements, and the presence of surfactants which disarm the water coalescence ability of filter-separators.

g. Dehydrating. Moisture or water will settle out of the light petroleum products if they are allowed to stand undisturbed. Water noted while gaging should be drained through the water draw-off.

h. Inhibiting. Aviation fuel generally contains an active added inhibitor. The applicable specification provides that a maximum content of approved inhibitors may be added to prevent gum formation and precipitation of lead compounds. Specifications for motor fuel include a minimum oxidation stability. To meet this requirement, it is generally necessary to add an inhibitor which functions for all practical purposes, the same as that in aviation fuel. Any program for reclaiming aviation or motor fuel by inhibiting, or by filtering and inhibiting, must be carried out under the direct and constant supervision of qualified personnel, assisted by adequate laboratory facilities.

2-14. TESTING CRITICAL PROPERTIES OF PETROLEUM PRODUCTS.

a. General. The quality and performance characteristics of various petroleum products are determined by testing the product's critical properties, Detailed descriptions of standard procedures for the test methods are set forth in publications of the American Society for Testing

and Materials (ASTM) and in Federal Test Method Standard No. 791. Sampling and testing requirements are defined in MIL-HDBK-200 and NAVAIRINST 10340.3B and should be consulted for further information. Critical properties commonly tested are described below.

b. Gravity. The specific gravity of a fluid is the ratio of the weight of a given volume of the fluid to the weight of an equal volume of water at the same temperature. Water is assigned a specific gravity of 1.00, therefore, a liquid lighter than water has a specific gravity less than 1.00, and a liquid heavier than water has a specific gravity of more than 1.00. Liquids expand when heated, causing an equal weight of liquid to occupy a greater volume, thus decreasing the specific gravity. Hence, a temperature reading must accompany the specific gravity test. Normally, the gravity of petroleum products is expressed in degrees API, in accordance with the American Petroleum Institute (API) scale. The relationship of specific gravity to API gravity, expressed as degrees API, is depicted in the following formula:

$$\text{Specific gravity} = \frac{141.5}{131.5 + \text{degrees API}}$$

It can be seen that a fuel of 10° API gravity has a specific gravity of 1.00, the same as water. All gravity determinations are correlated with a specific temperature and, using tables, are generally corrected to a standard temperature of 60° F. Gravity measurements are determined by use of a hydrometer. Hydrometers with the API scale are normally used for fuels, however, ordinary hydrometers may be used and the following formula applied to express the specific gravity reading in degrees API:

$$\text{Degrees API} = \frac{141.5}{\text{specific gravity}} - 131.5$$

Gravity determinations are used to make volume corrections at different temperatures and to check suspected contamination.

c. Flash and Fire Points. The flash point of a petroleum product is the temperature at which it first gives off sufficient flammable vapor to ignite. The fire point is the temperature at which its vapors will continue to burn. The fire point of any product ranges from 10° to 70° higher than its flash point. Flash and fire points are used primarily to indicate the fire hazards of petroleum products. There are three principal methods of determining flash and fire points: (1) Cleveland cup method; (2) Pensky-Martens closed cup method; and (3) Tagliabue (TAG) closed cup method. All three methods use the application of heat to the products being tested. While heat is being applied, a flame is passed periodically across the surface of the cup until a flash is observed.

d. Viscosity. The viscosity of a fluid is the measurement of its resistance to flow. High viscosity indicates a sluggish flowing liquid; a freely flowing liquid has low viscosity. Lubricating oils are chosen based upon their viscosity at operating temperatures. Viscosity should remain high enough to maintain a fluid film regardless of operating load, but not so high as to impose drag or excessive fluid friction. Fluid friction is a source of power loss and can raise the temperature of the oil. The viscosity of petroleum products is usually determined by employing a viscosimeter to measure the time necessary for a given quantity of oil to flow through a standardized capillary tube.

e. Cloud and Pour Points. The cloud point is the temperature at which a petroleum product's paraffin content, normally held in solution, begins to solidify and separate into tiny crystals, causing the product to appear cloudy or hazy, This test is performed on diesel fuels, fuel oils, and other petroleum oils that are transparent and have a cloud point below 120° F. Determination of the

cloud point is valuable in determining whether oil to be used in wick-feed oilers will form wax crystals, clogging the wick and preventing passage of oil and subsequent lubrication. Fuel oils and diesel fuels with high cloud point may clog fuel filters at low temperatures if not used in conjunction with a preheater. The pour point has greater value and a wider range of application than the cloud point. The pour point, performed on most petroleum products, is the lowest temperature at which the product can be poured. The pour point is particularly significant when evaluating the use of a petroleum product in a machine exposed to low temperatures, as in aircraft. If a product will not pour below required temperatures, its use will be restricted. Products having pour and cloud points that do not meet specifications usually are contaminated by a heavier product.

f. Sulfur Content. Free sulfur and sulfur compounds may be either desirable or undesirable ingredients in a petroleum product, depending on the product's intended use, They are desirable in certain lubricating and cutting oils because sulfur increases film strength. However, sulfur can be detrimental in lubricating oils which are exposed to copper, brass, or other nonferrous metals because free sulfur is corrosive to these metals. Sulfur, when present in gasoline or diesel, will burn to form sulfur dioxide which when mixed with water during the combustion process forms acids. These acids are highly corrosive to ferrous engine parts. Sulfur compounds also have a corrosive effect on brass fuel lines and carburetor parts. The presence of free and corrosive sulfur in gasoline and kerosine is usually determined by the copper strip method. A polished copper strip is immersed in a given quantity of sample and heated for a specified period of time. The discoloration of the strip that occurs is rated according to ASTM standards.

g. Reid Vapor Pressure. Vapor pressure is the outward pressure of a mass of vapor at a given temperature when enclosed in a gas-tight container. It is an index to the volatility of the liquid from which the vapor was produced. Vapor pressure is an important factor in gasolines and some aviation fuels to insure safety in handling and performance. The Reid method is commonly used to determine vapor pressure of volatile, nonviscous petroleum products.

h. Distillation. The process of distillation is commonly used in the laboratory to test various petroleum products such as gasolines, turbine fuels, and kerosene which are vaporized in the course of their use. The tests will yield a distillation range for the product, as well as the amount of product vaporized at various temperatures. Knowledge of distillation range aids in predicting performance characteristics. There are many possible variations in the details of distillation test methods, but all involve vaporizing then cooling the liquid under specific conditions and recording the results.

i. Cetane Number. Cetane number is the measure of the ignition quality of diesel engine fuels. When diesel fuel is injected into the combustion chamber of a diesel engine, ignition does not occur immediately. The interval between injection and ignition is the ignition delay. A long delay will result in engine roughness or knock. A short ignition delay is characteristic of high cetane numbered fuels. The test involves a comparison between a reference fuel with a known cetane number and the test specimen when both are used in a test engine under controlled conditions. The cetane number of diesel fuels is significant for engine starting and smoothness of operation. However, the cetane requirements of individual engines vary due to differences in design and service.

j. Color. Color tests aid in the detection of deterioration, contamination, and identity of petroleum products. Several different methods are used, most employing a color chart or color standards for comparison. A color darker than expected reveals possible contamination with a heavier product or deterioration due to age. A lighter color than expected may reveal contamination by a clear or straw-colored product.

k. Ash Content. The amount of noncombustible material (inorganic matter) in petroleum products is known as the ash content. The ash test is performed on fuel oils and nonadditive lubricating oils to detect contamination by inorganic matter, such as rust, sand, or metallic salts. These contaminants can abrade metal surfaces, clog injection nozzles, and form deposits. Additive-type lubricants are tested for ash content to determine the amount of additive present. In determining the ash content, a sample is weighed, ignited and burned until all combustible material has been removed, and the residue weighed.

l. Carbon Residue. All oils, when burned, leave deposits of carbon. Carbon residue tests indicate the amount of carbon which oils may be expected to deposit when subjected to high temperatures. The type of carbon residue resulting from the tests indicates the base of the crude oil used in the refining process, making the test useful in identifying a possible contaminant. Carbon residue tests are performed on distillate fuels, lubricating oils, and residual fuel oils.

m. Corrosion. Petroleum products generally make contact with metal, and when corrosion of the metal is detrimental, a corrosion test is required. Free sulfur found in gasoline and jet fuels is corrosive to copper. These fuels are required to pass a test involving contact with polished copper over a specified period of time. For certain other products which may contain corrosive free acids, tests determine their effect on iron and steel as well as copper.

n. Gum in Gasoline and Jet Fuels. The behavior of a fuel in an engine and the length of time it may be stored without deterioration depend on the nature and amount of unsaturated hydrocarbons in the fuel. Hydrocarbons differ considerably in their tendency to combine with other materials, such as oxygen in the air. When the hydrocarbons in gasoline or jet fuels combine with oxygen, compounds which are insoluble in the fuel are formed. These compounds are called gums. Several test methods have been developed to determine either the amount of gum which will form if such a fuel is used immediately or the tendency of a fuel to form gum in storage. Once the results are known, antioxidant additives may be employed by refiners to delay and limit gum formation.

o. Freezing Point. The freezing point is an important characteristic of aviation fuel, determining the lowest temperature at which a fuel will flow. It must be sufficiently low to avoid solidification and filter blockage at low operating temperatures. The test method involves cooling the fuel under specified conditions until hydrocarbon crystals appear, then determining the temperature at which the crystals disappear. The freezing point is the temperature at which the latter occurs.

p. Water Separometer Index. The index is used to determine the ability of jet fuels to release entrained or emulsified water when passed through a coalescer-type separator under controlled conditions. It predicts the effectiveness of water separation from fuels by conventional filter-separators.

q. Thermal Stability of Jet Fuels. The thermal stability test is indicative of fuel performance during jet aircraft operation and is used to assess fuel stability at a given temperature. Unstable fuels deposit unwanted decomposition products in fuel system components.

r. Sediment and Water (Centrifuge Method). Water and insoluble impurities in petroleum products may be determined by several methods. The centrifuge method is considered by ASTM to be the most desirable method for diesel fuels and burner fuels, grades 1,2, and 4. A specially calibrated centrifuge tube is centrifuged and the separated sediment and water accumulated at the bottom is measured. Other methods of testing for these contaminants are discussed in field testing methods (paragraph 2-16).

s. Fuel System Icing Inhibitor (FSII). This test is performed on jet turbine or diesel fuels containing the inhibitor monomethyl ether or diethylene monomethyl ether used to prevent freezing of free water present in the fuel. Refractometric, volumetric and calorimetric methods are used for the quantitative determination of FSII in fuels. All three methods remove the FSII from the fuel sample by means of water extraction and then analyze the remaining water/FSll extract according to the various principles.

2-15. SAMPLING REQUIREMENTS.

a. General. The delivery of a clean, bright fuel product is essential to the operation and maintenance of using vehicles, equipment, and aircraft. An effective quality surveillance program incorporates periodic sampling and testing of bulk fuel supplies. MIL-HDBK-200 details specific requirements for fuel sampling, testing, and specifications.

b. Samples. All samples taken will be in accordance with standard procedures described in ASTM D-4057, ASTM D-270, and MIL-HDBK-200. Precautions are necessary to ensure a representative sample; improperly taken samples can completely invalidate a test. Do not sample tanks during or immediately after filling. Allow at least a 30 minute relaxation time for JP-4 and AVGAS and 5 minutes for JP-5 or JP-8.

c. Types of Tests. Types A, B, and C tests describe levels of quality surveillance testing performed on petroleum products. Type A provides complete specification inspection tests. Type B tests are further subdivided into three categories, each providing partial analysis of different fuel properties and characteristics. Generally, Type A and B tests require reference laboratory services. Type C tests, which include specific gravity, color, and appearance checks, can be performed in the field using authorized allowance quality surveillance test equipment. NAVAIRINST 10340.3 and MI L-HDBK-200 should be consulted for detailed testing requirements and reference laboratory information.

d. Frequency of Testing. Standard Operating Procedures (SOP) prepared in accordance with NAVAIRINST 10340.3, MIL-HDBK-200 and NAVAIR 00-80T-109 shall dictate the frequency of petroleum product testing for each tactical unit/facility:

(1) Initial delivery to the TFS. When fuel is received from a source outside of the TFS, a sample is collected and shipped in an approved container to the reference laboratory designated for that receiving unit. DA Form 1804, figure 2-11, is used to document the receipt of fuel. Instructions for completing this form are detailed in FM 10-70. Concurrently, the fuel is checked on-site for color, appearance, and API gravity. If the results of the on-site tests are satisfactory, the fuel is unloaded to the TFS; it is not necessary to wait for the results from the reference lab. Unsatisfactory tests results from the reference laboratory will necessitate curtailment of fuel dispensing operations until the cause of the discrepancy IS Investigated, identified, and corrected.

(2) Daily. At a minimum, a visual examination (color and appearance), API gravity, and free water determination shall be performed on a daily basis.

(3) Weekly. Generally, a particulate contaminant test will be performed on a weekly basis.

(4) Monthly. Fuel samples are sent monthly to the designated reference laboratory for verification that in-house testing procedures and equipment are working properly,

(5) Special. Anytime that fuel is suspect or fails on-site testing, a sample is sent to the reference laboratory for confirmation.

DA FORM 1804
1 NOV 67
PETROLEUM SAMPLE
(TM 10-1105)

REPLACES EDITION OF 1 DEC 62, WHICH IS OBSOLETE
USE REVERSE SIDE FOR REMARKS

PRODUCT

FROM (Installation)

SAMPLE NO. | LABORATORY NO.

PRODUCT

SPECIFICATION NO. | AMT PRODUCT SAMPLE REPRESENTS

FROM (Installation)

MANUFACTURER / SUPPLIER

SAMPLE SOURCE	TRUCK NO.	TANK NO.	OTHER (Specify)

SAMPLED BY (Name) | ARMED SERVICES PROCUREMENT NO.

STOCK NO. | DATE SAMPLED

QUALIFICATION NO. | BATCH NO.

FILL DATE | SHIPMENT DELIVERY DATE

CONTRACT BULLETIN NO. | ITEM NO.

☐ FUEL BULK STORAGE ☐ ROUTINE SURVEILLANCE ☐ FUEL PACKAGED ☐ PROCUREMENT ORIGIN
☐ ALLIED PRODUCTS ☐ PROCUREMENT QUAL CONTRACT ☐ FILTER EFFECTIVENESS
☐ SPECIAL ☐ DEPOT

TYPE SAMPLE ☐ TOP ☐ MIDDLE ☐ BOTTOM
☐ COMPOSITE ☐ OTHER (Specify)

REVERSE SIDE *DA FORM 1804*

NAME AND TELEPHONE NUMBER OF PERTINENT PERSON TO CONTACT IF ADDITIONAL INFORMATION IS NEEDED

STORAGE SITE ROUTINE IDENTIFIER CODE

Figure 2-11. DA Form 1804, Petroleum Sample.

2-16. TESTS, TESTING INSTRUMENTS AND TEST KITS.

a. Tactical Fuel System Tests. The field test kits and equipment issued with the Tactical Fuel Systems are designed to support an effective quality surveillance program in the field. The kits provide quick, reliable methods of performing tests required by current directives. Each self-contained, portable unit is accompanied by detailed operating instructions. The importance of

accurate sampling procedures and techniques cannot be overstated; an improperly obtained sample can completely invalidate test results. It remains imperative that only well-trained personnel conduct these procedures. This section describes tests, instruments, and test kits currently available for use by the TFS. Refer to MIL-HDBK-200, NAVAIRINST 10340.3B, and ASTM Standard Test Methods 287, 2276, 3240, and Standard Practice 4057 for complete information and requirements.

b. AAFS and TAFDS Test Kit Allowances.

(1) AAFS. Each AAFS unit is issued an Aviation Fuel Contaminant Test Kit (AFCTK), a Fuel Sampling Kit, and a Petroleum Sampling and Gaging Kit.

(2) TAFDS. The TAFDS units are each supplied with a Combined Contaminated Fuel Detector (CCFD), an AFCTK, a Fuel Sampling Kit, and a Petroleum Sampling and Gaging Kit. The CCFD and AFCTK are functionally interchangeable: both measure solid and water contamination. The AFCTK is capable of using any one of three power sources: internal or external batteries or an AC power source. Accordingly, the AFCTK serves the far forward dispensing points while the CCFD is employed in the rear, secured areas.

c. Combined Contaminated Fuel Detector (CCFD). The CCFD (NSN 6640-01-013-5279) unites the Contaminated Fuel Detector (CFD) and the Free Water Detector (FWD) into one portable unit. The instrument includes basic systems for: (1) vacuum pumping of sample liquids through filters to collect contaminants; (2) determining solid contamination by means of light transmission (CFD); and (3) determining free water contamination by means of ultraviolet fluorescence (FWD). The CFD is an independent unit; the FWD uses the CFD's power source and sampling pump.

(1) Tabulated data:

Width	19in
Depth	9.75 in
Height	18.5 in
Weight (approximate)	48 lbs
Power source	115 VAC, 60 Hz

(2) Assemblies:

Aluminum case assembly
Filter holder assembly, including bottle receiver and stopper
Fuel flask assembly
CFD light detection base assembly
Lamp assembly
Photocell holder assembly
Milliammeter
Constant voltage transformer

Figure 2-12. Contaminated Fuel Detector

d. Contaminated Fuel Detector (CFD).

(1) Description. The CFD (NSN 6630-00-706-2302), also known as the AEL MK Ill, is a portable unit capable of measuring solid contaminants in fuel. Refer to figure 2-12. Fuel samples from a sampling bottle are passed through a detachable filter holder into a built-in fuel flask. A vacuum pump system accelerates the filtration. The membrane filters are then evaluated by placing them in a receptacle where they are illuminated from underneath. The amount of light transmitted through the filters is measured by a photovoltaic cell, connected to a milliammeter. A constant voltage transformer and adjustable potentiometer or lamp assembly are provided to control the light reading. Each CFD is furnished with Wratten calibration filters; the calibration curve established by measuring these filters is used to convert the meter readings to contamination levels in milligrams per liter (mg/L). The maximum allowable limit of solid contamination for Navy and Marine Corps aviation fuel is 2 mg/L. The kit contains 0.65 micron filters, wash bottle, bottle receiver assembly, filter base and stopper, fuel flask, drain cock, vacuum pump, grounding connector and forceps.

(2) Operating Principle. The level of solid contamination is measured by using the principle of light transmission through a suitable membrane filter. When a fuel sample is passed through the membrane, solid contaminants are retained on the membrane surface. If a beam of light is directed through the membrane, part of the light will be absorbed by the trapped solid particles. To eliminate error caused by the color of the fuel itself, a second filter is used as a control. The first filter traps the contaminant particles, then clean fuel passes through to the second filter. The difference in light transmission through the two filters depends only on the amount of solid contamination. By measuring this difference, it is possible to establish the level of contamination.

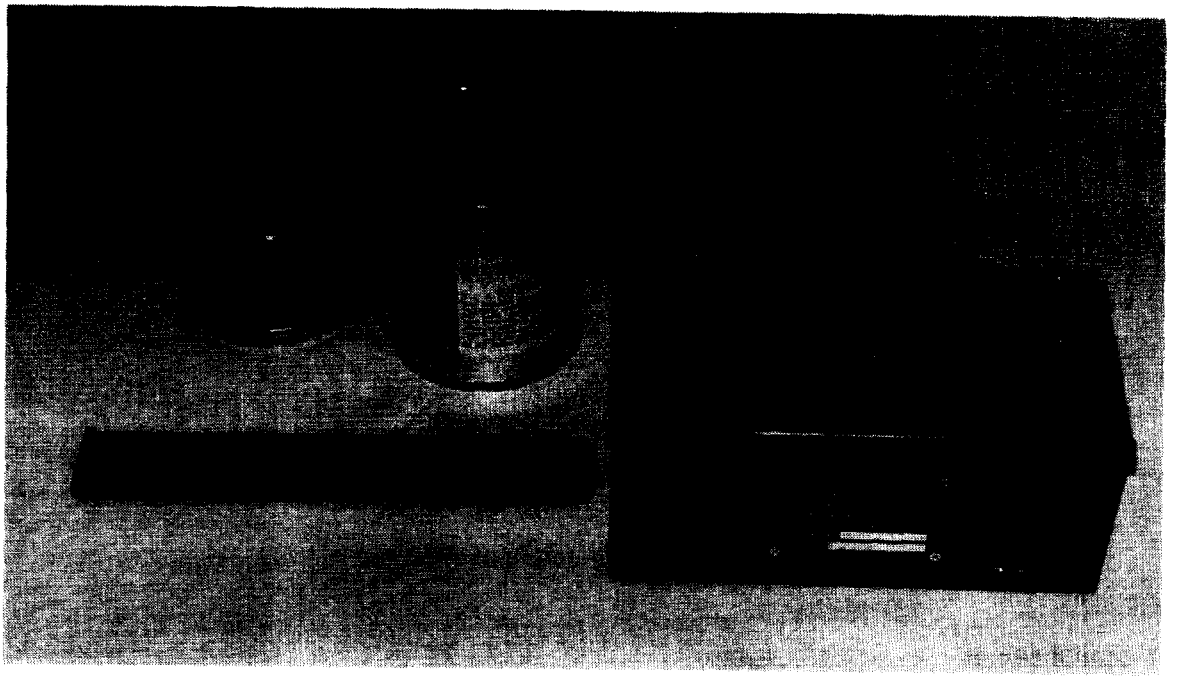


Figure 2-13. Free Water Detector

e. Free Water Detector (FWD).

(1) Description. The FWD (NSN 6640-00-999-2786), also known as the AEL MK II, is a portable kit capable of measuring free water in fuel. Fuel samples are passed through a chemically treated filter pad. When the pad is viewed under an ultraviolet light, free water will appear as fluorescing particles. A visual comparison is made with a series of standards having known quantities of water. The maximum allowable limit of free water in fuel at aircraft dispensing points is 5 parts per million (ppm) when tested by the FWD. The kit, figure 2-13, contains a viewer kit, detector test pads and standards, a slide plate, sample pads, a polyethylene bottle, a filter holder, forceps, and ultraviolet lamp assembly.

(2) Operating Principle. The level of free water contamination is measured by using the reaction between any undissolved water and sodium fluorescein to produce a yellow-green fluorescence under ultraviolet light. A sample of fuel is filtered through an absorbent water detector pad coated with sodium fluorescein. The test pad is then examined under ultraviolet light and the intensity of the resulting fluorescence is visually compared to that of a set of standards representing 0, 5, 10, and 20 mg/L (or parts per million (ppm)) free water contamination concentrations. An eye comparison is normally accurate to within 2 mg/L and this sensitivity is not affected by normal concentrations of anti-icing additives, corrosion inhibitors, and /or naturally occurring solid contaminants in the fuel.

Figure 2-14. Petroleum Sampling and Gaging Kit

f. Petroleum Sampling and Gaging Kit. The Petroleum Sampling and Gaging Kit (NSN 6630-00-151-5310), figure 2-14, is used as the first check upon receipt of fuel from any source outside the TFS. The kit is intended for sampling, water detection, and determining the quantity of petroleum products contained in tanks at bulk storage facilities. The kit contains the equipment needed to perform quality surveillance Type C tests (color, appearance and API gravity) which are used primarily for identification of fuel. Water-indicating paste provides a qualitative method of determining the existence of water bottoms in tank cars or trucks. Testing instructions are found in the ASTM Test Method pamphlet included in the kit.

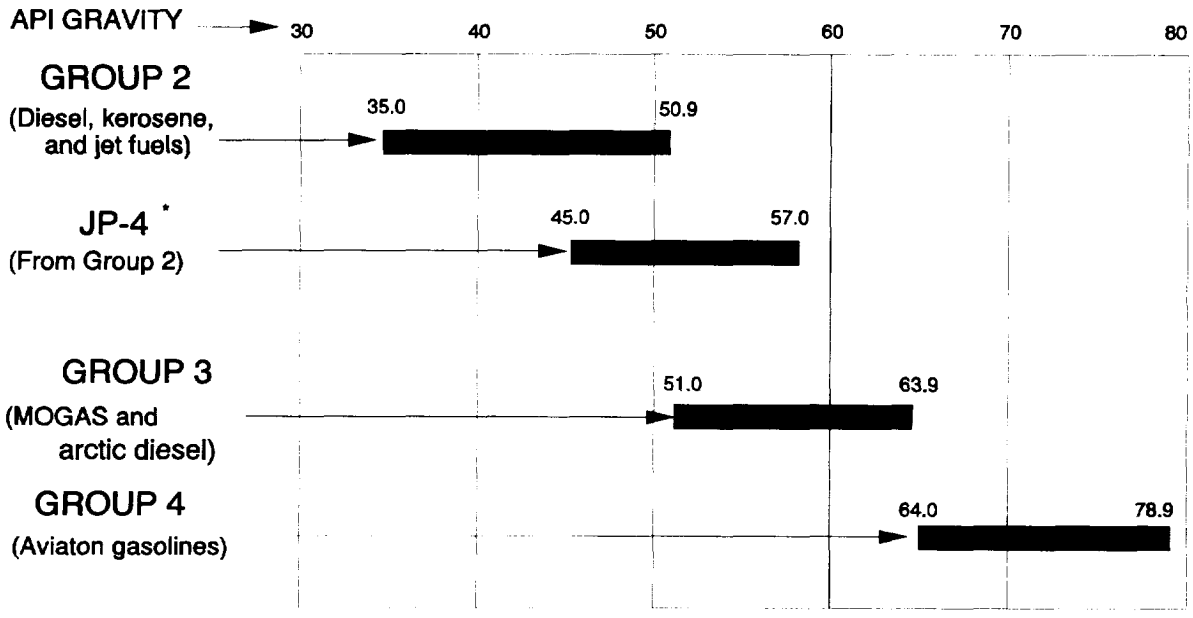
(1) Color and Appearance Test. The fuel should be clean, bright, and free of visible particles, water, and cloud. The fuel color should agree with the type of fuel; that is, MOGAS and AVGAS 80/87 are red, AVGAS 100/130 is blue or green, and jet and diesel fuels are colorless to amber. The appearance test requires collecting a fuel sample in a clean, clear container provided in the kit. The fuel in the container is swirled to form a vortex (whirlpool). Any sediment in the sample will accumulate on the bottom of the container directly under the vortex. Cloudiness indicates water; visible particles indicate sediment or other contaminants. Contaminants and their appearance, characteristics, and effects are listed in table 2-4. The sediment limit in fuel of acceptable quality is very slight or barely visible.

(2) API Gravity Test. Each type and grade of fuel has a characteristic API gravity range, as shown in table 2-3. API gravity confirms the identity of fuel received from multiproduct tanks and helps prevent commingling of fuel types. A hydrometer, hydrometer cylinder and thermometer are provided in the kit to conduct the API gravity test.

(3) Overall dimensions:

Height . . . .8.88 in
Width . . . . . 15.44 in
Weight . . . .20 lbs

Table 2-3. API Gravity Groups (Corrected to 60° F)



*The specification for JP-4 requires API gravity of not less than 45.0 and not more than 57.0. The specifications for diesel, MOGAS, and AVGAS contain no such positive API gravity requirements, but experience indicates that these fuels fall into the API gravity ranges indicated above for groups 2, 3, and 4.

Table 2-4. Visual Contamination Table (1 of 2)

TYPE OF CONTAMINANTS	APPEARANCE	CHARACTERISTICS	EFFECTS ON AIRCRAFT
WATER:			
Dissolved water	Not visible	Fresh water only; precipitates out as cloud when fuel is cooled.	None, unless separated by cooling; then acts as free water.
Free water	Light or heavy cloud; droplets cling to sides of the bottle or settle to the bottom in globules.	Salt water or fresh water. Cloud usually indicates water-in-fuel emulsion.	Fuel system icing; erratic fuel gauge readings. Large amounts cause flameouts. Salt water corrodes components.
SEDIMENT:			
Rust	Red or black powder, rouge or grains. May appear as dye-like material in fuel.	Red rust (Fe203) nonmagnetic. Black rust (Fe304) magnetic. Rust comprises 70-90% of total sediment.	Sticking, sluggishness or general malfunction of fuel controls, flow dividers, pumps, nozzles, etc.
Sand or dust	Crystalline, granular or glasslike	Up to 20% of total sediment.	Same as rust
Aluminum or magnesium	White or gray powder or paste	Sometimes sticky or gelatinous when hydrated. Up to 10% of total sediment.	Same as rust
MICROBIOLOGICAL GROWTH:	Brown, gray, or black. Stringy or fibrous.	Usually found with other contaminants in the fuel. Very lightweight; floats or swims. Develops only when free water is present.	Fouls fuel quantity probes, sticks flow dividers, makes fuel controls sluggish.

Table 2-4. Visual Contamination Table - Continued (2 of 2)

TYPE OF CONTAMINANTS	APPEARANCE	CHARACTERISTICS	EFFECTS ON AIRCRAFT
EMULSIONS:			
Water-in-fuel emulsion	Light or heavy cloud	Finely divided drops of water in fuel. Same as free water cloud. Will settle to bottom in minutes, hours, or weeks, depending upon nature of emulsion.	Same as free water
Fuel-in-water (Inverse emulsion)	Faint red, gray or black. Sticky material described as gelatinous, gummy, or "mayonnaise-like". May appear as stringy, fibrous material in clear or cloudy fuel.	Finely divided drops of fuel in water. Adheres to most materials. Will stand for days to months without separating. Contains 50-70% water, 30-50% fuel, and a small amount of fine rust.	Same as free water and sediment, only more drastic. Quickly plugs filters.
MISCELLANEOUS:			
Interface material	Lacy bubbles at fuel-water interface. May resemble jellyfish.	Extremely complicated chemically. Occurs only when emulsion and free water are present	Effects due to presence of free water.
Air bubbles	Cloud in fuel	Disperses upward within a few seconds.	None

g. Aviation Fuel Contaminant Test Kit (AFCTK1. The AFCTK (NSN 6630-01-008-5524), figure 2-15, contains components and testing equipment capable of determining the particulate contaminant level, API Gravity and temperature, and free water content in aviation fuel samples. This kit is used in forward dispensing point areas. A sampling apparatus is provided which connects directly to the fuel system through quick release attachments. The following discussion explains each type of test contained in this kit. TM 5-6630-218-10 should be consulted for detailed operating procedures and additional information.

(1) Overall dimensions:

Length . . . .21.5 in
Width . . . . . .14.5 in
Height . . . . . .16.5 in
Weight . . . .45 lbs

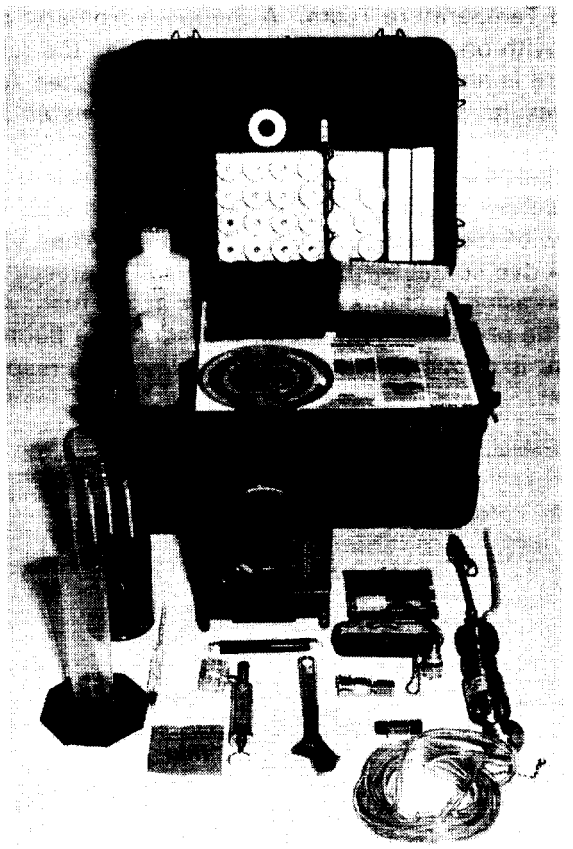


Figure 2-15. Aviation Fuel Contaminant Test Kit

(2) Particulate Contaminant Level. Measuring the amount of particulate contaminants can be accomplished using one or both of two test methods: the Color Comparator Method and/or the Gravimetric Method. The Color Comparator Method can be performed at the test location with visual analysis; this method is recommended for the initial check of the sample's particulate contaminant level. If color comparator test results are marginal or unacceptable, a gravimetric analysis is required. The Gravimetric Method involves measurement of contaminants through an off-site laboratory analysis and is a more exact method. Both tests involve the same initial sampling procedures; the difference is the method of analysis.

(a) Color Comparator Method. A sample of fuel is passed through a test membrane filter housed in a plastic monitor (known as contamination monitors) and the resulting color and particulate remaining on the filter are compared to standards contained in the Aviation Turbine Fuel Contaminants Standards booklet provided in the kit. The contamination monitors are identified by blue and red protective plugs.

(b) Gravimetric Method. A fuel sample is collected using a matched weight monitor (identified by yellow and red protective plugs) containing two filters. The monitor is labeled, wrapped and shipped to a designated reference laboratory for analysis. In the laboratory, the filters are weighed, washed, dried, and reweighed. The particulate contaminant level is determined from the increase in weight of the test membrane filter relative to the control membrane filter.

(3) API Gravity and Temperature Tests. A thermohydrometer permits measurement of API gravity and temperature with one instrument. After recording the readings, a gravity calculator attached to the tast kit placard is employed to determine the corrected API gravity, temperature, and relative density. These results are recorded and compared to established sits standards.

(4) Undissolved (Free) Water. A measured sample of fuel is passed through a uranine dye-treated filter pad. Undissolved water in the fuel sample reacts with the dye for subsequent detection and measurement with the Aqua-Glo Water Detector. When viewed under the ultraviolet (UV) light in the detector, the dye contacted by free water will fluoresce a bright yellow. The brightness increases with increasing amounts of free water in the fuel. A known standard is used to calibrate the instrument. The photocell comparator measures the fluorescent intensity on the test pad and the measurement is converted to a meter display. The results are expressed as parts per million (ppm) of free water.

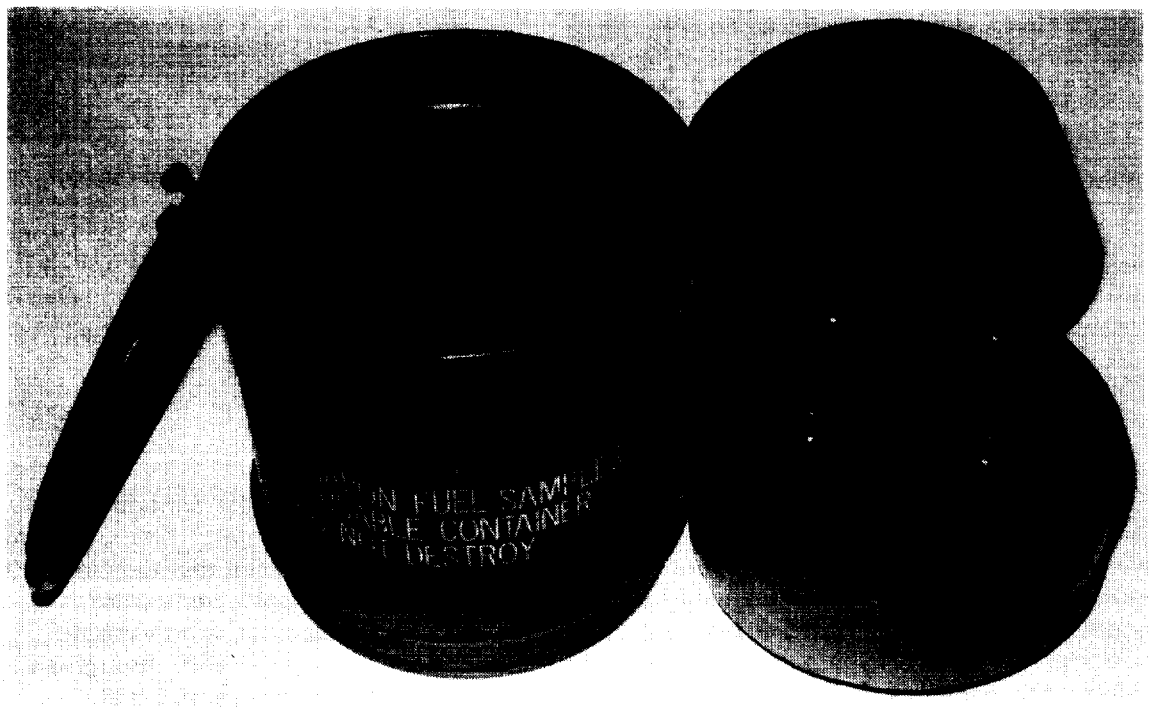


Figure 2-16. Fuel Sampling Kit

h. Fuel Sampling Kit. The Fuel Sampling Kit (NSN 8115-00-719-4111), figure 2-16, provides all the necessary equipment needed to ship fuel samples to reference laboratories. The containers meet requirements for shipment of aviation fuels by military and commercial transportation modes. Fuel samples are collected in the sample bottles provided, labeled with all the necessary identifying information, and shipped to an approved reference laboratory. Samples are classified as routine or special. Routine samples are taken as part of a quality surveillance program, when no fuel problems are known or suspected. Spatial samples are submitted for testing bacause the quality of the fuel is suspect; these specimens have the highest priority in handling, testing and reporting.

i. Tactical Petroleum Laboratory, Medium (TPLM).

(1) The TPLM, figure 2-17, has been designed to provide an organic quality control capability for bulk fuel operations in the field. It will provide the capability to test suspect deliveries for acceptability and suitability, and will permit captured fuels to be tested for suitability as well, The TPLM provides the essential testing components integrated into a standard USMC 8'x8'x20', International Standard Organization (ISO) shelter to monitor the critical physical and chemical characteristics of aviation and ground fuels. JP-4, JP-5, JP-8, Diesel and their commercial grade equivalents can be tested to composition and quality against minimum standards as specified in MIL-HDBK-200, Quality Surveillance Handbook for Fuels, Lubricants, and Related Products.

(2) General Characteristics:

Length . . . .20 ft.
Width . . . .8 ft.
Weight . . . . . 9960 lbs.
Height . . . .8 ft.

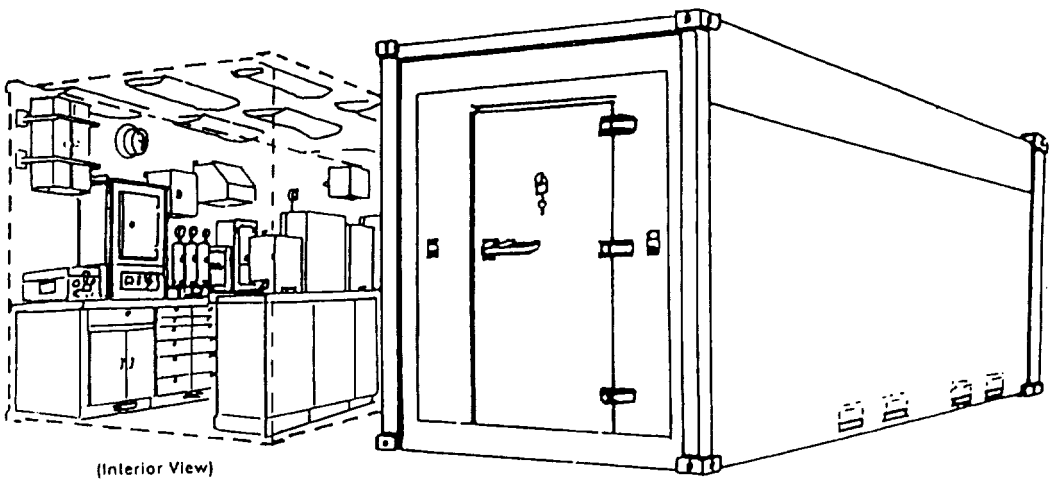


Figure 2-17. Tactical Petroleum Laboratory, Medium

Section IV. BULK FUEL TRANSFER

2-17. MEASUREMENT OF FUEL.

a. Special Considerations. Standard gaging and measuring procedures generally prescribed for petroleum products are not applicable to the TFS due to the nature of the collapsible tanks. The tanks are not designed to employ strapping charts, nor is there a practical method of sampling the product while it is in the tank. Accuracy of inventory determination is further compromised by the reliance on tactical metering devices as the only tool for fuel measurement. The meters are calibrated to tolerances of ± 5 percent accuracy. Although this may seem to be a reasonable level, it results in a large variation in fuel accounting in the field. An accounting procedure is

required which takes into consideration the special nature and limitations of the expeditionary force bulk fuel storage components and practices.

b. Summary Accounting. As applied to tactical fuel systems (i.e., collapsible storage tanks), summary accounting is defined as a disciplined process for controlling the receipt, issue, and storage of gross amounts of bulk petroleum product in the field. The process depends on locally developed and approved accounting procedures with POL management criteria tailored to the specific capabilities/limitations of expeditionary equipment. The basic provisions of DoD 4140.25 and MCO 4400.170 apply within the limitations of a particular TFS design, and security and control are stressed to prevent the unauthorized dispensing/theft of fuel. Local Standard Operating Procedures (SOP) shall address fuel accounting/inventory procedures. Reconciliation should be accomplished monthly, at a minimum, between receipts, issues (log book) and the physical on hand inventory to ensure proper accounting.

2-18. BULK FUEL TRANSFER TO AND FROM SMALL CONTAINERS.

a. General. Bulk fuel reduction plays a primary role in tactical operations. The TFS contain associated hardware required to fill and drain military 5-gallon cans and 55-gallon drums. The proper performance of these operations is necessary to ensure maintenance of product quality and safe operations. Refer to TM 10-1101 for more detail on the storage and issue of packaged fuel products.

b. Inspection. Prior to filling, all cans and drums must be carefully inspected for moisture, rust, and holes; for tight bung fittings; and for tight, perfectly formed gaskets. Any containers found to contain liquid, moisture droplets, pitted or scaled rust, or any foreign matter should be segregated for further cleaning or reconditioning. The type of fuel previously held by the container must be ascertained. If the grade is to be changed, the cleaning procedures outlined in Chapter 2, Section V, must be strictly followed.

c. Precautions. All fuel handling safety precautions discussed in paragraph 2-6 apply to bulk fuel reduction operations. Particularly, the following precautions should be observed:

(1) Filling operations must be performed in a well-ventilated area.

(2) Quality surveillance tests are required before dispensing fuel.

(3) Water cans must not be used as fuel containers.

(4) Inspect containers; replace worn or damaged gaskets and check closure threads for deformities.

(5) All fuel containers should be tightly closed for storage.

(6) Containers should be handled carefully to avoid damage and excessive agitation. Shaking the filled container will increase the internal pressure and cause fuel to splash out when opened.

(7) Fire extinguishers and loose sand or dirt should be readily available and properly located during filling operations.

(8) The use of spark-proof tools is required.

(9) The use of bonding and grounding measures is imperative. Never fill containers on a truck unless the truck is grounded. When filling a container, the hose nozzle must be in contact with the metal opening of the container before fuel discharge and must remain in contact during delivery. The nozzle or loading spout should be inserted well within the container opening to prevent spray or spill and remain in contact with the container opening until the nozzle valve is shut off.

(10) The filling operation should be closely watched to prevent overfill and to stop the operation in case of emergency. If a spill occurs, cover the spill area immediately with loose dirt or sand.

(11) Fill containers to the proper level as explained in the following paragraph.

d. Fill Levels. Cans and drums should be filled to the levels indicated in figure 2-18. The empty space shall be about one-twentieth of the container volume. Properly filled containers accommodate changes in volume due to temperature variations. Insufficient space may cause the container to leak or rupture when fuel volume expands as temperature rises. Too much space allows moisture from the air to condense in the container as the temperature drops or may provide an environment where an explosive fuel-air mixture forms as the temperature rises.

e. Emptying Cans and Drums. Containers should be placed on a level surface and openings wiped clean and dry before plugs are removed. With a spark-proof universal bung wrench or other suitable tool, the plug should be loosened gradually. This permits fuel vapor to escape slowly and prevents blowby. Blowby is a sudden release of air-vapor mixture from a confined space, often followed by a spillover of the liquid. A representative number of containers should be sampled and tested to assure product identification and quality of the lot or batch. Emptying a can or drum is accomplished using drum unloading valves connected by suction hose to drum unloading manifolds. Prior to storage, the containers should be completely emptied by pumping or pouring and the plugs installed wrenchtight.

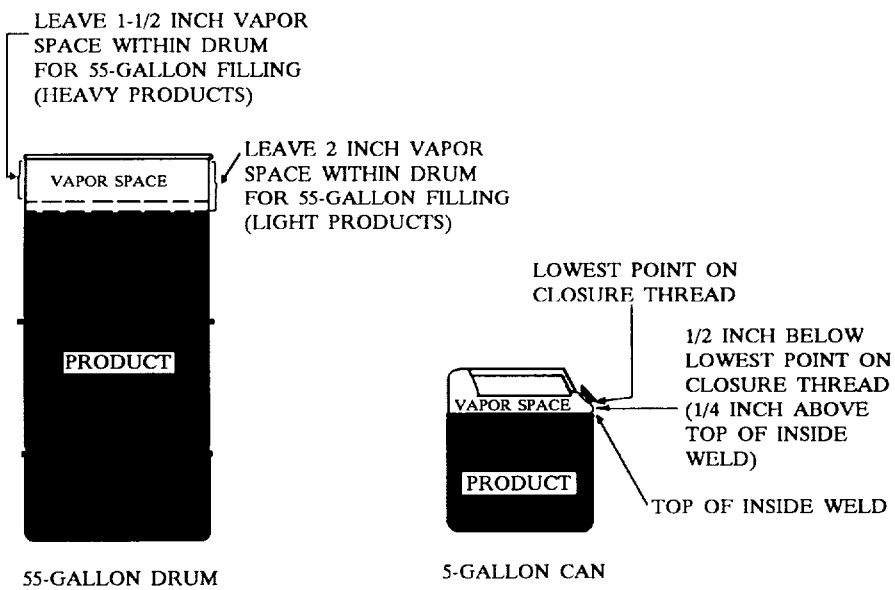


Figure 2-18. Fill Levels for 5-Gallon Cans and 55-Gallon Drums

f. Rotation of Packaged Products. Packaged petroleum products should be stored in sections by product date and batch number. The oldest batch should be issued first, safeguarding against deterioration due to long term storage.

g. Care of Packaged Products. The quality and performance value of petroleum products are significantly affected by bulk reduction operations. Damaged containers and seals, careless handling, improper marking, or inefficient control of stock can ultimately result in damage to and excessive maintenance of using equipment. The threat of water contamination is increased when containers are improperly sealed and/or stored upright. Areas of high humidity and salty atmosphere promote corrosion; packaged products stored in such areas require more frequent inspection.

h. Storage of Drums. A level site should be selected. Drums should be stacked horizontally on suitable dunnage. Normally, low flash products should not be stored in rows more than 35 drums long nor more than 3 tiers high. High flash products may be stacked up to six tiers with proper blocking and shoring. Use double rows with the closures (bungs and vents) facing the aisles at the 3- and 9-o'clock positions. Keep approximately 1 foot of space between the butts of drums in the double row. See figure 2-19 for details. By making the closures accessible, it is easier to identify contents, detect leaks, tighten bungs, and change gaskets. Space between the butts of the drums permits efficient operation of drum-handling attachments and ease of inspection. Except in an emergency, containers must not be stored in direct contact with the ground. If the drums are stored on end, rainwater, snow, or ice will collect in the drum heads, deteriorate markings and rust the heads. Water may also seep through bungs and vents and contaminate the product.

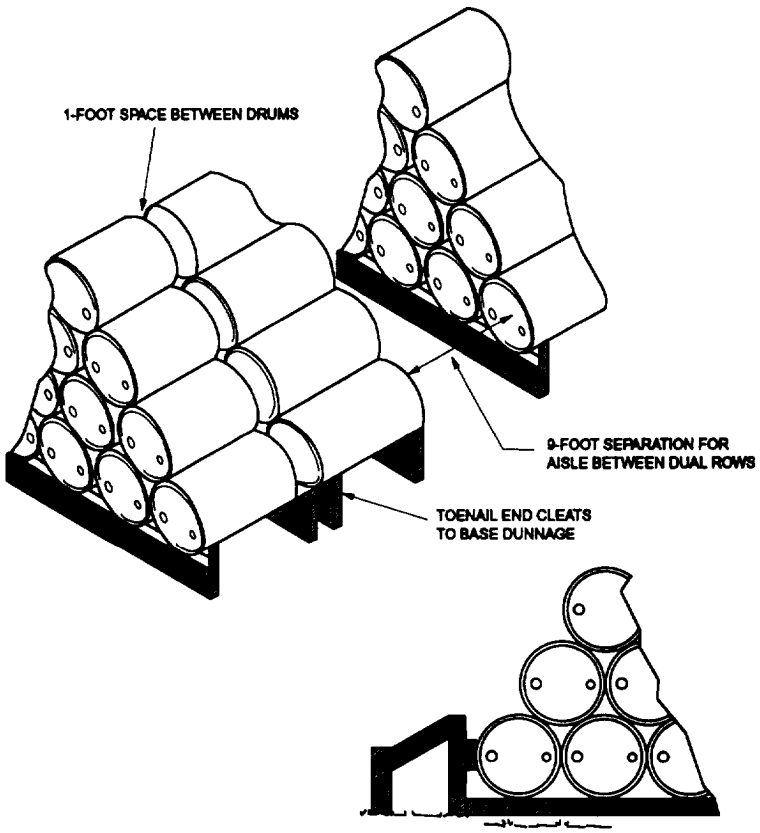


Figure 2-19. Proper Alignment for Stacked Drums

i. Storage of 5-Gallon Cans. To conserve space and provide stability, filled 5-gallon cans should be stacked in pyramids, normally four tiers high, unless cans are palletized. This method is shown in figure 2-20.

j. Storage of Empty Containers. Empty containers should be protected from damage by careless handling and from contamination of the interior by dirt, water, or other foreign matter. Tightly closed containers will retard corrosion and prevent escape of combustible vapors. Empty containers previously containing petroleum products should be treated as explosion hazards and handled accordingly. Empty drums and cans may be stacked by any of the methods prescribed for filled drums and cans but without height limitation.

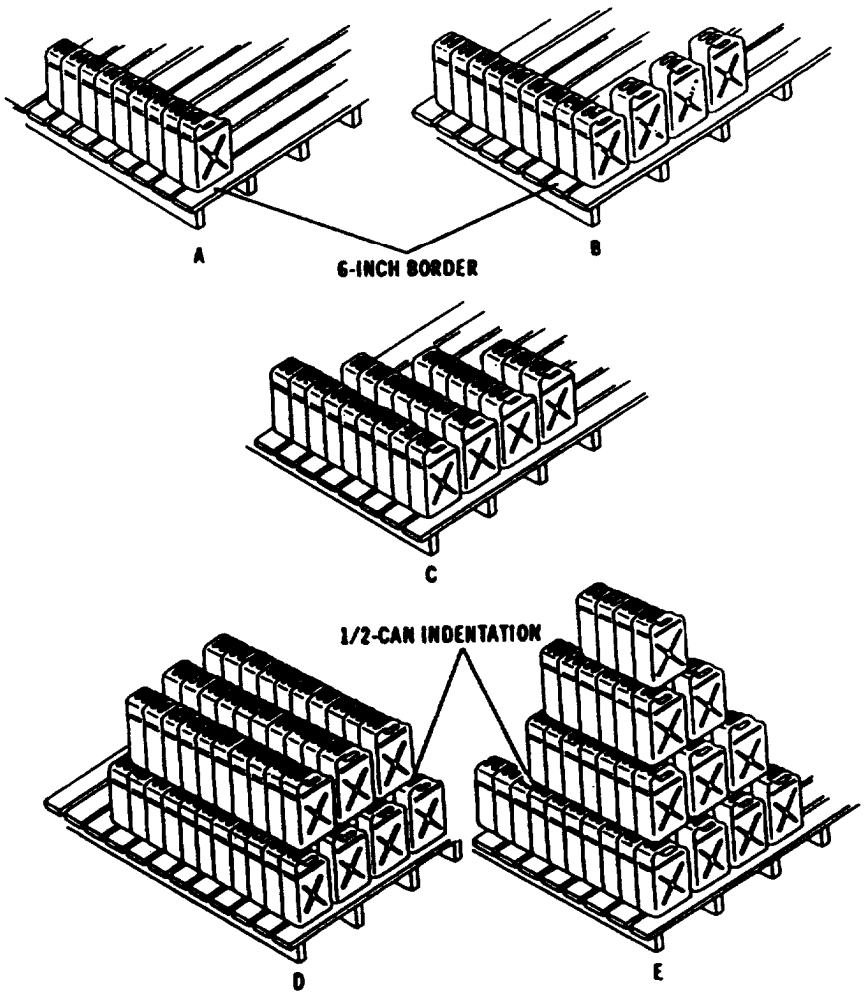


Figure 2-20. Pyramidal Stacking of Filled 5-Gallon Cans

2-19. REFUELING GROUND VEHICLES.

a. Preliminary Procedures. All fuel handling safety procedures, including bonding and grounding, must be closely observed. In particular, the following steps should be taken:

(1) Ensure that the dispensing system is functioning properly. Inspect all components and fittings daily and check for leaks.

(2) Inspect the receiving vehicle or equipment. Ensure the product last carried is the same as the product being dispensed.

(3) Perform quality surveillance tests before delivery of fuel.

(4) Record amount of fuel dispensed according to prescribed accounting methods.

b. Personnel Requirements and Procedures. Ground vehicle refueling procedures will be established by local SOP; however, for safety reasons, a minimum of two personnel will be required at all times.

(1) The dispensing operator (pump operator) ensures that proper bonding and grounding connections are made, sets up the hose assemblies, and starts the pump. He adjusts manifolds and valves, and supervises/monitors the dispensing procedure.

(2) The receiving vehicle operator (nozzle operator) maneuvers the hose and nozzle to dispense fuel, assuring that the nozzle remains in firm contact with the vehicle filler neck throughout the refueling operation.

2-20. REFUELING AIRCRAFT.

a. Reference. The NATOPS Aircraft Refueling Manual (NAVAIR 00-80T-109) shall be consulted for complete descriptions and procedures concerning aircraft refueling requirements.

b. Aircraft Refueling Area. The aircraft refueling area is an essential part of the overall airfield ground traffic pattern. The site must be accessible to but not interfere with taxiing aircraft. Clear access must be provided for rescue vehicles and firefighting equipment. The safety of adjacent equipment and installations must also be considered.

c. Cold Refueling. Cold refueling is defined as the process of fueling an aircraft when the aircraft's engines and electrical power units are off.

(1) Preliminary Procedures. TFS personnel will recirculate fuel and perform quality tests daily prior to refueling aircraft, and will ensure that the refueling site is clear of foreign object damage (FOD). Before entering the refueling area, the pilot will disarm the aircraft's ordnance and shut off all electrical and electronic equipment. Brakes must be checked to make sure they are not hot. The aircraft is moved into the refueling position, chocked securely, engines shut down and switches turned off.

(2) Personnel Requirements and Procedures. Cold refueling requires the efforts of three people: nozzle operator, driver/operator, and fire extinguisher operator. First, the refueling area must be checked for ignition sources. Than the type of fuel is verified and, if requested, a sample is taken by the fuel operator. The nozzle operator connects the bonding devices. During fuel delivery, the fuel operator monitors meter readings and remains in position throughout the entire operation. Both nozzle and fuel operators complete the paperwork and dismantle refueling operations.

d. Hot Refueling. Hot refueling is defined as the process of fueling an aircraft while the aircraft's engines and electrical power units are on.

(1) Preliminary Procedures. Hot refueling is significantly more dangerous and labor intensive than cold refueling, and, therefore, is only performed when operational necessity dictates. Before the aircraft enters the refueling area, the activity's crash crew is placed on alert. (When JP-

4 is refueled, a fire truck is placed in the immediate vicinity.) All unnecessary electrical and electronic equipment is secured, ordnance is safed, and a hot brake check performed. All aircraft and refueling equipment is checked and a nozzle sample taken, if requested, before the aircraft enters the refueling site, Ear protection devices are mandatory for the ground crew. After the area is policed for loose objects, the aircraft is guided into position by a qualified aircraft director.

(2) Personnel Requirements and Procedures. At a minimum, each direct hot refueling station must have the following personnel: a refueling coordinator, qualified fuel operator, nozzle operator, aircraft pilot, and firewatch operator. After the aircraft taxies into the refueling pit, the brakes are checked, grounding cable attached, and quantity of fuel determined. Once the bonding cable is attached, the pressure locking nozzle is inserted into the refueling receptacle. Crew members must constantly attend the refueling nozzle and fire extinguisher. Flow rate and meters are monitored, and at the pilot's signal, fuel flow is terminated. Operations are shut down in reverse order. Should it be necessary to refuel the aircraft through the aerial refueling probe, all the same measures apply except those specific to the SPR nozzle. In addition, a platform is needed to reach the probe.

2-21. DEFUELING AIRCRAFT.

a. Reference. The NATOPS Aircraft Refueling Manual (NAVAIR 00-80T-109) shall be consulted for complete descriptions and procedures concerning aircraft defueling.

b. General. Defueling is one of the most technically demanding and potentially dangerous operations performed by fuel personnel. Most aircraft defueling equipment has the capability of defueling an aircraft faster than the aircraft can release it. The precarious balance of pump suction and discharge requires constant attention to valve manipulation by a qualified fuel operator. Strict tolerances must be maintained throughout the procedure and a log kept detailing the entire operation. Disposition of the fuel will be in accordance with NAVAIRINST 10340.3_ and local instructions.

c. Precautions. All safety precautions and procedures for aircraft refueling apply. In addition, the following measures must be observed:

(1) Vehicles will be plainly marked "DEFUELER" as required by current directives. If a collapsible tank is used, it must be completely separated from the rest of the TFS.

(2) A vehicle marked "DEFUELER" will not be used to fuel a using vehicle nor will a vehicle marked "REFUELER" be used to remove fuel unless specifically authorized.

d. Preliminary Procedures. The aircraft to be defueled is spotted 100 feet from all structures and aircraft in an area free of other maintenance operations and ignition sources. Bonding and grounding connections are made and fire extinguishers are in place.

e. Personnel Requirements and Procedures. Every aircraft defueling operation requires a minimum of three people: the defuel truck operator, a nozzle operator, and a fire watch. A determination is made on the fuel status (suspect or nonsuspect) and quantity to be defueled. Pumping must be carefully monitored for cavitation throughout the procedure. Defueling is completed by manually draining the remaining fuel from the aircraft low point drains and then securing all equipment.

Section V. PRODUCT CHANGES AND SYSTEM STORAGE

2-22. GENERAL.

a. Product Changes. When changing fuel types or grades in storage tanks, provisions must be made to assure that no commingling of fuel products occurs. This is accomplished by following the guidelines outlined in MIL-HDBK-200.

b. System Storage. When tactical field operations are discontinued, TFS unit assemblies and components should be disassembled, purged of residual fuel and fumes, cleaned and repacked for future use.

2-23. PROCEDURES.

a. Disassembly Procedures. The following steps should be observed when disassembly of the fuel dispensing system is required:

(1) Pump fuel remaining in system into the smallest number of tanks possible, maintaining separation of fuel products.

(2) Remove fuel in the tanks by filling drums or other suitable containers.

(3) Drain back all hoses and close both end fittings with caps. Use the fuel hose evacuation kits supplied in the AAFS general repair kit to evacuate hose lines in the AAFS and TAFDS. (See Hose Evacuation Procedure (2-23b).)

(4) Drain, ventilate, and dry all components as necessary; purge as required.

WARNING

Exercise extreme caution using compressed air to purge hose lines of residual fuel or fumes. Serious injury or death could occur if compressed air is directed at the skin.

(5) Preserve interior of components by coating with a thin layer of SAE No. 10 non-detergent oil.

(6) Seal all quick-disconnect fittings with dust caps and plugs; turn all valves one-quarter open.

(7) Repack complete units in their original chests when possible. Take care to ensure that collapsible tanks are packed so as to prevent damage to the cloth.

b. Hose Evacuation Procedure. The Hose Evacuation Kit facilitates removal of fuel and vapor from the 4-inch and 6-inch hose lines of the AAFS and TAFDS. Complete instructions are furnished in TM-05672A-15. The hose evacuation operation is described below:

(1) To begin removing fuel from the system, place a hose clamp on the section of hose just in front of the pump discharge manifold where the hose line system starts, e.g. Beach Unloading Station. Clamp the hose securely, Disconnect the hose from the pump and attach the ball sender unit, with the properly sized ball, to the hose.

(2) Move the pump to the other end of the hose line and connect it to the system. Alternately, utilize an existing pump positioned at the desired location, e.g. Booster Pump Station. Place a second hose clamp on the upstream side of the “Y” fitting. Clamp securely. Completely close both gate valves. Disconnect the hose from the "Y" fitting and attach the ball receiver to the hose and to the “Y” fitting. Release the hose clamp and open one or both gate valves.

(3) Attach an air compressor hose to the ball sender unit at the start of the system, release the hose clamp, and supply air pressure at 70 psi maximum. When the air pressure at the compressor drops off, or when advised that the ball has arrived at the receiver unit, secure the air pressure. It takes approximately 5 to 8 seconds for a 4-inch ball to travel through a 50-foot hose. Completely close both gate valves at the ball receiver end of the system.

(4) After the displacement ball has removed the greater portion of fuel from the hose line, it is then necessary to remove vapor and residual fuel. To begin, disassemble the ball receiver from the "Y" fitting at the end of the hose line.

(5) At the beginning of the hose line attach the short leg of the eductor assembly to the ball sender unit. Connect the air compressor line to the pneumatic coupling of the eductor assembly and supply air at 70 psi maximum.

(6) Repeat the preceding steps throughout the system until all transfer lines are evacuated.

(7) Stow hose evacuation equipment when the operation is complete.

Section VI. DEMOLITION

2-24. GENERAL.

a. Decision to Demolish. When capture or abandonment of fuel handling equipment to an enemy is imminent, the responsible unit commander must make the decision either to destroy the equipment or to render it inoperative. Based on this decision, orders are issued which cover the desired extent of destruction. Unit standard operating procedures should have a destruction plan developed to fit the local situation.

b. Demolition of Equipment and Fuel. Precautions must be heeded to ensure the safety of personnel when complete destruction of the fuel and delivery system is undertaken

2-25. METHODS OF DEMOLITION.

a. Mechanical Means. Puncture cans and drums with axes, picks, bayonets, or other available tools. Make at least two holes in each on opposite sides or ends. Cut hoses and fabric tanks, using slashes large enough to prevent repair. Smash metal equipment, gages, meters, controls, fuel monitors, and filter-separators with sledge hammers, crowbars, picks, or axes.

b. Misuse. Drain the radiator (if applicable) and crankcase of motor-driven equipment. Put sand, nuts, bolts, sugar, or broken glass into the radiator opening, oil filler tube, and fuel tank. Disconnect the radiator fan and run the engine at full throttle.

c. Explosives or Weapons Fire. If time permits and equipment is available, destroy major items by demolition with explosives, supplemented by incendiary rounds to ignite the spilled fuel and complete the destruction by burning.

CHAPTER 3

TACTICAL FUEL SYSTEMS EQUIPMENT

Section I. TANKS, HOSES, FITTINGS, AND ACCESSORIES

3-1. GENERAL.

a. Scope. This section provides general operational information on tanks, hoses, fittings, and other accessory components of the tactical fuel systems. The following discussion assumes that the equipment is unpacked, in place, and ready to be placed into operation.

b. Model Variations. With the exception of the tanks, the majority of the items discussed in this section have not changed since their original design. However, there may be minor variations between like items produced by different manufacturers.

c. Preparation for Use. Once the system is installed following the guidelines provided in Chapter 2, Section 1, all tanks, hoses, fittings, and accessories must be thoroughly inspected before being placed into operation. The need for repair/replacement of defective components should be ascertained during inspection and corrective action immediately undertaken.

3-2. GENERAL OPERATING GUIDELINES.

a. Operator's Daily Checks and Services. Frequent and regular inspection of the collapsible tank and other components prior to operation will detect minor deficiencies in the equipment. This practice enables the operator to effect repair before it becomes necessary for higher echelon maintenance. This is particularly true of small tears and punctures in the tank walls. Preventive maintenance for the tanks, hoses, fittings, and accessories is primarily the responsibility of the operator, aided as necessary by organizational maintenance personnel. Table 3-1 lists the operator's daily checks and services with intervals designated as before operation (B), during operation (D), and after operation (A).

Table 3-1. Operator's Daily Checks and Services for Tanks, Hoses, and Fittings (1 of 2)

INTERVAL			PROCEDURE
B	D	A	
			System Area
♦			1. Police the area for stones, sticks, sharp objects, or other debris which might cause tank punctures or create a fire hazard.
♦	♦	♦	2. Handle spilled fuel according to local SOP.
♦			3. Cut grass and weeds using a manual mower or explosion-proof power mower.
			Berm
♦			Keep the berms clean, dry, and free from combustible vapors.

Table 3-1. Operator's Daily Checks and Services for Tanks, Hoses, and Fittings - Continued (2 of 2)

INTERVAL			PROCEDURE
B	D	A	
			Tanks
♦			1. Inspect the vents to ensure that there are no obstructions.
♦			2. Inspect the inlet and outlet fittings to ensure that they are securely fastened.
♦			3. Inspect the operation and position of drain plug.
♦			4. Visually inspect the tank exterior, checking for leaks, signs of corrosion, or weathering.
			NOTE If a leak develops, isolate and repair the leak immediately. If unable to effect repair, empty the tank.
♦			5. Inspect the weather protection and guy lines.
♦			6. Inspect the general integrity of the tank position in the berm.
			Hose Assemblies
♦	♦		1. Inspect the connections to ensure tightness, that the cam-lock lever arms are in the down position, and there is no leakage.
♦			2. Inspect for proper hose type (suction or discharge).
♦			3. Inspect for straight-line flow; there should be no kinks or sharp curves in the hose.
♦			4. Ensure that a closed system exists; every hose section and component must be properly connected to another with no open ends.
		♦	5. On a daily basis, inspect the integrity of the hoses and check for any damage, blisters, or cuts in the outer covering or fabric wall. Inspect for soft spots adjacent to nozzles or couplings.
			Fittings
♦			1. Inspect the operation and position of the gate valves.
♦			2. Inspect wye couplings and manifold nuts to ensure that they are securely fastened.
			Dispensing Nozzles
♦			1. Inspect the operation of the hand-operated valve, including the locking ratchet if applicable.
♦			2. Inspect the grounding equipment to ensure that it is securely fastened.
*			3. On a weekly basis inspect and clean screens.
♦			4. Ensure that the nozzle spouts are securely fastened.

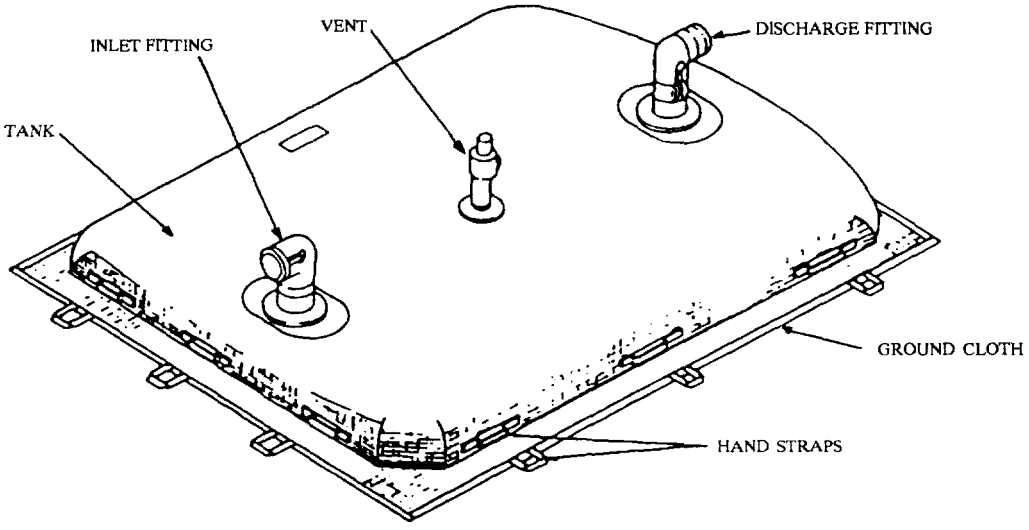


Figure 3-1. 20,000 Gallon Tank

b. Repair Kits. Emergency repair kits and a general repair kit are provided for the maintenance of the tactical fuel systems.

(1) Emergency repair kit. An emergency repair kit is furnished with each collapsible tank and is stored in the partitioned end of the tank chest. The kit includes mechanical repair clamps, O-rings, and gaskets necessary for emergency tank repairs.

(2) General repair kit. The general repair kit (GRK) consists of spare parts, gaskets, packing, and a limited number of tools for routine maintenance, replacement, and repair of individual components in the AAFS and TAFFDS.

3-3. TANKS.

a. General. The 20,000 gallon collapsible fabric tank is illustrated in figure 3-1. The following tabulated data for the tank is nominal and may vary according to manufacturer.

Tank:	
Filled:	
Capacity	20,000 gal
Width	22 ft 3 in ±2 in
Height	5 ft 9 in ±2 in
Length	25 ft 8 in ±2 in
Empty:	
Width	24 ft ±4 in
Length	28 ft
Ground Cloth:	
Length	28 ft
Width	24 ft
Chest:	
Width	31 in
Height	27 in
Length	164 in
Weight (empty)	325 lbs

b. Tank Serviceability Standards. The serviceability of the collapsible tank is determined by the type and extent of the defect. Table 3-2 lists the tank serviceability standards. Defects are categorized as minor, major, critical, and unlisted according to the following definitions:

(1) Minor. A minor defect is one that does not materially reduce the usability of the tank for its intended purpose, This type of defect does not require repair.

(2) Major. A major defect is one other than critical that materially reduces the usability of the tank for its intended purpose. This type of defect is reparable in the field.

(3) Critical, A critical defect is one that experience and judgment indicate will result in hazardous conditions for individuals maintaining the tank. The tank is unserviceable and beyond field repair.

(4) Unlisted. Unlisted defects are those that adversely affect the strength or serviceability of the tank and shall be classified as critical defects.

NOTE

Small seepage areas, characterized by slightly damp spots on the outer wall, may develop when the tank is first placed into service. These areas will self-seal in a few hours as the rubber coating expands slightly upon contact with the fuel contents.

c. Procedure for Filling the Tank.

(1) Position the tank evenly on the ground cloth within the berm boundaries,

(2) Remove the dust cap from the vent fitting and install the vent assembly.

(3) Check the installation of the filler/discharge assemblies and remove the dust cap and plug.

(4) Connect the suction hose to the tank discharge; connect the discharge hose to the tank filler.

(5) Open all valves between the upstream pumping station and the tank. Close the valve on the tank discharge unless the next station is prepared to receive fuel.

(6) Start filling the tank and make frequent checks of the fuel path for leaks. If the tank tends to roll while filling, pack loose dirt or place sandbags under the tank ground cloth on the low side.

d. Pumping Fuel From the Tank.

(1) Inspect all suction hose connections between the pump and the tank. Open ail valves on the suction line.

(2) Check to be sure that the next station is ready to receive fuel.

(3) Commence the pumping operation.

(4) If a leak develops at any point, isolate the leak by closing valves or using hose clamps, and replace/repair the source of the leak. If a leak develops in a tank, empty the tank immediately and repair the leak point to prevent the puncture from enlarging.

Table 3-2. Tank Serviceability Standards (1 of 3)

DEFECT	DESCRIPTION	EXTENT OF DEFECT AND SERVICEABILITY OF TANK
TANK EXTERIOR		
Pinhole	A minute opening through the tank wall in which the cloth cords are displaced with no apparent damage.	Major: Acceptable if satisfactorily repaired by applying an emergency repair clamp or plug. The pinhole must be carefully enlarged to admit passage of the inside portion of the patch. One inch of undamaged material must remain from the defect to the clamp edge. Critical: Unserviceable when the puncture cannot be repaired by applying an emergency repair clamp.
Blistered fitting area	A raised, circular area of nonadhesion in a seam, panel, or fitting showing evidence of trapped gas or liquid.	Minor: Acceptable if: the affected area does not exceed 1/2 inch in diameter; the area has a 1/2 inch effective bond all around; and tank serviceability is not affected. Critical: Unserviceable when minor limits are exceeded.
Seam weeping	A discolored area along the seam with no visible flow of fuel.	Major: Acceptable provided the total number of weep spots does not exceed 4 per seam or the length of any one spot does not exceed 12 inches. Critical: Unserviceable when minor limits are exceeded.
Loose seam reinforcement patch		Minor: Acceptable provided a 1/2-inch seal exists around the patch perimeter. Critical: Unserviceable when minor limits are exceeded.
Wet spotting	A discolored area, normally circular, with no visible flow of fuel.	Minor: Acceptable if isolated and provided the total number of wet spots does not exceed 4 per panel or the diameter of any one spot does not exceed 12 inches. Critical: Unserviceable when minor limits are exceeded.

Table 3-2. Tank Serviceability Standards - Continuedd (2 of 3)

DEFECT	DESCRIPTION	EXTENT OF DEFECT AND SERVICEABILITY OF TANK
TANK EXTERIOR - CONTINUED		
Puncture or tear	An opening through the wall in which one or more cloth cords are severed.	Major: Acceptable if satisfactorily repaired by applying an emergency repair clamp. One inch of undamaged material must remain from the tear or puncture to the clamp edge (all around). Critical: Unserviceable when the puncture cannot be repaired by applying an emergency repair clamp.
Seam looseness		Major: Acceptable up to a width of 1/4 inch, provided a 1-inch effective bond to the seam edge exists and the length of the seam looseness does not exceed 3 inches. Critical: Unserviceable when minor limits are exceeded.
Loose tank fitting reinforcement patch		Minor: Acceptable provided a 1/2-inch seal exists around the patch perimeter. Critical: Unserviceable when minor limits are exceeded.
Loose outside coating		Minor: Acceptable if the pocket formed does not contain liquid and provided the loose area does not exceed 2 square feet or extend into the fitting or seam area. Critical: Unserviceable when minor limits are exceeded.
Loose, broken, or missing tank handles		Minor: Acceptable provided there is no structural damage to the tank wall causing a tank leak/failure. Critical: Unserviceable when minor limits are exceeded.
Loose, torn, or missing tank labels		Minor: Acceptable provided there is no structural damage to the tank wall causing a tank leak/failure. Critical: Unserviceable when minor limits are exceeded.

Table 3-2. Tank Serviceability Standards - Continued (3 of 3)

DEFECT	DESCRIPTION	EXTENT OF DEFECT AND SERVICEABILITY OF TANK
TANK INTERIOR		
Blistered fitting area	A raised, circular area of non-adhesion showing evidence of trapped gas or liquid.	Minor: Acceptable if: the area does not exceed 1/2 inch in diameter; the area has a 1/2 inch effective bond all around; and serviceability is not affected. Critical: Unserviceable when minor limits are exceeded.
Loose inside coating (no external evidence)		Major: Acceptable if: the pocket formed by the area of non-adhesion does not contain liquid; the loose area does not exceed 2 square feet; and the pocket does not extend into the fitting or seam area, or open to the tank interior. Critical: Unserviceable when minor limits are exceeded.
Loose chafing patch (no external evidence)		Minor: Acceptable since the tank is serviceable with or without chafer patches. Trim or remove the patch.
Seam looseness		Major: Acceptable provided 1/2 inch of effective bond exists along each seam edge. Critical: Unserviceable when minor limits are exceeded.

e. Shutdown and Movement to a New Location. Remove excess fuel from the tank by rolling the end of the tank toward the outlet fitting. Syphon the residue with a hand pump and remove any accumulated sludge. Remove vent and hose fittings and install dust caps. When packing or rolling the tank, avoid creating sharp creases which might wear or crack. Do not kneel on the folded or rolled portions of the tank walls. Remove shoes if it is necessary to walk on any part of the tank during cleaning or repairing. When folding the tank, exclude all foreign objects which might abrade the tank during shipment or storage. When not in use, the tank must be protected from exposure to air and light in order to minimize drying.

f. Cleaning. If fuel is stored for any period of time, contamination may accumulate in the bottom of the tank. These substances may be removed by opening the closure plates and flushing the tank with compressed air.

g. Operation Under Specific Conditions.

(1) Extreme Heat. The maximum operating ambient temperature for the tank is 125°F (52°C). In extreme heat, petroleum fuels will vaporize rapidly and may even boil. To prevent this, provide shade for the tank by covering it with leafy branches, camouflage net, shade cloths,

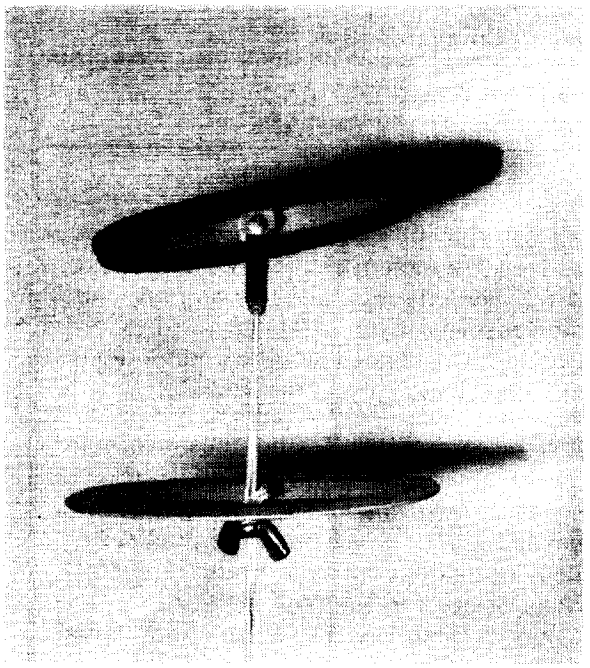
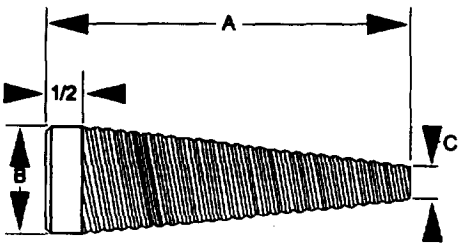


Figure 3-2. Mechanical Repair Clamp



SIZE	A	B	C
3 INCH	3	3/4 DIA.	1/4 DIA.
5 INCH	5	1-1/2 DIA.	1/2 DIA.

DIMENSIONS IN INCHES

Figure 3-3. Threaded Tapered Wood Plug

tarpaulins, or a tent. The covering should be supported so that air may circulate about the tank. Place wet burlap or other fabric on the tank and soak frequently with water.

(2) Extreme Cold. Do not handle the tank in temperatures below -20°F (-29°C) since the material becomes stiff and brittle and cracks easily. The tank may be used at low temperatures; however, care must be taken to prevent wrinkles or bends during handling or maintenance.

(3) High Winds. Properly constructed berms will protect the tank from high winds. When a low or no berm rim is present, bank dirt around the tank sides to prevent rolling. Place guy ropes over the tank and anchor them to ground stakes.

CAUTION

Do not tie guy ropes to the tank handles; a failure will rupture the tank.

h. Repairing Tank Walls. Tank walls may be temporarily repaired with 3-, 5-, or 7 1/2-inch mechanical repair clamps (see figure 3-2), or with tapered wooden plugs (see figure 3-3). If the puncture is too large to be sealed with a mechanical repair clamp, the tank is unserviceable. Permanent repairs cannot be made in the field; no materials for permanent repair are included in the repair kit. The procedure for repairing tank walls is as follows:

(1) Select an oval, gasketed, mechanical repair clamp of proper size so that the narrowest dimension will push through the wound.

(2) Remove the top plate of the metal clamp, fold the hinged bottom plate down, and push the bottom plate through the slit. If necessary, enlarge the wound by carefully slitting with a sharp knife so that the repair clamp can be pushed through the opening.

(3) Place the oval plate inside the tank, Straighten the stud and rotate the plate 90 degrees so that the long dimension is in line with the slit. Slide the outer plate over the stud, match up the inner and outer plates, and tighten the nut firmly.

(4) The threaded tapered wood plugs are used for the rapid repair of small holes where wound slitting would otherwise be necessary to apply a mechanical repair clamp.

3-4. HOSE

a. General. When the hose is damaged, the defective section should be replaced. However, emergency repairs can be made in the field while continuing operations without shutting down the system and draining the hoses.

b. Repair.

(1) A slightly damaged suction hose can be temporarily repaired by covering the damaged area with sealing compound. When a break, tear, or blister occurs, the hose must be replaced.

(2) Discharge hoses can be repaired by first sealing off the damaged section with hose clamps (figure 3-4). Cut the damaged section from the hose and install a coupling to replace the damaged section. Hose clamps, steel strapping, clamping tool, and couplings needed for reassembly are found in the general repair kit.

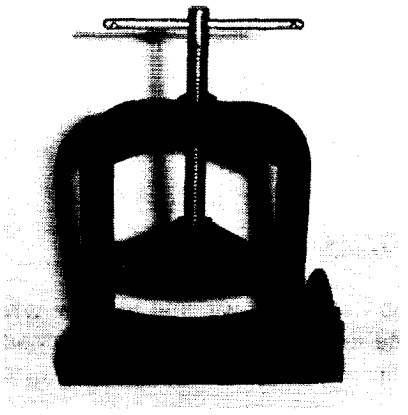


Figure 3-4. Hose Repair Clamp

3-5. SIX-INCH STRAINER ASSEMBLY.

a. Description. The 6-inch strainer assembly, configured in the AAFS, consists of two complete strainer units. While one strainer is in service, the other may be removed for cleaning without disruption of the fuel transfer operation. A tool box welded to the skid frame contains two spare strainer baskets, four cap gaskets, and one double open-end wrench (3/4 x 7/8 inches).

b. Operator Maintenance. Required maintenance includes cleaning the strainer baskets, replacing the strainer cap gaskets and repacking the gate valves. The following paragraphs give maintenance instructions for the strainer baskets; instructions for repacking gate valves can be found in paragraph 3-8.

c. Interchanging Strainer Units.

(1) Close the inlet gate valve on the strainer unit being removed from service, then close the outlet gate valve on the same unit. The strainer basket can now be removed from this unit for inspection, cleaning, and reinstallation, as explained in d, following.

(2) When the strainer basket has been reinstalled, open the outlet valve then slowly open the inlet valve to put the strainer unit back into operation.

(3) Repeat steps (1) and (2), preceding, for the other strainer unit,

d. Removal, Cleaning, and Installation of the Strainer Basket.

(1) Unscrew the set screw pressing down on the yoke; remove the yoke and cap. Squeeze the inner loops together to compress the basket retainer clip; remove the clip. Lift out the basket.

CAUTION

Do not use a wire brush or other sharp edged instrument to clean the basket screen. The resulting damage will render the screen unserviceable.

(2) Clean the basket screen with low pressure air or wash with the fuel being transferred.

(3) Insert the basket and install the retainer clip, cap and yoke. Screw in the set screw and lock into place with the locknut.

NOTE

Replace the cap gasket if worn and unserviceable.

3-6. FUEL SERVICING {GRAVITY) NOZZLE.

a. Description. The gravity-type nozzle allows fuel to flow when an internal poppet valve is opened by moving the hand lever. The inlet coupling half is attached to a swivel assembly for ease in positioning the nozzle. Figure 3-5 illustrates the fuel servicing (gravity) nozzle.

CAUTION

Automatic fuel nozzles can be used. However, lock-open or latch-open devices which allow unattended operation must be modified so that the dispensing nozzles must be held open by hand and attended while dispensing fuel.

b. Operator Maintenance.

(1) Release the quick-disconnect coupling and remove the nozzle from the hose.

(2) Open the coupling (1) to remove the spout assembly (2).

(3) Remove and discard the packing (3).

(4) Remove the strainer (4) and check for wear or corrosion; replace if necessary.

(5) Check the grounding cable (5) for corrosion; replace if necessary.

WARNING

Dry cleaning solvent is a safety and health hazard. Avoid breathing vapors and avoid skin contact with the solvent. Do not use near ignition sources. The flash point of cleaning solvent P-D-680 is 100 to 138°F, (38 to 59°C). An adequate supply of fire extinguishers must be located in the vicinity of cleaning operations. Foamite type fire extinguishers are recommended for solvent fires.

(6) Clean all parts with solvent (Federal Specification P-D-680, Type II or equivalent), and dry thoroughly with a lint-free cloth or compressed air.

(7) Insert the strainer (4) into the spout assembly (2) and replace the packing (3).

(8) Install the spout assembly onto the nozzle and secure the coupling.

(9) Test the nozzle after reassembly for leaks and proper operation.

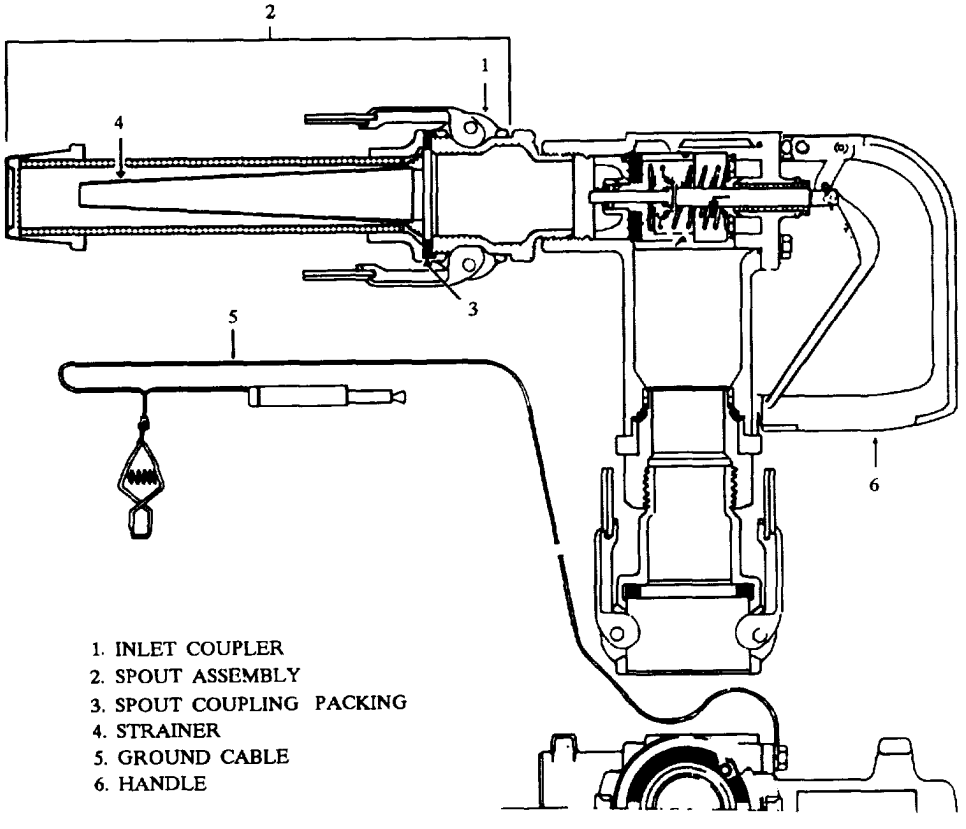


Figure 3-5. Fuel Servicing (Gravity) Nozzle

3-7. PRESSURE FUEL SERVICING NOZZLE, LOCKING.

a. Description. Operation of the pressure fuel servicing nozzle, locking, is mechanical through manual control. A poppet-type valve seals the nozzle outlet against leakage of fuel when it is not attached to a mating adapter. The control for this valve is locked against operation until after the nozzle has been coupled to an adapter. This action compresses the nose seal on the nozzle against the sealing surface of the bayonet flange of the adapter to form a leak-proof connection. Completion of this coupling action unlocks the valve flow control handle. Subsequent rotation of the handle lifts the poppet valve into the adapter, opening a passage for fuel flow.

b. Types. The 2-inch and 4-inch pressure fuel servicing nozzles, Types D-1 and D-2, differ only in the coupling half that mates with the hose. The 2-inch nozzle assembly has a female 2-inch cam-locking coupler, and the 4-inch has a male 4-inch cam-locking adapter.

c. Maintenance. Maintenance requirements for the pressure fuel servicing nozzle are the responsibility of the operator.

3-8. GATE VALVES.

a. Description. The bronze, hand-operated, gate valves (see figure 3-6) are the double-disk type with a self-aligning seat. A slight leak around the packing gland nut at the top of the valve bonnet may be corrected by tightening the packing gland nut. This action will cause the packing gland to compress the packing tightly against the valve stem sealing the leak. If tightening does not correct the leak, replace the packing. Gate valves are repacked with standard graphite-grease packing. Repacking may be performed by the operator.

b. Repacking. Refer to figure 3-6.

(1) Shut off the fuel flow and remove the gate valves from the system component.

(2) Unscrew the hand wheel nut (2) and remove the hand wheel (3). Unscrew the packing nut (1) and slide the spring (17) and packing retainer (16) from the stem (4).

(3) Pry the packing (15) from its seat in the bonnet (12), taking care not to damage the packing seat or threads on the bonnet. Insert new packing (15) (usually two loops) in the bonnet seat, and reinstall the retainer (16), spring (17), and the packing nut (1).

NOTE

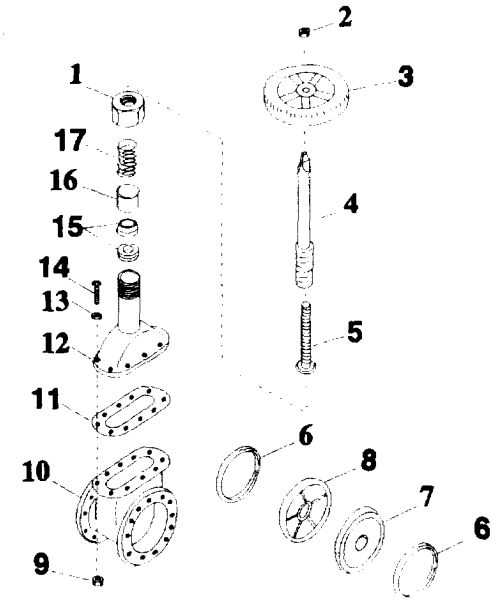
Tighten the packing nut only enough to ensure that the packing is fully recessed and the valve stem is not leaking.

(4) Attach the hand wheel (3) and secure it with the nut (2).

c. Proper Operation.

(1) Open and close the valves slowly. This avoids hydraulic shock in the system and possible damage to the valve. Slow closing helps to keep dirt and sediment from the seat.

(2) Avoid operating the valves in a "cracked" (slightly opened) position. This may result in rapid erosion of the seat.



1. Packing nut
2. Hand wheel nut
3. Hand wheel
4. Bonnet stem
5. Disk stem
6. Seat
7. Female disk
8. Male disk
9. Nut
10. Body
11. Bonnet
12. Bonnet
13. Lockwasher
14. Screw
15. Packing ring
16. Retainer
17. Spring

Figure 3-6. Gate Valve

3-9. FITTINGS AND ACCESSORIES.

a. Skid-Mounted Manifolds. Before installation, skid-mounted manifolds should be drained and flushed with the fuel to be pumped. During operation, check for leaks frequently. Most leeks can be stopped by tightening the flange attachment bolts. Persistent leaks require replacing the flange gasket. Gate valve repairs are at the operator level are limited to repacking. Instructions for repacking are detailed in paragraph 3-8.

b. Drum Unloading Valve. The most common repair to the drum unloading valve is repacking, performed by the operator in a manner similar to gate valve repacking (paragraph 3-8). Maintenance will be kept to a minimum by installing the drum unloading valves immediately prior to fuel transfer. Remove the valve when transfer is complete.

c. Other Fittings and Accessories. All other fittings and accessories are maintained by the operator. These include the quick-disconnect cam-locking fittings, wye fittings, drum unloading manifolds, fuel dispensing manifolds, sight indicators, elbows, reducers, flanged adapters, dry-break check valves, nozzle stands, culvert, and chests. Frequent inspection is the key to early detection of leaks and other potential problems. The most common defects are loose connections, broken cam arms, faulty gaskets, and cracks in hardware items or in the glass of sight indicators. The operator should correct the defects through prompt repair/replacement of the defective item.

Section II. PUMPS

3-10. 600 GPM PUMP.

a. Description. The 600 gpm pump and diesel engine assembly is capable of pumping all types and grades of automotive and aviation gasoline, aviation jet fuels, and diesel fuel within a specific gravity range of 0.67 to 0.85. This size unit is used by the AAFS and TAFDS. There are five models currently fielded, including trailer-mounted and skid-mounted versions. The pump unit contains six major assemblies: the suction manifold assembly, suction strainer assembly, pump housing, air eliminator assembly, discharge manifold assembly, and check valve assembly. Fuel is drawn into the pump unit through hoses coupled to the suction manifold assembly. From the suction manifold, the fuel enters the suction strainer assembly that filters out large particles of debris which are likely to come from a bulk storage fuel container. Next, the fuel enters the pump housing and impeller where it is pumped into the air eliminator and discharge manifold assembly. The fuel then flows through the bend and down through the check valve assembly which, when manually operated, prevents the fuel from backing up or the pump from losing its prime. The check valve will also prevent the fuel from flowing in reverse through the pump and back to the storage container, The fuel is discharged through the discharge manifold assembly to the discharge hoses, The air eliminator assembly removes and maintains the system free of air throughout the operation. The following descriptions are common to all models, except where noted. Refer to individual TMs for more specific information.

b. Major Components.

(1) Pump. The pump unit has one 6-inch suction port and one 6-inch discharge port; it also has two 4-inch suction ports and two 4-inch discharge ports. The unit is a single-stage, centrifugal-type which is self-priming after the pump housing is initially filled. The pump consists of a drive plate, a balanced enclosed-type bronze impeller, impeller shaft, mechanical-type shaft seal, bearings, air vent, air eliminator, and an intermediate housing. The pump is designed to deliver 600 gpm of hydrocarbon fuel against a head (H) of 340 feet; the minimum net positive suction head (NPSH) is 2 feet at 2,400 revolutions per minute (rpm) plus or minus 25 rpm. The working discharge pressure of the pump is 125 pounds per square inch gage (psig) at this condition.

(2) Engine. The pump unit is driven by a liquid-cooled diesel engine with a brake horsepower output rated for the pump's specific operating characteristics. Models vary from two to four-stroke cycle, multiple cylinder engines with or without turbocharger. The engine is equipped with the appropriate automatic and manual controls to permit operation of the pump/engine assembly at a selected speed from idling to maximum governed speed. The engine is directly connected to the pump unit with a flywheel, dry-type flexible coupling.

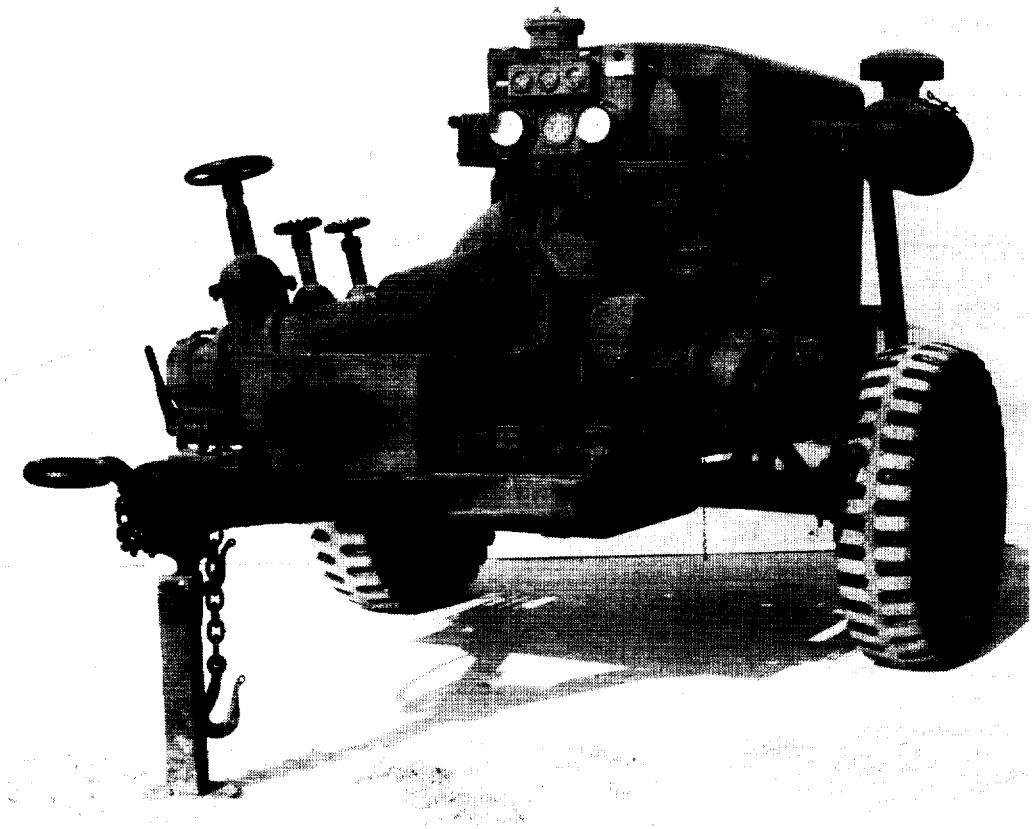
(3) Control and Instrument Panel. Engine controls and gages, and pump suction/discharge gages, are mounted on the unit's instrument panel. The panel is fitted with shock mounts between the panel and engine to lessen the vibration and shock to the instruments. It is located in a readily accessible area to enable the operator to perform required maintenance on the controls and gages, and to repair or replace the panel if required. Some variations exist in panel arrangements and control features among models.

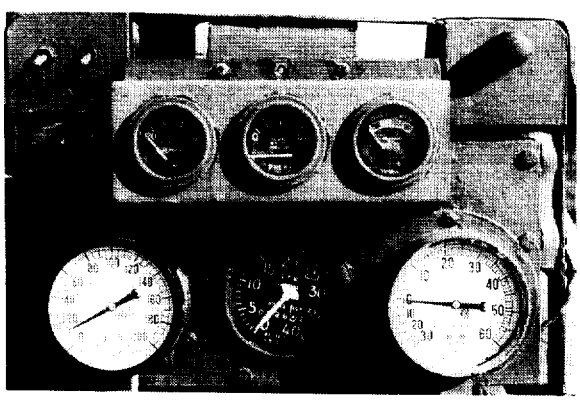
(4) Trailer Chassis. On trailer-mounted versions, the pump/engine assembly is mounted on a chassis capable of carrying a maximum payload of 2,840 pounds. The trailer-mounted assembly can be towed over cross-country terrain, ascending and descending longitudinal grades up to 40 percent and side slopes up to 20 percent. The unit may be towed cross-country at

speeds up to 15 miles per hour (mph), on gravel roads at up to 35 mph, and on highways at up to 50 mph. In addition to the pump/engine assembly, the trailer chassis is fitted with a battery box, accessory storage box, a 20-gallon engine fuel tank, front landing gear leg assembly, and rear stabilizing legs. The standard suspension, shock absorbers, brakes, and electrical system are common with other trailer-mounted engineer equipment. The trailer's running equipment has a shallow water, short duration fording capability.

(5) Skid Assembly. On the skid-mounted version, the pump/engine assembly is mounted on a steel skid base approximately 7 feet long. The skid assembly has an entry for forklift vehicles in addition to front and rear lifting rings. The total weight of the equipment is approximately 3,089 pounds.

c. Model Variations. The following models are currently fielded: Models 604, 604B, 604C, 604D and Model US690ACD-1. The 604 series models are two-stroke cycle, multiple cylinder engines. Modal 604 was originally designed as a multifuel engine, but that capability has been deleted. Model 604B differs from model 604 in that the multifuel feature was deleted in production, and the fuel booster pump and switch are not provided. Model 604C includes a control to permit operation of the engine from either the integral fuel tank or from an external fuel supply. For Model 604D, the trailer chassis was replaced by a steel skid base. The pump in model US690ACD-1 is driven by a turbocharged, four-stroke-cycle, four cylinder diesel engine. Accordingly, operating and maintenance instructions differ to some degree; the appropriate equipment TM must be consulted. The skid-mounted and trailer-mounted versions are illustrated in figures 3-7 through 3-11.

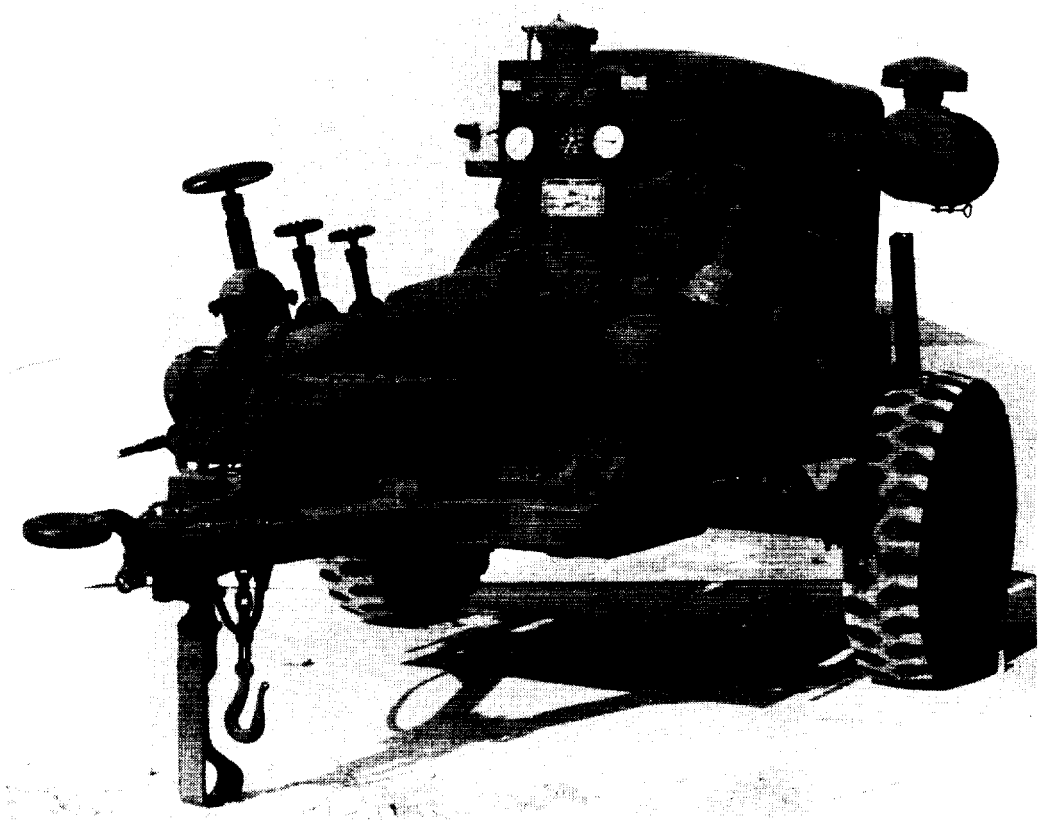


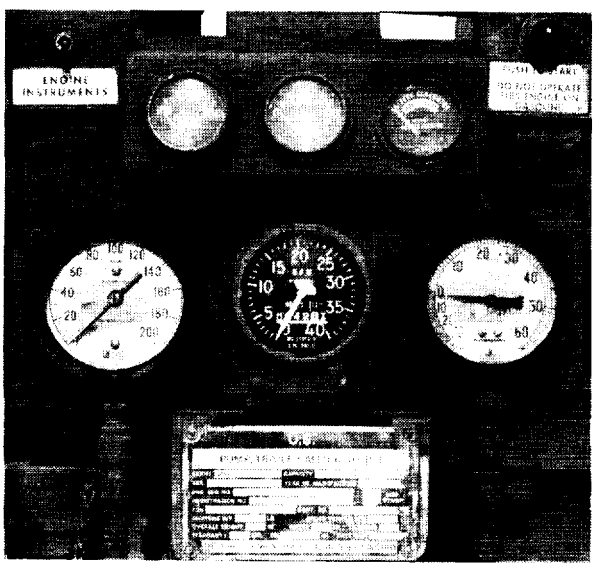


Control Panel

NSN	4930-00-110-5777
Model	604
Dimensions:	
Length	152.5 in
Width	72 in
Height	71.75 in
Weight	4725 lbs
Volume flow (output)	600 gpm
Discharge pressure	125 psi
Suction ports	4-inch (2) and 6-inch(1)
Discharge ports	4-inch (2) and 6-inch (1)
Engine	water cooled, 2-stroke, 3 cylinder
Fuel	Diesel

Figure 3-7. 600 GPM Pump, Model 604

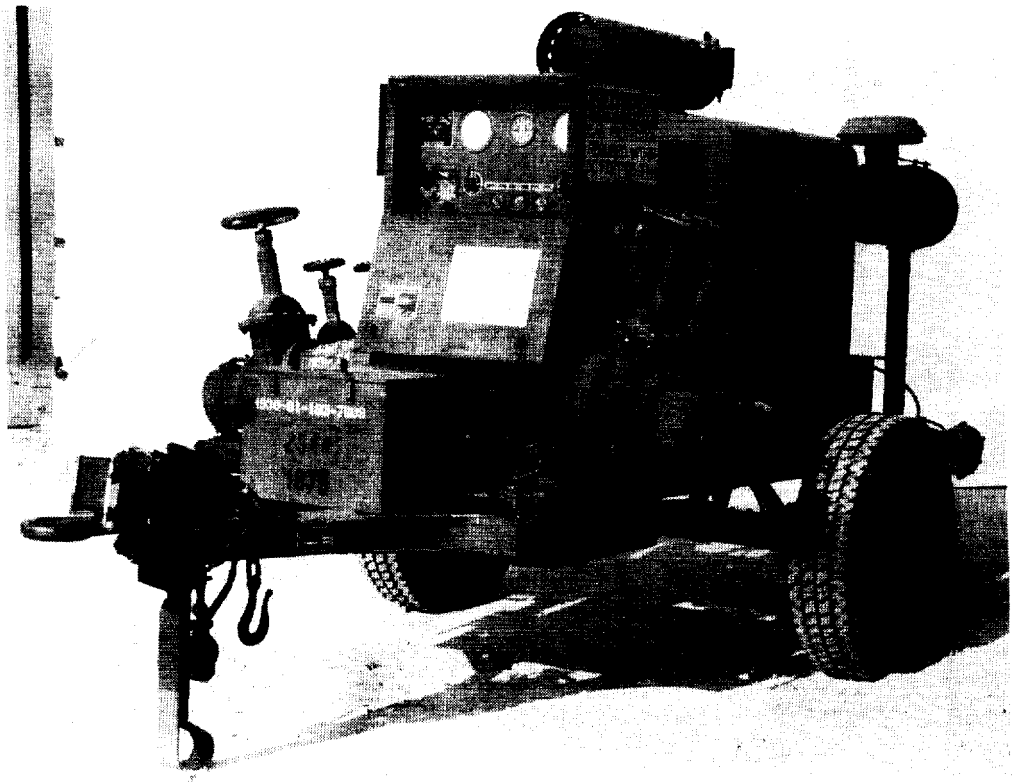


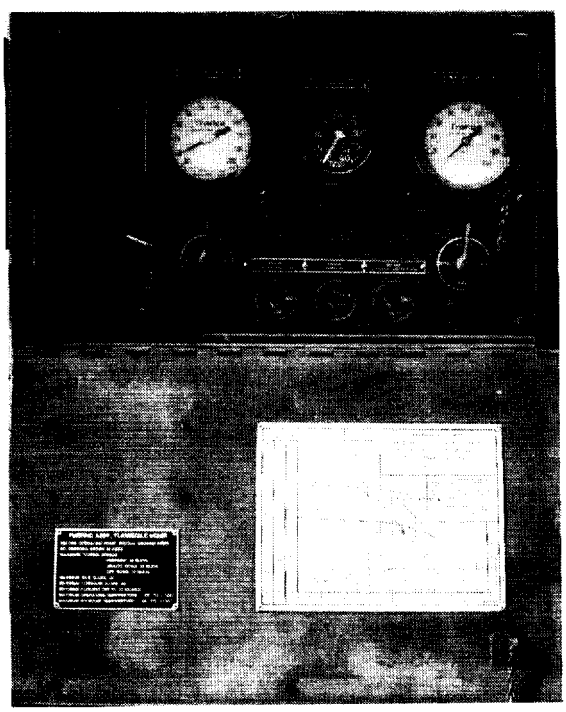


Control Panel

NSN	4930-00-505-7449
Model	604B
Dimensions:	
Length	153 in
Width	72 in
Height	72 in
Weight	3230 lbs
Volume flow (output)	600 gpm
Discharge pressure	125 psi
Suction ports	4-inch (2) and 6-inch(1)
Discharge ports	4-inch (2) and 6-inch (1)
Engine	water cooled, 2-stroke, 3 cylinder
Fuel	Diesel

Figure 3-8. 600 GPM Pump, Model 604B

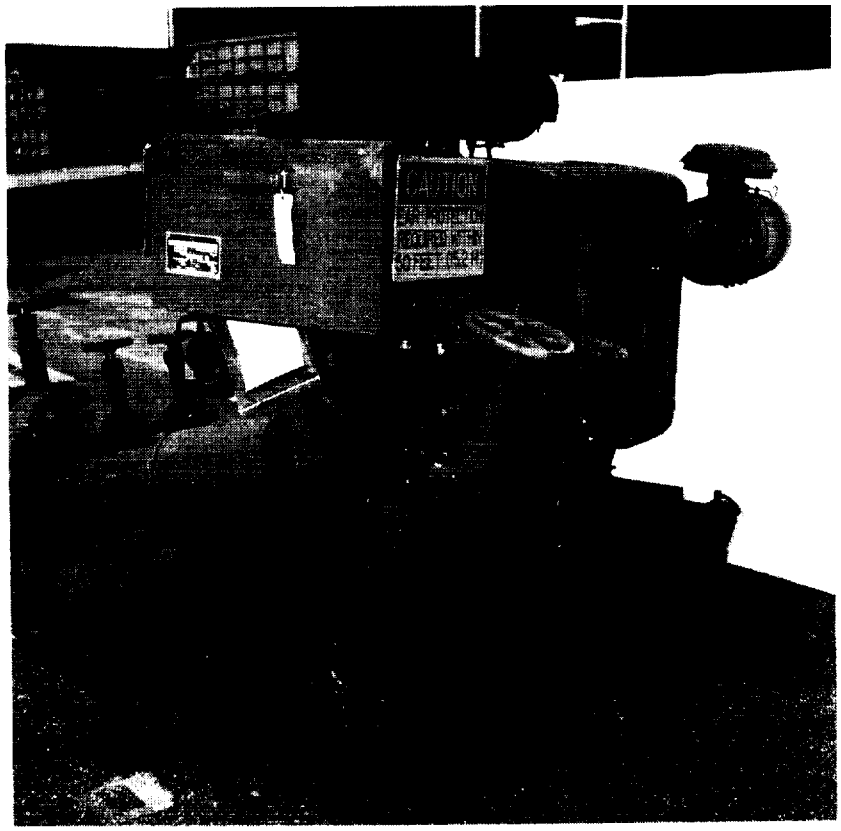


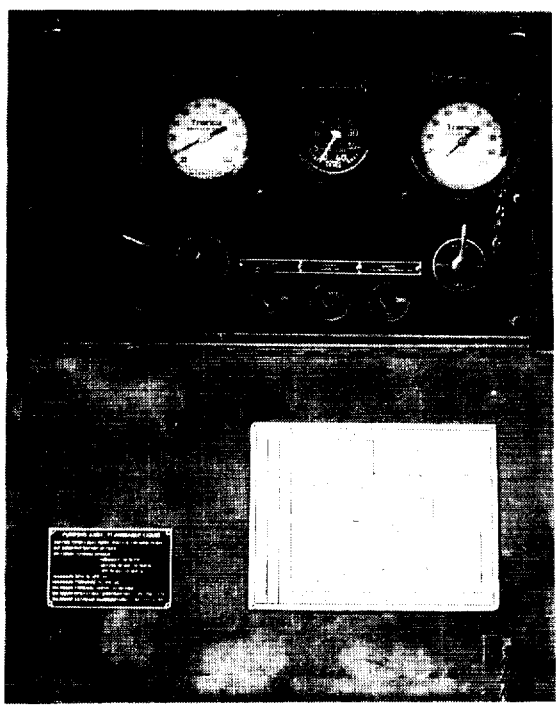


Control Panel

NSN	4930-01-103-7609
Model	604C
Dimensions:	
Length	153 in
Width	72 in
Height	80 in
Weight	3448 lbs
Volume flow (output)	600 gpm
Discharge pressure	125 psi
Suction ports	4-inch (2) and 6-inch(1)
Discharge ports	4-inch (2) and 6-inch (1)
Engine	liquid cooled, 2-stroke, 3 cylinder
Fuel	Diesel

Figure 3-9. 600 GPM Pump, Model 604C

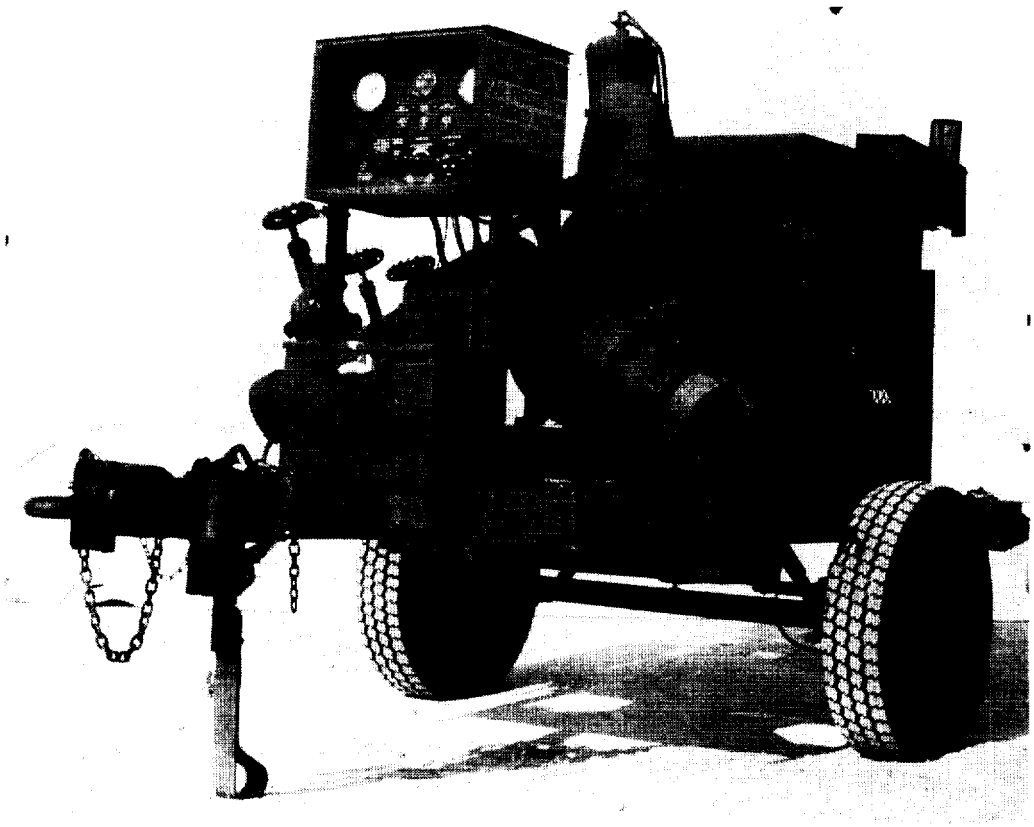




Control Panel

NSN	4930-01-131-4999
Model	604D
Dimensions:	
Length	85 in
Width	66.1 in
Height	72.2 in
Weight	3089 lbs
Volume flow (output)	600 gpm
Discharge pressure	125 psi
Suction ports	4-inch (2) and 6-inch(1)
Discharge ports	4-inch (2) and 6-inch (1)
Engine	water cooled, 2-stroke, 3 cylinder
Fuel	Diesel

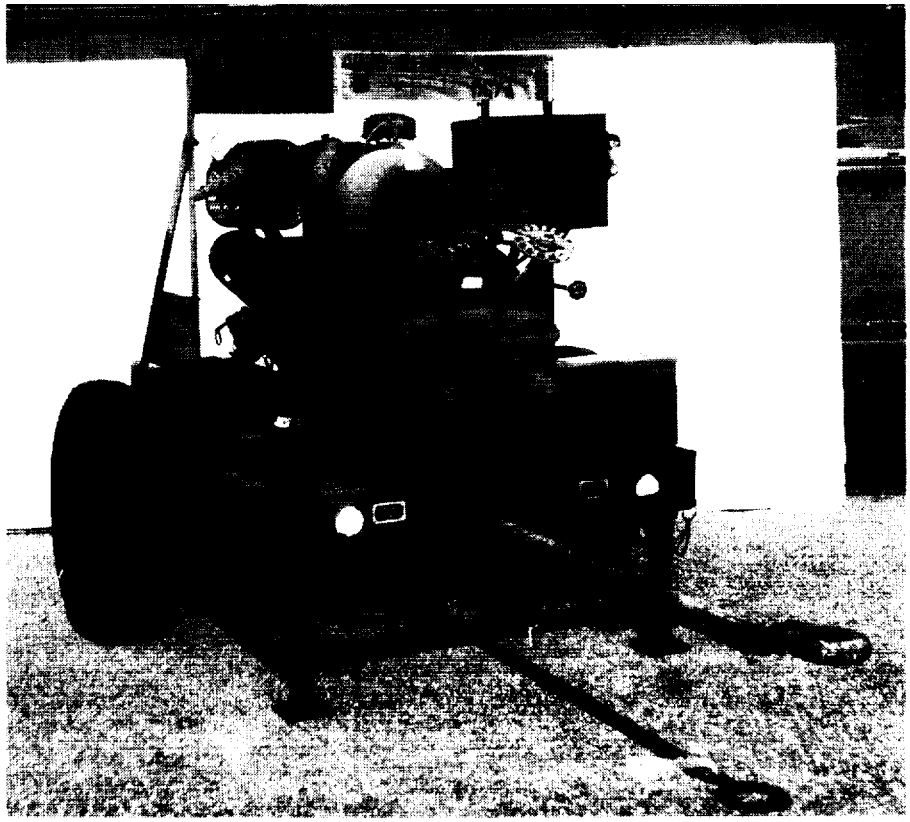
Figure 3-10. 600 GPM Pump, Model 604C

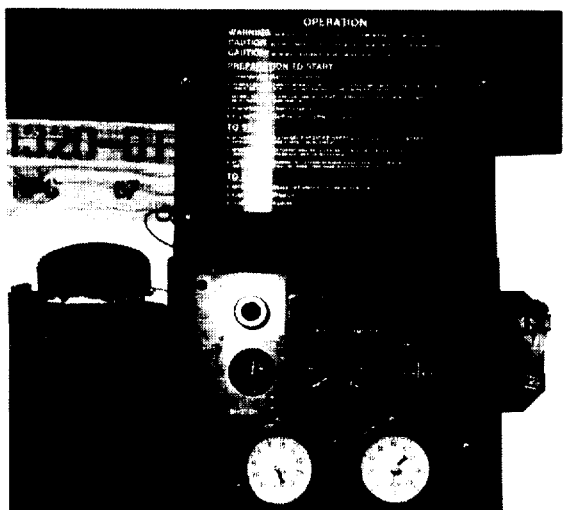


Control Panel

NSN	4930-01-195-9723
Model	US690ACD-1
Dimensions:	
Length	146 in
Width	72 in
Height	78 in
Weight	3200 lbs
Volume flow (output)	600 gpm
Discharge pressure	125 psi
Suction ports	4-inch (2) and 6-inch(1)
Discharge ports	4-inch (2) and 6-inch (1)
Engine	liquid cooled, 4-stroke, 4 cylinder
Fuel	Diesel

Figure 3-11. 600 GPM Pump, Model US690ACD-1





NSN	4320-01-215-7671
Model	LPP-TM
Dimensions:	
Length (towbar retracted)	78 in
Width	70 in
Height	68 in
Weight	2140 lbs
Volume flow (output)	350 gpm
Discharge pressure	125 psi
Suction ports	4-inch (2)
Discharge ports	4-inch (2)
Engine	air cooled, 4-stroke, 3 cylinder
Fuel	Diesel

Figure 3-12. 350 GPM Pump

3-11. 350 GPM PUMP.

a. Description. The 350 gpm pump and diesel engine assembly is designed specifically to transfer gasoline, jet fuels, and light liquid petroleum products. It replaces the older gasoline-fueled model. This size unit is used only by the TAFDS and is mounted on a two-wheel frame assembly for towing purposes. Refer to TM 5-4320-226-14 for complete information. The 350 gpm pump is illustrated in figure 3-12.

b. Major Components.

(1) Pump. The pump is a self-priming, single stage, centrifugal flow, variable displacement type equipped with 4-inch suction and discharge ports. It is designed to deliver 350 gpm of hydrocarbon fuel against a head of 250 feet.

(2) Engine. The unit is powered by a three cylinder, four-stroke, air-cooled, diesel engine with direct injection. An internal fuel tank supplies fuel to the engine.

(3) Frame. The two-wheel frame houses the entire assembly and permits cross-country transport and shallow water fording. Maximum towing speeds are as follows: hard surface, 20 mph; gravel road, 10 mph; and rough cross-country, 8 mph. The weight of the entire assembly is 2140 pounds.

3-12. 125 GPM PUMP.

a. Description. The 125 gpm pump assembly is used to transfer fuel in the HERS, ERS and SIXCON fuel pump modules. The frame-mounted unit consists of a diesel engine, fuel system, and pump. Figure 3-13 depicts the 125 gpm pump assembly. Refer to TM 4320-14/1 for complete information.

b. Major Components.

(1) Pump. The continuous duty centrifugal pump is equipped with 2-inch suction and discharge couplings. It is designed to deliver fuel at a rate of 125 gallons per minute at 50 feet total head. The system is self-priming after the initial filling.

(2) Engine. The pump is powered by a four-stroke, one cylinder, 3.8 horsepower, air-cooled, diesel-fueled engine.

(3) Frame. The original design includes a sound enclosure housing mounted onto the frame which provides noise reduction and directs the engine intake/outlet air. The enclosure contains a hinged door which swings up, providing access to the engine controls. The weight of the entire assembly is 144 pounds.

Figure 3-13. 125 GPM Pump.

c. Tabulated Data for the 125 GPM Pump.

NSN 4320-01-313-9442
Dimensions:
Length . . . . . .37.25 in
Width . . . . . 32 in
Height . . . . . 23.75 in
Weight . . . . . .144 lbs
Volume flow (output) 1259pm
Discharge pressure . . . . . .50 psi
Suction ports 2-inch (1)
Discharge ports 2-inch (1)
Engine . . . . . air cooled, 4-stroke, 1 cylinder
Fuel . . . . . Diesel

3-13. 100 GPM PUMP.

a. Description. The 100 gpm pump assembly provides the pumping capability for the HERS and ERS systems. Designed to transfer flammable liquids, the assembly consists of a gasoline engine, fuel system, and pump mounted in a tubular frame. Required references for the pump and gasoline engine are TM 5-4320-256-14 and TM 5-2805-257-14, respectively. Figure 3-14 shows the 100 gpm pump assembly.

b. Major Components.

(1) Pump. The self-priming, centrifugal pump is equipped with 2-inch suction and discharge couplings. It is designed to deliver fuel at a rate of 100 gallons per minute.

(2) Engine. The pump is powered by a two cylinder, 3 horsepower, air-cooled, gasoline-fueled military standard engine.

(3) Frame. A tubular frame houses the assembly. The weight of the entire assembly is 137 pounds.

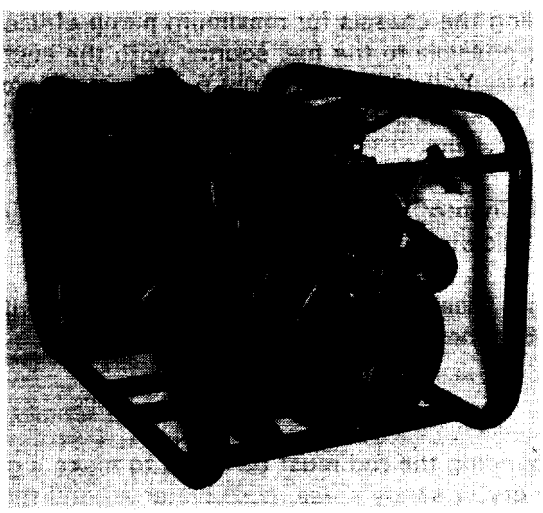


Figure 3-14. 100 GPM Pump.

c. Tabulated Data for the 100 GPM Pump.

NSN	4320-00-427-0002
Dimensions:	
Length	32 in
Width	20 in
Height	21 in
Weight	137 lbs
Volume flow (output)	100 gpm
Discharge pressure	35-45 psi
Suction ports	2-inch(1)
Discharge ports	2-inch (1)
Engine	air cooled, 1 cylinder
Fuel	gasoline

3-14. PREPARATION FOR USE.

a. Initial Handling.

WARNING

To avoid endangering personnel, do not use a lifting device with a capacity less than 4,000 pounds.

(1) Unloading. Use equipment such as a crane, forklift or other lifting device to unload larger pump units. When using cables for lifting, spreader bars of adequate length must be used to prevent cables from closing in and crushing the pump unit. The 100 and 125 gpm pump assemblies are man-portable and may be removed from the carrier by two or more Marines.

(2) Pump location. Locate the pump unit on a hard, flat surface capable of sustaining its weight. A foundation of planking, logs, or other suitable material may be needed when locating the unit on soft ground. For trailer-mounted models, engage the brake to lock the wheels and block all wheels in both directions. Disconnect intervehicular connectors and uncouple safety chain assemblies and couplings from the tow vehicle. Lower the front trailer leg and adjust rear jackstands (if provided), leveling the chassis for maximum pump efficiency and safety. The unit should be located as close as possible to the fuel source, with the suction (inlet) side toward the fuel source and the discharge (outlet) side toward the fuel hose system. Suction hose and the amount of lift should be kept as short as possible. Ample space should be provided on all sides of the equipment for access in servicing.

b. Grounding. Consult Chapter 2, Section II for additional bonding and grounding information. In general, the following procedures must be followed:

(1) Ground the pump assembly by driving a grounding rod into the ground to within approximately 6 inches of the end of the rod.

NOTE

The earth surrounding the rod must be moist to make a good electrical connection. In dry or sandy areas, pour water around the rod or pack salt in the hole between the rod and the dry earth. The salt will draw moisture from the surrounding earth and thus improve the connection.

In the event that impregnable soil is encountered, bury a grounding rod with the grounding cable attached at least 8 inches beneath the surface,

(2) Clamp one end of the grounding cable to the rod and the other to the pump assembly frame/chassis, ensuring that a tight electrical connection has been made.

c. Hose Installation. Once the pumping assembly has been positioned, secured, and grounded, connect the suction and discharge hoses.

NOTE

Minimize friction loss by positioning hoses in a straight line.

(1) Disconnect and remove the coupling half from the suction valve. Connect the suction hose to the suction valve.

(2) Disconnect and remove the coupling half from the discharge valve. Connect the discharge hose to the discharge valve.

NOTE

The first pump in a multipump installation must use suction hose on the suction side of the pump where a vacuum will be encountered. All other hoses in a multipump installation will use discharge hose. To prevent hose collapse, a minimum of 10 psi positive pressure must be sustained on the suction side of the pump.

(3) Connect the suction hose to the component containing the fuel to be pumped. The highest point in the suction hose should be at the pump.

(4) Connect the discharge hose to the component which is to receive the fuel.

(5) Ensure that hoses are free from twists and pinch points after installation. Support and secure hoses to avoid strain and vibration during operation. Ensure that the connections are tight.

3-15. GENERAL OPERATING GUIDELINES.

a. Operator's Daily Checks and Services. To ensure proper function and operation, the pump unit must be systematically inspected before, during, and after operation. Necessary maintenance will be performed before operation. During operation, all defects found will be noted for future correction unless the defects would interfere with or damage the unit should operation continue. Postoperative maintenance will be performed after each operating period. Pertinent equipment TMs must be consulted for specific operating instructions and scheduled maintenance. In general, the requirements include:

(1) Inspection. Visually inspect the entire unit for any damage which may have occurred during unloading or initial placement. Check for cleanliness, chips, cracks, and defective parts. Verify that those pump valves that are to be closed are tightened and that caps and plugs are secured in place. Inspect to ensure that all required spare and repair parts, accessories, publications, and records/report forms are available.

(2) Fluids (fuel, oil, coolant, etc.). Inspect to ensure adequate supply and correct type.

(3) Lubrication. Maintain the recommended lubrication schedule,

(4) Repair/Replacement. Ensure that all parts are in good working order. Replace/repair as necessary.

(5) Service. Service those elements which require periodic maintenance.

(6) Instruments, gages, and switches. At the start of operations, inspect all gages for cracked or broken glass. Test gages to ensure pre-operation set readings. Ensure that all instrument settings are in the OFF position and that the switches are in their proper position. Wiring and switches should be secure. Correct as necessary. During operation, inspect gages to ensure proper operation of the pump unit.

(7) Leaks. Inspect for leaks. Correct deficiencies, or log for future correction, depending on severity.

b. Operational Considerations. Potential problems may be avoided by understanding the operation of the pump and making required adjustments when needed. The following recommendations may prove useful to the operator:

(1) To activate the self-priming capability of the centrifugal pump, the pump volute must first be filled manually with the appropriate fuel to be pumped. When the pump assembly is started, the pump will prime and reprime as necessary as long as the pump body is full to the bottom of the suction port. As the unit begins to pump, reduce the engine speed and the discharge valve opening to prevent hydraulic shock to the system. Hose rupture and fitting failure may result when the hose line is filled too rapidly.

(2) The operating rpm will vary in accordance with the physical layout of the system and output demand. Regardless, the pumping capacity has been reached when there is no gain in vacuum (suction) as indicated on the suction gage, Impeller inlet cavitation occurs when engine speed is increased beyond the point of maximum suction vacuum. Cavitation is harmful to the pump assembly and should be avoided at all times, Cavitation can be detected by an excessively loud cracking noise in the pump housing. Adjust the throttle as necessary and observe the gages.

(3) The operator of the pump is responsible for correcting or reporting unusual sounds or odors, deficiencies in performance, or other signs of abnormal operation. Check for any abnormal operation such as engine overheating; engine running at below governed speed; failure of the pump to deliver full volume; or failure to respond to controls. If any unusual noise is noticed, stop the operation immediately and examine the pump for signs of undue heating.

(4) Check all gage readings frequently. Watch for any unusual drop in engine oil pressure.

(5) Check the entire unit for leaks, paying particular attention to the pump seal. If a leak is noticed, it must be corrected or promptly reported to the proper authority. Look under the trailer for signs of leaks and check the engine fuel lines and connections. In the case of a bad leak, stop operation and make the necessary correction or report the leak to the proper authority. If leaks are found which do not seriously affect the operation of the equipment, and if continued operation will not cause damage to the pump or engine, make note of the deficiency and see that it is corrected as soon as possible. Examine the suction and discharge hose assemblies, and check valve connections for leaks.

(6) When pumps are operated in a series, the capacity of the series remains the same as one individual pump, but the discharge head (pressure) becomes a multiple of the number of pumps in the series. Consequently, engine speed must be reduced and discharge pressure constantly monitored to ensure that excess pressure, which may cause hose line bursting, is avoided.

(7) Insufficient net positive suction head (NPSH) available can cause the pump to deliver at less than its rated capacity or not at all. This condition may be a result of the pump being located too far from the fuel source, an excessively high suction lift or fuel vapor pressure, or a clogged strainer or other restrictions in the suction system.

(8) Refer to paragraph 1-8 for additional considerations.

Section III. FILTER-SEPARATOR

3-16. 350 GPM FILTER-SEPARATOR.

a. Description and Function. The 350 gpm filter-separator is a two-stage, vertical type unit designed to remove undissolved water and solid contaminants from fuels in the AAFS and TAFDS systems. The filter-separator contains 18 elements and canisters, a water level indicator, a manual water drain valve, and a differential pressure indicator (gage). Refer to TM 5-4330-211-12 for complete details. Figure 3-15 depicts the 350 gpm filter-separator. Figure 3-16 is an interior view of the filter-separator with the canisters and elements shown.

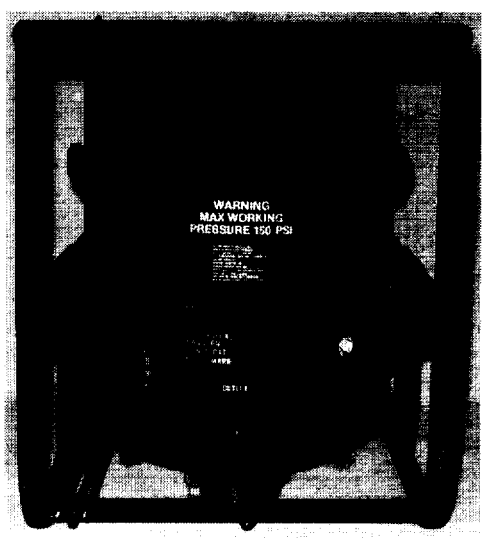


Figure 3-15. 350 GPM Filter-separator

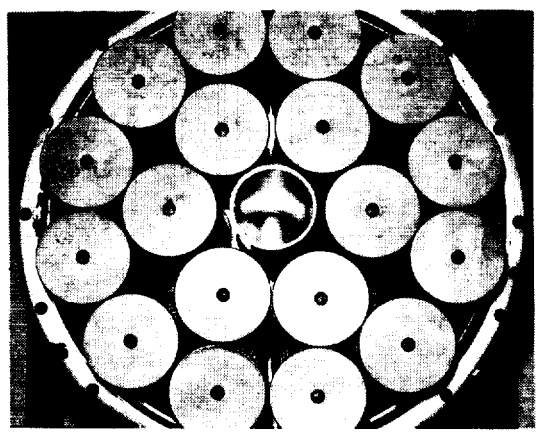


Figure 3-16. Elements and Canisters

b. Major Components.

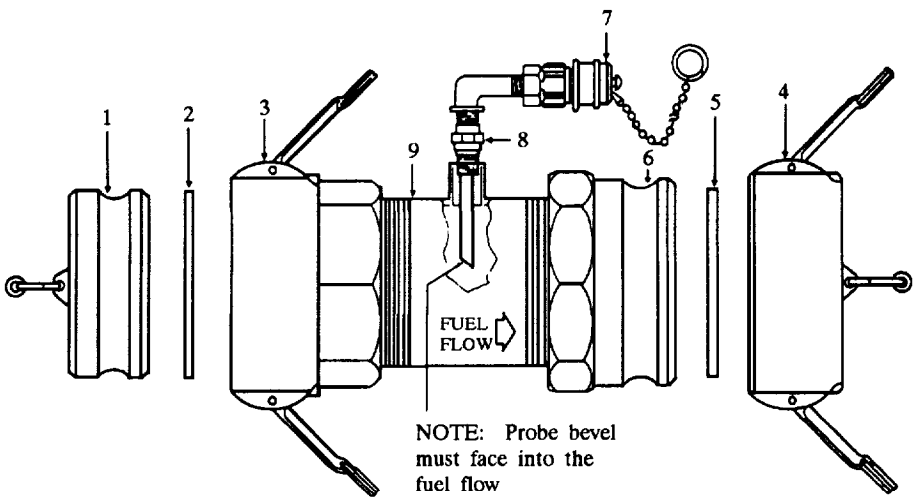
(1) Filter Element. The filter element consists of a perforated center tube surrounded by a pleated paper tube filtering material which is wrapped with several layers of fiberglass mats. Each layer acts to filter the fuel. A fiberglass screen supports the element against rupture from high differential pressure.

(2) Canister. The canister is a cylindrical device constructed with an outer tube of perforated metal and lined internally with a teflon-coated screen. The screen is protected by en aluminum wire mesh inner screen.

(3) Differential Pressure Indicator. A direct reading dial type gage provides an indication range of 0-35 psid.

(4) Detector Kit Assembly. This assembly provides the point of attachment for the Fuel Contamination Test Kit (NSN 6640-00-244-9478) at the filter-separator outlet. Included in the Detector Kit is an adapter fitted with a sampling probe used to obtain a fuel sample from the filter-seperator outlet. The Test Kit is not furnished with the filter-separator, but is an authorized usage item. The adapter and probe are pictured in figure 3-17.

(5) Frame Assembly. The filter-separator tank and frame are constructed of welded aluminum alloy. The entire unit weighs approximately 375-500 pounds, depending on the model.



1. Dust plug
2. Gasket
3. Female coupling
4. Dust cap
5. Gasket
6. Male coupling
7. Probe
8. Hexagon
9. Pipe nipple

Figure 3-17. Water Detector Kit Adapter

c. Tabulated Data for the 350 GPM Fiber-Separator.

NSN	4330-00-177-8485
Dimensions:	
Length	33 in
Width	47 in
Height	40.5 in
Weight	375 lbs
Capacity	350 gpm
Working pressure, max....	150 psi
Differential pressure: clean	0-20 psid
dirty	$\geq$ 35 psid
Element quantity	18

3-17. 100 GPM FILTER-SEPARATOR.

a. Description and Function. The filter-separator is designed to filter and separate particles of contamination and water from light petroleum fuels at a rate of 100 gallons per minute (gpm). This size unit is used in the HERS system. It consists of a vessel with removable cover, five replaceable filter elements and canisters, a differential pressure indicator (gage), and inlet and outlet connections for quick disconnect couplings. Consult TM 5-4330-217-12 for further information. Figure 3-18 depicts the 100 gpm filter-separator.

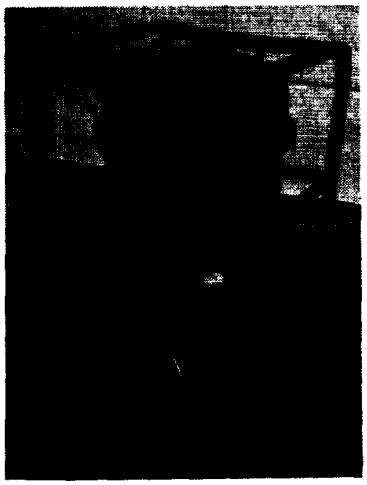


Figure 3-18. 100 GPM Filter-Separator

b. Major Components.

(1) Filter Element. The filter element consists of a perforated center tube surrounded by a pleated paper material which is wrapped with several layers of fiberglass mats. Each layer acts to filter the fuel. A fiberglass screen supports the element against rupture from high differential pressure.

(2) Canister. The canister is a cylindrical device constructed with an outer tube of perforated metal and lined internally with a teflon-coated screen. The screen is protected by an aluminum wire mesh inner screen.

(3) Detector Kit Assembly. This assembly is supplied with the 100 gpm filter-separator and provides the point of attachment for the Fuel Contamination Test Kit (NSN 6640-00-244-9478) at the filter-separator outlet. Included in the Detector Kit is an adapter fitted with a sampling probe used to obtain a fuel sample from the filter-separator outlet. The Test Kit is not furnished with the filter-separator but is an authorized usage item. The adapter and probe are pictured in figure 3-17.

(4) Frame Assembly. The filter-separator tank and frame are constructed of a welded aluminum alloy, The entire unit weighs approximately 100 pounds.

c. Tabulated Data for 100 GPM Filter-Separator.

NSN	4330-00-491-4957
Capacity	100 gpm
Element quantity	5
Working pressure max	75 psi
Weight (lbs)	100

3-18. PREPARATION FOR USE.

a. Initial Handling.

(1) Unloading. The crated 100 gpm filter-separator assembly may be unloaded from the carrier manually. The 350 gpm filter-separator will require a forklift truck or handled manually by four men.

(2) Location. Provide a level site to ensure efficient operation. Run the water drain hose away from the unit to prevent water accumulation around the filter-separator.

b. Grounding. Consult Chapter 2, Section II for grounding procedures.

c. Hose Installation. Remove the dust cap from the inlet coupling and attach the hose. To install the adapter for the Detector Kit, remove the dustcap from the filter-separator outlet coupling, check that the gasket is installed, and attach the adapter. Ensure that the directional arrow on the probe's hexagonal nut faces into the fuel flow. Attach the outlet hose to the adapter. Inspect the connections to ensure that they are secure and free of leaks. Keep the hoses free of kinks. Remove the cover of the filter-separator and visually check to be sure that the canisters are in place. Reinstall the cover.

3-19. GENERAL OPERATING GUIDELINES.

a. Operator's Daily Checks and Services. To ensure that the filter-separator is ready for operation at all times, it must be systematically inspected so that defects may be discovered and corrected. Defects discovered during operation shall be noted for future correction. If a defect is noted which could potentially damage the equipment should the operation continue, stop the operation immediately. Pertinent equipment TMs must be consulted for specific operating instructions and scheduled maintenance. In general, the requirements include:

(1) Inspection. Check for leaks, loose or missing bolts in the cover assembly, and breaks or dents in the frame. Ensure that all valves work freely and are tight. Check the coupling gaskets for damage or wear. Check the ground rod assembly for missing or broken cable and clamps. Confirm that the clamps are secured to an unpainted portion of the frame.

(2) Instruments and gages, Check for breaks and damage in the sight glass and verify that the ball floats freely. Check the differential pressure gage for a reading below the red band on the gage. If a reading in the yellow area is indicated, change the elements after the operation.

b. Operational Considerations. Carefully follow the specific operating instructions as detailed in the pertinent TM. Potential problems may be avoided through thorough understanding of the operation of the filter-separator and timely adjustments. The following recommendations should be observed:

(1) The manual water drain valve, located at the bottom of the filter-separator, should be opened and sampled at least once per day prior to commencing fueling operations. Drainage from the valve should discharge into a portable container, a slop tank, or an oily water drainage system leading to an oil/water separator. Oily water or fuel drained should not be dumped onto the ground or into untreated or uncontrolled drainage systems. When draining water, open the valve wide to get maximum flow, This will stir up water pockets in the bottom of the sump. After the water stops flowing out, continue to drain until approximately one gallon of fuel is expelled before closing the drain.

(2) The differential pressure gage detects the pressure drop across the filter-separator elements. Frequent reading/recording of the gage readings during use at or near rated flow is an important maintenance function. Proper interpretation of the pressure drop (differential pressure) measured across the elements provides a good indication of their condition. New clean elements properly installed should show a pressure drop of about 4 to 5 psi. As dirt accumulates in the elements, the pressure drop should gradually increase until it reaches the level where it becomes necessary to replace the elements. This level is indicated by a reading in the red band portion of the gage. If a sudden drop in differential pressure at comparable flow rates is observed, it may indicate dumping or break-through of the filter elements. This means that the elements have suddenly dumped a built-up accumulation of dirt or that the element material has broken through and is permitting the free passage of dirt. In either case, the unit should be opened for internal inspection and replacement of the elements anticipated.

(3) Filter-separator elements require replacement when any of the following occur:

(a) The pressure drop across the filter elements reaches the maximum prescribed by the element manufacturer.

(b) When a sudden drop in differential pressure indicates that a break-through has occurred in the elements.

(c) When poor fuel quality indicates that the elements are not performing properly.

(d) When a sudden or premature shutdown of the fuel monitor occurs or when the fuel monitors differential pressure is 15 psi or greater.

(4) Under extreme cold conditions, the filter-separator should be frequently drained of water by opening the manual drain valve. This will prevent freezing of the water which could cause internal damage and cracks in the housing. In addition, when operating in sub-freezing climates, the unit should be installed in a well-ventilated, heated shelter.

Section IV. METER ASSEMBLIES

3-20. 3-INCH AND 2-INCH METERS.

a. Description. The skid-mounted meter assemblies consist of a meter register mounted in a protective tubular frame with quick disconnect coupling halves provided for hose connection. The assembly is used to measure the amount of fuel dispensed or received into the fuel system. Two sizes of meters are employed: the 3-inch meter serves the AAFS and TAFDS, and the 2-inch meter is used with the AAFS, TAFDS, and HERS. Total assembly weights are 55 pounds and 25 pounds, respectively. Since the design characteristics (except for size) are similar; the following descriptions and instructions are common to both, except where noted. The meters are illustrated in figures 3-19 and 3-20.

b. Major Components.

(1) Meter. The meter contains a rotor capable of metering fluids at flow rates of 50 to 650 gpm for the 3-inch meter and 25 to 250 gpm for the 2-inch meter. The maximum pressure ratings for the 3-inch and 2-inch meters are 400 psi and 225 psi, respectively. The meter is factory tested and calibrated before shipment and is field adjustable over a span of $\pm$ 5 percent with no special tools required. The rotor, powered by the fuel flow, uses a permanent magnet and coupling to drive an externally mounted mechanical register. The inlet and outlet connections of the meter are threaded and equipped with quick-disconnect coupling halves.

(2) Register. The visible register is a mechanical digital totalizer consisting of a magnetic input coupling, a gear train, and mechanical counters encased in an anodized aluminum housing. The magnetic coupling permits the register to be driven by a magnet on the rotor shaft inside the meter. The counters are viewed through a sealed Pyrex glass window. The 3-inch meter provides two seven-digit counters: one records the gallons of fuel dispensed in each individual operation and the other provides a cumulative total of all fuel dispensed. The 2-inch meter has only one resettable five-digit counter for recording individual operations.

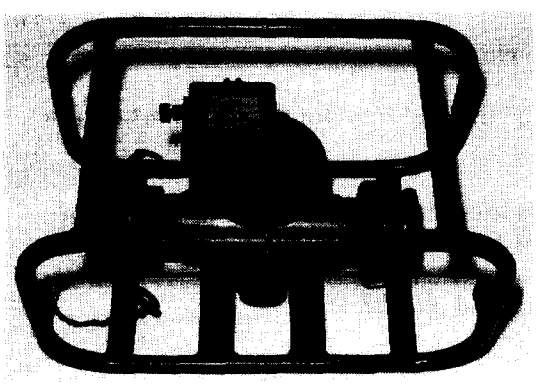


Figure 3-19. 3-inch Meter Assembly

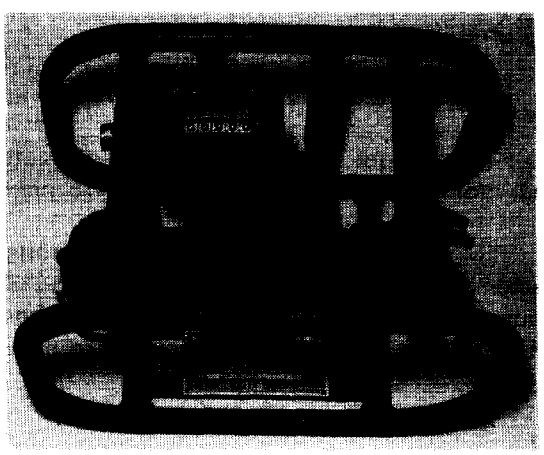


Figure 3-20. 2-inch Meter Assembly

(3) Grounding Assembly. The electrical grounding assembly of the 3-inch meter consists of a ground rod and wire which are attached to the skid when not in use. The 2-inch meter skid contains no ground rod fasteners.

(4) Coupling Halves. The quick-disconnect coupling-halves are designed with a 4- to 3-inch reduction. The 4-inch male and female halves connect the 4-inch inlet and outlet hoses. The 3-inch threaded ends connect to the inlet and outlet ports of the meter.

(5) Frame. The arrangement of the assembly support braces are different between the 2- and 3-inch meters as shown in figures 3-19 and 3-20.

(6) Controls.

(a) Calibrating Plug Assembly. The calibrating plug assembly located on the discharge side of the meter housing, is used to adjust the meter to compensate for differences in fluids and to correct inaccuracies determined by testing procedures.

(b) Reset Knob Assembly. The reset knob assembly located on the register housing, is used to reset the mechanical counter that records gallons of individual fuel batches dispensed.

c. Tabulated Data for the 3-inch Meter Assembly.

NSN 4930-00-106-8672
Dimensions:
Length . . . . . 25 in
Width . . . . . 15 in
Height . . . . . 14 in
Capacity . . . . . 50-650 gpm
Pressure rating, max . . . . . 400 psi
Max °F . . . . . .200°F

d. Tabulated Data for the 2-inch Meter Assembly.

NSN 4930-00-106-8673
Dimensions:
Length . . . . . 18 in
Width . . . . . 12 in
Height . . . . . 12.5 in
Capacity . . . . . 50-250 gpm
Pressure rating, max . . . . . 225 psi
Max °F . . . .100°F

3-21. PREPARATION FOR USE.

a. Initial Handling.

(1) Unloading. The crated meter assembly may be unloaded manually.

(2) Location. The meter assembly must be operated in a level position and remain full of fuel during and between deliveries; therefore, a low, level site should be selected. Level the ground and police the immediate area for metal and rocks which when struck might generate a spark. The placement of the meter assembly must agree with the direction of fuel flow (from coupler (female) to adapter (male)).

b. Grounding. Consult Chapter 2, Section II on grounding procedures.

c. Hose Installation. The meter assembly is shipped completely assembled, serviced, and ready for use upon arrival. Prior to installing and operating the assembly, conduct an initial inspection to ensure that the condition of the assembly has not changed during shipment. Check for evidence of rough handling, bent frames, broken register window glass, and missing nuts and bolts. Inventory all parts. Inspect the equipment before operation to detect any deficiencies which might result in further damage to the assembly or affect its operational status. To install the meter into the fuel system:

(1) Remove the dust cap and plug and inspect all coupling halves and gaskets for cleanliness and damage.

(2) Insert the supply hose adapter into the coupler on the inlet fitting and lock with cam arms. Fit the discharge hose coupler on the discharge adapter and lock with cam arms.

3-22. GENERAL OPERATING GUIDELINES.

a. Operator's Daily Checks and Services. Inspect the equipment before, during, and after operation and at temporary stops to detect any deficiencies which might result in damage to the assembly or affect its operational status. Table 3-3 lists the operator's daily checks and services with intervals designated as before operation (B), during operation (D), and after operation (A).

Table 3-3. Operator's Daily Checks and Services for 2-inch and 3-inch Meters (1 of 2)

INTERVAL			PROCEDURE
B	D	A	
			Register.
♦			1. Inspect the mounting screws to ensure that the register housing coupling ring is securely fitted to the meter (open cover plate).
♦			2. Inspect housing for cracks, broken window, and other defects.
♦			3. Manually check operation of counter assemblies by turning reset knob; reset counter to zero and record cumulative counter total.
	♦		4. Visually check the register for erratic rotation of the counter wheels. Using at least two separately operated 2-inch assembly registers, check accuracy by comparing counter readings during a specific time span. If faulty, the register can be replaced while the meter is still in full operation.

Table 3-3. Operator's Daily Checks and Services for 2-inch and 3-inch Meters - Continued (2 of 2)

INTERVAL			PROCEDURE
B	D	A	
			Meter.
♦			1. Inspect the housing for cracks, insecure mounting, defective gaskets, or other defects.
♦			2. Inspect the inlet and outlet bores of the meter to be sure that they are free of foreign matter which could interfere with register accuracy.
			NOTE Calibration of the meter, if required, is detailed in paragraph 3-23.
			Quick-disconnect fittings.
			CAUTION An excessive application of torque will cause distortion of the meter housing and rotor.
♦			1. Ensure that coupling halves are properly secured to the meter.
♦			2. Ensure proper operation of the coupler arm assembly.
♦			3. Ensure that the nozzle spouts are securely fastened.
			Grounding rod and wire.
♦			1. Ensure that the grounding rod is securely installed.
♦			2. Ensure that the grounding wire is in good condition and that the clips firmly grasp the grounding rod and skid.
			Skid assembly.
♦			1. Inspect for distortion and broken welds.
♦			2. Record defects for future repair.
			Hose assemblies.
♦			1. Arrange the inlet and outlet hoses for the longest and straightest approach possible.
♦			2. Ensure that the hose and meter couplings are properly secured.
	♦		Leaks. Normally a leak can be stopped by tightening the flange bolts or the coupling-halves. If unable to stop the leak in this manner, halt operations and take corrective measures. If unable to stop the operation immediately, record the deficiency and ensure that it is corrected as soon as possible. In addition, take increased precaution against fire and explosion.
		♦	Temporary-Stop Services. When the operation is stopped, even for short periods, visually inspect the meter assembly. If time permits, correct minor deficiencies.

b. Operational Considerations. Once the unit is installed into the TFS, follow the instructions listed in table 3-3, Operator's Daily Checks and Services. In addition, the following should be considered:

(1) Protect the assembly from sand or dust. Do not leave dust caps or plugs off the couplings any longer than necessary during installation, removal, or inspection of the assembly.

(2) When operating in sandy or dusty conditions, or if there is a suspicion of foreign matter contamination, flush the meter during startup operations by raising the line pressure to about 2 psi, and, one at a time, momentarily removing the cover assembly cleanout plugs.

(3) Protect the meter assembly from extreme temperatures with a tarpaulin or other protective covering. During conditions of ice and snow, place the assembly on a platform.

(4) Salt air causes rapid deterioration of metal. To combat, remove existing rust/corrosion and apply paint or a light coat of oil to exposed surfaces.

(5) When shutting down operations, drain or pump as much fuel as possible from the meter. Release couplings and remove hoses.

(6) Before moving to a new location, observe the shutdown procedure then ventilate the unit; after ventilating, install the dust cap and plug. Secure grounding rod and the grounding wire and clip assembly to the meter skid. When preparing for limited storage, drain and flush the meter to prevent formation of gummy fuel deposits. Store the meter with dust caps and plugs installed.

Section V. FUEL MONITOR

3-23. 350 GPM FUEL MONITOR.

a. Description and Function. The primary element of the fuel monitor assembly (figure 3-21), trade name Go-No-Go, is mounted horizontally on a rollover skid frame. Internally, the monitor is configured in two chambers: the larger, outer chamber houses filter elements (fuses) and the smaller, inner chamber provides a passage for fuel discharge from the unit. A representative fuse is shown in figure 3-22. Four-inch quick-disconnect fittings provide inlet (female) and outlet (male) connections for the fuel hoses. Inlet/outlet fuel flow pressure is monitored by a pressure gage and three-way valve. The flow rate is 350 gpm at a maximum pressure of 150 psi. A 4-foot ground rod and separate 6-foot ground lead are provided. The total weight of the unit is 140 pounds. The fuel monitor assembly is designed to remove solid contaminants and undissolved water from fuel. It also acts as a fuel cleanliness monitor by shutting off flow when safe levels of contamination are exceeded.

b. Major Components.

(1) Fuses. Twenty filter elements (fuses) are set in holes in a bulkhead separating the inlet and outlet chambers and are held in position by a retainer. The fuses are either the absorbent type or the expansion type, as discussed in paragraph 1-10. The fuses act to absorb water and contaminants; when the contaminant level exceeds a preset limit, the fuses shut off the flow of fuel.

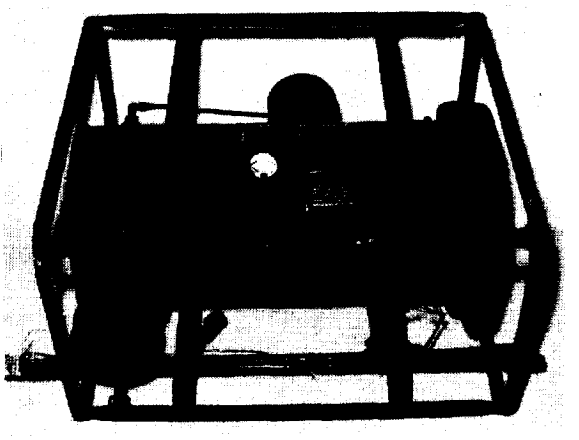


Figure 3-21. Fuel Monitor, 350 GPM

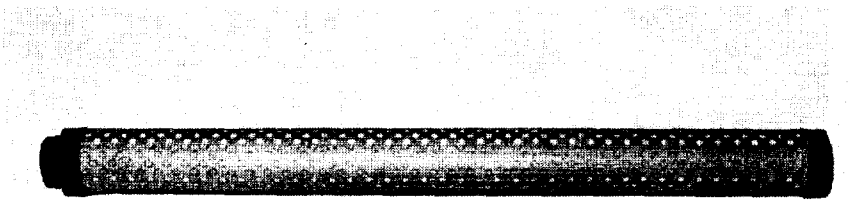


Figure 3-22. Fuse

(2) Quick-Disconnect Couplings. The inlet quick-disconnect coupling is provided with a dust plug which can be secured in the coupling with a cam-lock arrangement when the coupling is not in use. The outlet is provided with a dust cap.

(3) Controls.

(a) Pressure Gage. The pressure gage, base-mounted on the selector valve near the outlet end of the monitor, provides readings of O to 35 psi. The pressure in the inlet chamber is indicated by the pressure gage when the selector valve is in the INLET position and in the outlet chamber when in the OUTLET position.

(b) Selector Valve. The selector valve is a three-way plug valve mounted on a bracket welded to the skid frame near the outlet end of the monitor. The selector valve switches the pressure gage to indicate either inlet or outlet pressure as desired.

c. Tabulated Data for the 350 GPM Fuel Monitor.

NSN 4930-01-131-1917
Dimensions:
Length . . . . . 29.5 in
Width . . . . . 25.5 in

Height . . . . . 19 in
Weight (total assembly) . . . . . 140 lbs
Flow rate . . . . . 350 gpm
Differential pressure, max . . . . . 35 psi
Pressure capacity, max . . . . . 0.150 psi
Element quantity 20

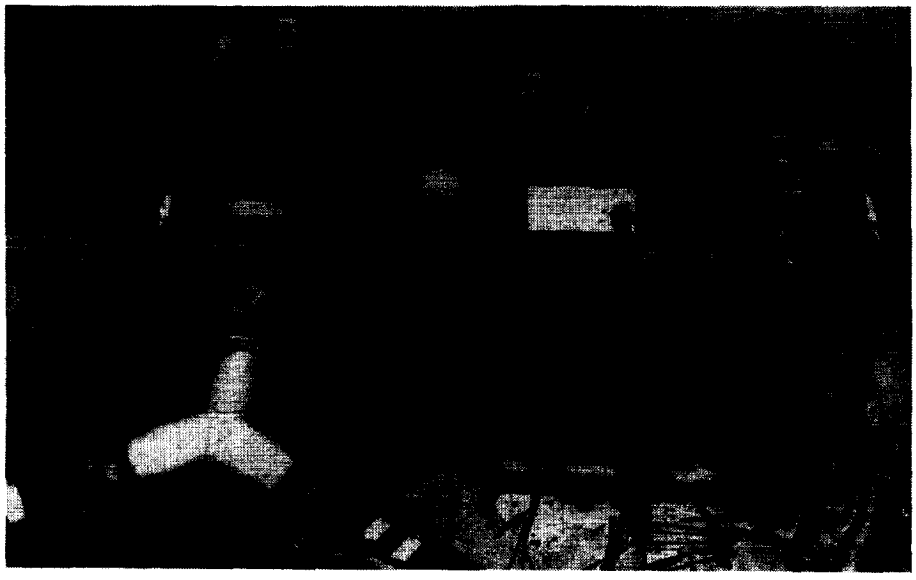


Figure 3-23. 100 GPM Fuel Monitor

3-24. 100 GPM FUEL MONITOR.

a. Description and Function. The 100 gpm fuel monitor is similar in design and function to the 350 gpm monitor, but has a lower flow rate and fewer fuses. The unit is pictured in figure 3-23.

b. Tabulated Data for the 100 GPM Fuel Monitor.

NSN 4930-01-125-6032
Working pressure, max . . . . . 100 psi
Fuse quantity 8

3-25. PREPARATION FOR USE.

a. Initial Handling.

(1) Unloading. The crated unit may be unloaded manually.

(2) Location. The unit can be mounted on any reasonably flat surface capable of supporting the weight of the equipment. Place the unit at a point in the fuel line downstream of

the filter-separator. Select an installation site which permits a 30-second relaxation time between the fuel monitor and prior to fuel entering aircraft or other recipients.

b. Grounding. Consult Chapter 2, Section II for grounding information.

(1) Position the ground rod next to the skid base. Drive the rod into the ground to within 6 inches of the end of the rod.

(2) Attach the ground lead assembly clips to the ground rod and to the frame or skid. Make sure that the clips bite through any paint or dirt and into the metal to provide a good electrical connection.

c. Hose Installation. New equipment is shipped completely assembled and ready for use. Inspect the equipment visually, checking for bent tubing, cracked glass on the pressure gage, external physical damage to the monitor, and a loose V-band coupling on the monitor head. Remove the dust cap and dust plug from the couplings and check the couplings for cracks, chips, dents, dirt, or defective gaskets which might cause leaks during operation. To install the unit in a bulk fuel system, proceed as follows:

(1) Remove the dust plug from the inlet quick-disconnect coupling and the dust cap from the outlet coupling.

(2) Close a valve upstream of the connection point or shut off flow with a hose clamp.

(3) Uncouple the hose connections at the point the unit is to be inserted.

(4) Couple the free end of the upstream hose to the inlet coupling on the fuel monitor assembly and couple the free end of the downstream hose to the outlet coupling.

(5) Open the upstream valve or clamp to allow fuel to flow through the fuel monitor assembly and the remainder of the system.

3-26. GENERAL OPERATING GUIDELINES.

a. Operator's Daily Checks and Services. To ensure that the equipment is ready for operation at all times, it must be inspected systematically before, during, and after operation to discover/correct defects before serious damage or failure results. The necessary preventive maintenance services will be performed before operation. Defects discovered during operation of the unit will be corrected immediately. After-operation services shall be performed by the operator after every use. Reduce the maintenance intervals to compensate for abnormal conditions. Defects or unsatisfactory operating characteristics beyond the scope of the operator must be reported at the earliest opportunity to organizational maintenance. Table 3-4 lists the operator's daily checks and services with intervals designated as before operation (B), during operation (D), and after operation (A).

Table 3-4. Operator's Daily Checks and Services for Fuel Monitor

INTERVAL			PROCEDURE
B	D	A	
♦			Cleaning. Clean all external parts of the fuel monitor assembly by wiping with a cloth saturated with an approved solvent (note warning in paragraph 3-6, b). Take care that excessive solvent does not enter around the edges of the quick-disconnect dust cap and dust plug or the head of the monitor; solvent will harm the synthetic rubber gaskets. Remove gaskets from quick-disconnect coupling and clean all dirt, sand, and foreign matter from the gaskets; reinstall.
♦			General. Ensure that the required repair parts, publications, and accessories are with the unit.
♦	♦	♦	Leaks. Inspect for leaks, paying particular attention to the quick-disconnect couplings, tubing, tube connectors, pressure gage, selector valve, and the joint around the head of the monitor. Correct all deficiencies noted or report them to organizational maintenance personnel.
♦	♦	♦	Visual Inspection. Inspect the entire unit for damage or lost parts. See that the ground rod cable is not broken or frayed and that the clips are capable of biting through paint to base metal. See that all connections are tight. Tighten loose hardware and replace missing hardware. Inspect the pressure gage for cracked or broken glass.
	♦		Pressure Differential. At hourly intervals, check inlet and outlet pressures and record in a log. If the inlet pressure exceeds the outlet pressure by 15 psi, start making pressure checks at 30-minute intervals to determine whether a gradual or rapid pressure drop is developing. A gradual drop is a normal occurrence during routine operation; a rapid pressure drop indicates a high contamination buildup which will reduce the life of the fuse.

b. Operational Considerations. After completing the pre-operations checklist in table 3-4, perform the following:

(1) Turn the pressure gage selector valve to the inlet position, and record the INLET pressure shown on the pressure gage.

(2) Turn the pressure gage selector valve to the OUTLET position, and record the outlet pressure.

(3) Subtract the outlet pressure obtained in step (3) from the inlet pressure obtained in step (2) and record the resulting differential pressure.

(4) Repeat steps (2), (3), and (4) at hourly intervals.

(5) A rise in the differential pressure to over 15 psi in a relatively short period of time (5 minutes) indicates that filter-separators upstream are not performing properly. The problem must be located and corrected before continuing the operation.

(6) After the problem has been located and corrected, shut down the system as soon as convenient and change the fuel monitor fuses. To shut down, first close a valve upstream of the fuel monitor assembly to stop flow of fuel into the unit. Remove the hose on the outlet coupling and allow the monitor to drain.

(7) To shut down the unit, first perform the after-operation services in table 3-10. Then shut off the fuel flow with an upstream valve or with a hose clamp. Uncouple the hoses from the inlet and outlet couplings of the fuel monitor assembly and couple the free ends of the hoses together. Drain the fuel monitor assembly, and then install dust plugs and dust caps. Pull up the ground rod and reinstall on the frame together with the ground lead. Secure the equipment and load the unit.

(8) When storing the unit, provide indoor shelter if possible, or cover with a tarpaulin.

(9) Although not materially affected by extreme conditions, the fuel monitor must be stored within a specific temperature range. The high storage temperature is 155°F (68°C) for a maximum of 4 hours per day. The low storage temperature is -65° F (-54°C) for a maximum of 3 days. If these ranges are exceeded, the monitor should be carefully checked for damage before placing in service.

c. Procedure for Changing Fuses. If it is necessary to change the fuses, proceed with the remaining steps:

CAUTION

Do not attempt to replace individual fuses. Fuses shall be replaced by complete sets, and new packing (O-rings) shall be used with each change.

(1) Using an open-end or box wrench, loosen or remove the compression-type self-locking nut from the V-band coupling on the monitor head.

(2) Remove the V-band coupling and lift off the head.

(3) Remove the jam nuts, attaching nuts, and washers which attach the fuse retainer to the studs. Lift off the retainer.

(4) Remove the fuses and wipe the inside of the housing with a clean, dry, lint free cloth.

(5) Install new fuses in the holes from which the old fuses were removed. Make sure each fuse is seated properly. Ensure that only one type of fuse is used in each monitor; do not mix fuse types.

(6) Install the fuse retainer, being sure that the positioning protrusions on the retainer enter the openings in ends of the fuses. Reinstall the attaching hardware for the retainer.

(7) Lubricate the new preformed packing (O-ring) with any clean lightweight lubricating oil and place the packing in position on the housing. Carefully seat the head over the packing and place the V-band coupling over the flanges on the head and housing.

(8) Carefully tighten the self-locking nut on the V-band coupling stud. Do not exceed a torque of 260 pounds-inches.

(9) To return the fuel monitor to service, fasten the hose to the outlet coupling and depress the cam-lock arms. Open the upstream valve to allow fuel to flow through the fuel monitor assembly.

Section VI. PRESSURE REGULATOR ASSEMBLY

3-27. PRESSURE REGULATOR.

a. Description. The pressure regulator assembly is essentially a diaphragm activated hydraulic regulating valve equipped with quick-disconnect fittings capable of accepting 6-inch hoses. The skid-mounted unit has a flow capacity of 350 gpm and weighs 190 pounds. Its primary purpose is to limit line pressures on downhill grades. The pressure regulator is shown in figure 3-24.

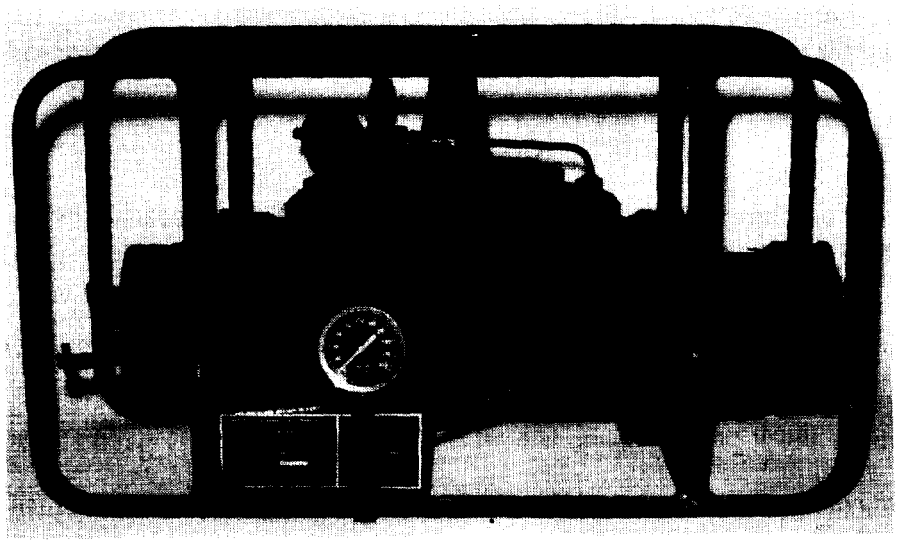


Figure 3-24. Skid-Mounted Pressure Regulator

b. Major Components.

(1) Internal Fuel Pressure Control. Fuel pressure is controlled by the pressure regulator valve, which in turn is governed by the adjustment of the reducing valve located on top of and toward the discharge end of the regulator assembly.

(2) Reducing Valve. The reducing valve is designed to provide sensitive control of the pressure regulating valve in order to ensure accurate regulating of the fuel discharge pressure, The reducing valve is adjustable within a range of 30 to 110 psi.

(3) Flow Control Valve. The flow control valve, which is connected to and works in conjunction with the reducing valve, controls the rate of pressure flow to and from the top of the pressure regulating valve diaphragm providing a balanced opening or closing of the valve.

(4) Skid Assembly. The pressure regulating valve assembly is skid-mounted in a protective welded aluminum frame.

(5) Controls.

(a) Pressure Gage. The pressure gage, located on the side of the pressure regulator, indicates inlet or discharge pressure.

(b) Reducing Valve. The reducing valve is located on top of the pressure regulator towards the discharge end. It provides a sensitive control of the pressure regulating valve.

(c) Pressure Regulating Valve. The pressure regulating valve is centrally mounted between the inlet and discharge flanges and is used to regulate the pressure of the system on downhill grades.

(d) Selector Control. The selector control is located in the tubing directly beneath the pressure gage. It is a three-way valve which enables the operator to obtain readings of the inlet and discharge pressures of the pressure regulator assembly.

(e) Directional Arrow. The directional arrow indicates the direction of flow through the regulator and is located on the regulator housing behind the three-way selector valve.

c. Tabulated Data for the Pressure Regulator.

Size (in)	6
Maximum pressure (psi)	300
Set pressure (psi)	30
Minimum pressure (psi)	30
Capacity (gpm)	350
Volume (cu ft)	15
Length (in)	37
Width (in)	18
Height (in)	22
Weight -Total assembly (lbs)	190

3-28. PREPARATION FOR USE.

a. Initial Handling.

(1) Unloading. Generally, unloading can be handled by two men. When extensive lifting is required, a forklift or hoist may be necessary.

(2) Location. A pressure regulator is sometimes required to protect the hose from excessive pressures when the hose line is positioned on downhill grades. Calculations used to locate pressure reducing stations are explained in Chapter 2. After determining the proper location of the regulator, place the regulator into position with the directional arrow pointed in the direction of fuel flow.

b. Grounding. Consult Chapter 2, Section II for grounding information. In general, drive the ground rod into the ground to within 6 inches of the end of the rod. Use the clips to attach the ground wire from the frame to the rod, ensuring a clean metal-to-metal connection.

c. Hose Installation. New equipment is shipped completely assembled and ready for use with a preset pressure of 65 psi. Inspect the equipment visually, checking for bent tubing, cracked glass on the pressure gage, and external damage to the regulator. Inspect the assemblies to ensure that they are connected properly and securely. Remove the dust cap and the dust plug, and check the coupling and adapter for cracks, chips, or dents that would cause them to leak during operation, Remove the dust cap and dust plug from the couplings and check the couplings for cracks, chips, dents, dirt, or defective gaskets which might cause leaks during operation, To install the unit in a bulk fuel system, proceed as follows:

(1) Remove the dust plug from the inlet quick-disconnect coupling and the dust cap from the outlet coupling.

(2) Close a valve upstream of the connection point or shut off flow with a hose clamp,

(3) Uncouple the hose connections at the point the unit is to be inserted.

(4) Couple the free end of the upstream hose to the inlet coupling on the fuel monitor assembly and couple the free end of the downstream hose to the outlet coupling.

(5) Open the upstream valve or clamp to allow fuel to flow through the pressure regulator assembly and the remainder of the system.

3-29. GENERAL OPERATING GUIDELINES.

a. Operator's Daily Checks and Services. To ensure proper function and operation, the pressure regulator assembly must be systematically inspected before, during, and after operation. All inspections of assemblies, subassemblies, or parts shall include any supporting members or connections. Any mechanical condition that may result in further damage to the unit shall be corrected before the equipment is operated. Table 3-5 lists the operator's daily checks and services with intervals designated as before operation (B), during operation (D), and after operation (A).

b. Operational Considerations. After the pressure regulator has been installed and the fuel is moving through the system, check the pressure on the inlet and discharge sides. Previous calculations will have indicated the desired discharge pressure (see Chapter 2).

(1) If the desired discharge pressure is not being realized, it will be necessary to adjust the reducing control valve (2, figure 3-25). In addition, the flow control valve (3) may need adjustment to eliminate pulsating of the pressure regulating valve. Make sure that the locknuts on the adjustment screws are loosened before attempting to adjust either control and tightened after adjustment. Adjust the reducing control valve as follows:

(a) Increase the discharge pressure from the regulating valve by turning the reducing valve adjusting screw (1) in a clockwise direction. Tighten the locknut when the desired pressure is achieved,

(b) Decrease the discharge pressure by turning the reducing valve adjusting screw (1) in a counterclockwise direction.

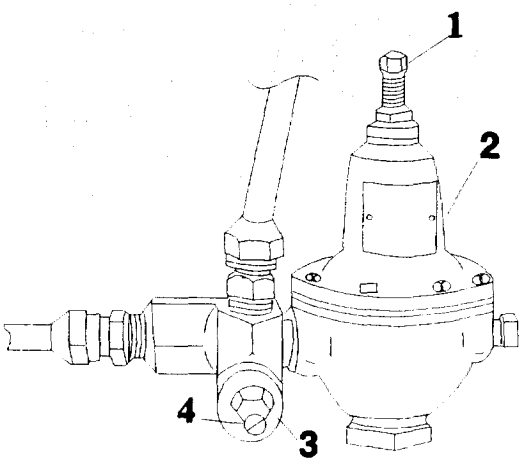
(c) Eliminate pulsating or abrupt opening and closing of the pressure regulating valve by turning the adjusting screw (4) clockwise or counterclockwise as needed. Tighten the locknut after adjustment.

Table 3-5. Operator's Daily Checks and Services for Pressure Regulator

INTERVAL			PROCEDURE
B	D	A	
♦			General. Check the pressure gage for a cracked lens or dents which would indicate the possibility of internal damage. Check all tubing and piping for bends or cracks. Check all connections for tightness, dents, breaks, or cracks which would cause leaking during operation. Check for stains and gummy deposits around fittings. Remove the dust covers from the couplings and check inside the inlet and discharge flanges for foreign matter and gummy deposits. The presence of heavy gummy deposits indicates that the equipment was improperly drained and cleaned. In this event, the unit must be referred to the proper maintenance echelon for dismantling and thorough cleaning. Clean the pressure gage window.
♦	♦		Pressure regulating valve. Make a visual inspection for missing parts and cracks in the housing. If dust covers are not secure, make sure there is no foreign matter inside the unit. Check for leaks around the cover gasket and flange gaskets. Check the bottom of the valve body for the presence of fuel which would indicate a leak. Observe inlet and outlet pressures for pulsating operation; adjust the flow control valve as necessary.
♦	♦		Reducing valve. Make sure the locknut on the adjusting screw is tight, and the cover is secure. Check tubing connections. Check for leaks. Adjust to the desired pressure if necessary.
♦	♦		Selector control. Move the selector control to all three positions. Check for binding or looseness. Check for leaks.
♦	♦		Couplings. Make sure the locking action of the cam arm is functioning properly. Replace the gasket in the coupling if the old one is not usable. Check for leaks.
♦			Screens. Check upper and lower screens. Clean, if necessary.
		♦	Pressure regulator assembly. No service is necessary unless the assembly is to be removed from the system (see paragraph 3-29, b).

(2) Before removing the pressure regulator from the system, be certain that the hoses on the inlet and outlet sides have been drained and that the pressure reading on the regulator is zero. The selector control assembly which permits pressure flow to the gage should be shifted to the inlet and outlet positions to ensure that a zero reading registers for both sides of the regulator. Disconnect the couplings and remove the hoses. Drain the excess fuel in the regulator unit into a proper receptacle and replace the dust covers on the inlet and outlet fittings. Retrieve the ground wire and rod. If the equipment is to be stored or shipped, it must be thoroughly purged and cleaned before repacking.

(3) When moving the unit to a new location, ensure that the regulator unit is drained thoroughly and that the dust covers are secured properly. Remove all fuel on the outside of the equipment as a safety precaution. The ideal method of transporting the pressure regulator is to place it in a vehicle or trailer, but for short distances it can be hand-carried. In either case, care shall be taken to prevent damage to the reducing valve, tubing, and pressure gage.



1. Adjusting screw
2. Reducing control valve
3. Flow control valve
4. Adjusting screw

Figure 3-25. Flow Control Adjustment

(4) During operation in extreme cold, protect the regulator unit from rain, snow, and moisture. To prevent the couplings, selector valve, and adjustments from freezing, check the pressure and readjust as necessary.

(5) At temperatures of about 100°F (38°C) gasoline begins to boil thereby changing the composition of the fuel. Use a tarpaulin or suitable cover to protect the regulator unit from extreme heat. Cover with moistened burlap and shade from the sun.

(6) Hose couplings and adapters have close tolerances making installation difficult and preventing proper sealing of connections should sand or dust be introduced into the openings. Leave the dust covers off the regulator unit only long enough to install or remove the hoses.

(7) Salt air will quickly attack unprotected surfaces. Remove any rust or aluminum oxide formations immediately. Clean, thoroughly dry, and cover the exposed surfaces with paint. Protect machined surfaces with a light coat of oil. Avoid removing anodized coating from aluminum fittings.

APPENDIX A

REFERENCES

Code of Federal Regulations, Title 40, Part 300	National Contingency Plan
Federal Register, October 22, 1991	Spill Prevention Control and Countermeasure Plan (proposed)
Code of Federal Regulations, Title 40, Part 355 SARA Title 3	Emergency Planning and Community Right to Know Act
DoD 4140.25-M	Management of Bulk Petroleum Products, Storage and Distribution Facilities
MIL-HDBK-114	Mobility Fuels User Handbook
MIL-HDBK-200	Quality Surveillance Handbook for Fuels, Lubricants, and Related Products
NATOPS 00-80T-109	Aircraft Refueling Manual
NAVFAC MO 230	Maintenance Manual - Petroleum Fuel Facilities
NAVAIR 00-80R-14	Aircraft Firefighting and Rescue
NAVAIR 06-5-502	Aircraft Refueling for Shore Facilities
NAVAIRINST 10340.3B	Maintaining Quality and Limiting Contamination of Aircraft Fuels
TI 10340-15/1B	Authorized Fuels
TM 5-343	Military Petroleum Pipeline Systems
TM 5-4320-226-14	Operator's, Organizational, Direct Support and General Support Maintenance Manual for Pumping Assembly, Diesel Engine Driven, Wheel Mtd, 350 GPM, 275 FT. Head, Models 13220E1070 (97403) and 13226E2289 (97403)
TM 5-4320-256-14	Operator, Organizational, Direct Support and Generel Support Maintenance Manual Including Repair Parts and Special Tools: Pump Assembly, Flammable, Liquid, Centrifugal, Self-Priming, GED, 2-in., 100 GPM (American Air Filter Inc. Model Fare 3950)
TM 5-2805-257-14	Operator, Organizational, Intermediate (Field), Direct Support, General Support, and Depot Maintenance Manual: Engine, Gasoline, 3 HP, Military Standard Models
TM 5-4320-309-14	Operator, Unit, Direct Support and General Support Maintenance Manual:

TM 4320-14/1	Pump Unit, Centrifugal, Self-Priming, 125 GPM, Water/Fuel, Class 3, Diesel Driven
TM 5-4330-217-12	Operator and Organizational Maintenance Manual Including Repair Parts and Special Tools List: Filter-Separator, Liquid Fuel, 100 GPM, Frame Mounted (Keene Corp. Model 844-5-V-100AL)
TM 5-4330-211-12	Operator and Organizational Maintenance Manual Including Repair Parts and Special Tools List: Filter-Separator, 350 GPM Optimum Performance
TM 3835-15/1	Installation and Maintenance Amphibious Assault Fuel System (AAFS) and Tactical Airfield Fuel Dispensing System (TAFDS)
TM 86702D-14/1	Installation, Operation, Maintenance, and Repair Instruction: Pump, Centrifugal, Engine Driven, 600 GPM
TM 4930-15/2	Installation, Operation, Maintenance, and Repair Instruction: Pump Assembly, Flammable Liquid, Bulk Transfer, Diesel-Engine-Driven, 600 GPM Capacity, 340 Feet Total Head, Two Wheel Chassis Mounted
TM-07661B-14/1	Extinguisher, Fire, Dry Chemical and AFFF Self-Contained
TM 5-6630-218-10	Aviation Fuel Contaminant Test Kit
TM 10-1101	Storage and Issue of Packaged Fuel
FM 10-69	Petroleum Supply Point Equipment and Operations
FM 10-68	Aircraft Refueling
MCO P5090.2	Environmental Compliance and Procedures Manual
MCO 6280.8	Hazardous Waste Minimization
MCO 6240.5A	Hazardous Material Disposal Program
MCO 4400.170	Control and Accountability of Petroleum and Related Products/Coal
ASTM D 287	Standard Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)
ASTM D 2276	Standard Test Method for Particulate Contaminant in Aviation Fuel
ASTM D 3240	Standard Test Method for Undissolved Water in Aviation Turbine Fuels
ASTM D 4057	Standard Practice for Manual Sampling of Petroleum and Petroleum Products

APPENDIX B

OIL SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN GUIDELINES

B-1 . INTRODUCTION.

a. Legislation. United States Environmental Protection Agency (USEPA) enforces legislation governing all aspects of hazardous materials management. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, mandates that Commanders notify the National Response Center (NRC) upon the release of a hazardous substance into the environment. Requirements are detailed in Code of Federal Regulations Title 40 (40 CFR), Part 300: National Contingency Plan. Additional reporting requirements are mandated by 40 CFR, Part 355, SARA Title 3: Emergency Planning and Community Right to Know Act. This regulation requires a telephone and written report to the appropriate state emergency response commission and local emergency planning committee. The Resource Conservation and Recovery Act (RCRA) regulates the generation, transportation, storage and disposal of hazardous waste. Permits and pretreatment programs required by the Clean Water Act regulate the introduction of any pollutant or hazardous substance into public water. The Clean Air Act provides penalties for violation of State and Federal emissions standards.

b. Hotlines. The following telephone hotlines are available for reporting hazardous material spills:

National Response Center: 1-800-424-8802
Emergency Planning and Community Right to Know: 1-800-535-0202

Paragraph B-4 provides the National Response Center reporting form. This form may be used as a guide in the creation of local checklists.

c. Responsibility. The aforementioned regulations dictate the development of a comprehensive written plan for the prevention and containment of oil and other hazardous materials spills. Wide variations in state and local regulations compel all plans to be tailored to each tactical unit and situation. The following discussion serves as a guideline to formulating an Oil Spill Prevention Control and Countermeasure (SPCC) Plan.

B-2. POLICIES.

a. Responsibility. The Commanding Officer (CO) is charged with responsibility for preventing spillages or the unauthorized discharge of oil and other hazardous materials within his area of operation. The CO will develop and implement plans and procedures which are consistent with applicable regulations governing the prevention, reporting, containment, and clean up of such spillage or discharge. Furthermore, the CO will assign responsibility for the following tasks:

(1) The procurement and maintenance of pollution abatement facilities, materials, and equipment

(2) Personnel required for routine monitoring, surveillance, upchannel reporting, and enforcement of spills and unauthorized discharges

(3) An on-scene coordinator to direct operations in the event of a spill

(4) An initial response team to handle a hazardous material spill.

b. Actions. The CO will take the following actions:

(1) Publish and prominently post directives setting forth detailed policies and procedures for the control and prevention of oil and hazardous substance pollution specifically applicable to the local situation

(2) Review the Command's maintenance and operational procedures to ensure that they support sound environmental practices

(3) Conduct frequent inspections of areas and facilities assigned to the Command to ensure compliance with published procedures

(4) Establish immediate action procedures to remedy past or potential pollution resulting from spills

(5) Ensure that all personnel within the Command receive adequate training regarding the environmental impact of oil and hazardous substance spills, as well as instruction in proper hazardous material disposal techniques

(6) Encourage the reuse and reclamation of salvageable fuel in accordance with prescribed procedures

(7) Maintain up-to-date materials management records.

B-3. GUIDELINES.

a. Reporting Spills of Oil and Other Hazardous Substances. Develop, implement and post a procedure for reporting the spill. Include:

(1) A list of materials and substances classified as hazardous if spilled in the water or on the ground

(2) The office or agency requiring spill notification

(3) A report checklist covering the location, substance and approximate amount of material involved in the spill.

b. Response to a Spill. Develop, implement and post a procedure detailing responsibilities and actions required to deal with a spill. Include:

(1) Identification of the initial response team and on-scene coordinator

(2) Actions to be taken to minimize health and environmental hazards

(3) Specific containment and cleanup procedures

(4) Actions required to ensure personnel and public safety.

B-4. NATIONAL RESPONSE CENTER (NRC) REPORT COLLECTION FORM. This form is similar to that used by the NRC to collect information from parties reporting the release of hazardous material.

Call #

(A) Reporting Party
Last name
First name
Phones

Company
OrgType
Position
Address

(S) Suspected Responsible Party
Last name
First name
Phones

Company
OrgType
Position
Address

Were materials released (Y/N) ?
Meeting Federal obligation to report, calling for responsible party (Y/N)

Record number
Confidential?
Date/Time received:

Incidence Description
Source and/or cause of incident
Date Time DTG Type RR Hot (Y/N)?
Continuous release type Continuous release #
Cause Vessal/Vehicle #

Incident Address/Location

Nearest city
State
County
Zip
Direction from city
Range
Units
Latitude Quadrant
Longitude Quadrant
Milepost

Distance from city Units
Section Township
Container type Tank Cap. Units Facility Cap.
Latitude Degrees Minutes Seconds
Longitude Degrees Minutes Seconds
Area ID Block ID

Material
CHRIS code
Released quantity
Unit of measure

Released material
Quantity in water
Units of measure

Remedial Action
Actions taken to correct or mitigate incident

Impact
Number of injuries
Number of fatalities
Were there evacuations (Y/N/U)?
Number evacuated
Was there any damage (Y/N/U)?
Damage in dollars
Medium affected Description
More information about medium

Additional information
Any information about the incident not recorded elsewhere in the report

Caller Notifications
EPA STATE USCG OTHER DESC

NRC Notifications
(This block is reserved for NRC initiated notifications to the appropriate agency,)

APPENDIX C

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AAFS	Amphibious Assault Fuel System
AFFF	aqueous film forming foam
amp	ampere
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
AVGAS	aviation gasoline
°C	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFD	Contaminated Fuel Detector
CFR	Code of Federal Regulations
CO	commanding officer
CO_2	carbon dioxide
DF	diesel fuel
DiEGME	di-ethylene-glycol-mono-methyl-ether
EGME	ethylene-glycol-mono-methyl-ether
ERS	Expedient Refueling System
°F	degrees Fahrenheit
FWD	Free Water Detector
FSII	fuel system icing inhibitor
ft	feet
gal	gallon
gpm	gallons per minute
HERS	Helicopter Expedient Refueling System
in	inches
in^3	cubic inches
JP	jet propulsion
K	potassium
lb	pounds
MAGTF	Marine Air Ground Task Force
mg/L	milligrams per liter
mph	miles per hour
MOGAS	combat automotive gasoline
MOS	military occupational specialty
NATO	North Atlantic Treaty Organization
NATOPS	Naval Air Training and Operating Procedures Standardization
NFPA	National Fire Protection Association
NPSH	net positive suction head
ODC&S	operator daily checks and services
OJT	on the job training
POL	petroleum, oil and lubricants
ppm	parts per million
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
RCRA	Resource Conservation and Recovery Act
rpm	revolutions per minute
SAE	Society of Automotive Engineers
SARA	Superfund Amendments and Reauthorization Act

SDA	static dissipator additive
SH/FL	static head/friction loss
SOP	standard operating procedure
SPR	single point pressure
SPCC	spill prevention and control countermeasure
TAFDS	Tactical Airfield Fual Dispensing System
TBD	to be determined
TEL	tetra-ethyl lead
TFS	Tactical Fuel Systems
TPLM	Tactical Petroleum Laboratory, Medium
USEPA	United States Environmental Protection Agency

APPENDIX D

EQUATIONS

CONVERSION FACTORS

LENGTH

mile = 5280 feet = 1760 yards = 1,60935 kilometers
kilometer = 0.621 miles = 1000 meters
yard = 3 feet = 36 inches = 0.9144 meters
meter = 3.281 feet = 39.37 inches = 100 centimeters
foot = 12 inches = 30.48 centimeters
inch = 2.54 centimeters
millimeter = 0.03937 inches

VOLUME

barrel = .159 m^3 = 5.61 cubic feet = 42 gallons = 158.98 liters
cubic meter (m^3) = 6.29 barrels = 264.2 gallons
cubic foot (ft^3) = 7.48 gallons = 28.32 liters = 1728 cubic inches = 62.4 pounds (water)
gallon = 231 in^3 = 3.7854 liters = 8.34 pounds (watar)
liter water = 1 kilogram
gram water = 1 cubic centimeter
MBBL = 1000 bbls = 42,000
CBBL = 100 bbls = 4,000

WEIGHT

ton = 2000 pounds (short) = 2240 pounds (long)
pound = 16 ounces = 0.453592 kilograms
kilogram = 2.205 pounds = 35.27396 ounces = 1000 grams
gram = 1000 milligrams

PRESSURE, WORK AND ENERGY

psi = 2.31 feet of (water) head
kilogram/square centimeter = 14.223 psi
horsepower = 550 ft-lbs/sec = 2545 Btu/hr = 746 watts
inch of mercury (Hg) = 0.491 psi
centimeter of mercury (Hg) = 0.193 psi
atmospheric pressure at sea level = 14.7 psi
Btu = 778 ft-lbs

COMMON EQUATIONS

Specific Gravity	$SG = \frac{141.5}{°API + 131.5}$
°API Gravity	$°API\ Gravity = \frac{141.5}{SG} - 131.5$
Area of a Rectangle	$A = LW$
Area of a Triangle	$A = 1/2\ bh$
Circumference of a Circle	$C = \pi d = 2\pi r$
Area of a Circle	$A = \pi r^2 = \frac{\pi d^2}{4} = .785d^2h$
Volume of a Rectangular Solid	$V = LWh$
Volume of a Cylinder	$V = \pi r^2 h = \frac{\pi d^2 h}{4} = .785d^2h$
Degrees Fahrenheit	$°F = \frac{9}{5}\ °C + 32$
Degrees Celsius	$°C = \frac{5}{9}\ (°F - 32)$
Pressure	$P = \frac{HSG}{2.31}$
Flow Rate	$Q = VA$
Horsepower	$HP = \frac{ft.\ lbs/min}{33,000}$
Friction Loss in Hoseline	$HL = \frac{.031 \times F \times L \times Q^2}{d^5}$

LEGEND

L = length
SG = specific gravity
π = 3.1416
W = width
b = base
h = height
d = diameter
r = radius
V = volume

A = area
H = pressure (feet or head)
HL = friction loss in hoseline
F = friction factor
Q^2 = flow in GPM (squared)
d^5 = inside diameter in inches

APPENDIX E

TACTICAL FUEL SYSTEM COMPONENTS FOR THE AMPHIBIOUS ASSAULT FUEL SYSTEM (AAFS) NSN 4930-01-113-9173

NSN	QUANTITY AND ITEM IDENTIFICATION
	ADAPTING ASSEMBLY, FUEL -2 per system
4730-00-705-9534	1 -ADAPTER, STRAIGHT, FLANGE TO HOSE: 4 in adapter and 6 in flange
4730-00-705-9531	1 -ADAPTER ASSEMBLY, STRAIGHT, FLANGE TO HOSE: 4 in. adapter and 3 in. flange
4730-00-034-2174	1 -ADAPTER ASSEMBLY, STRAIGHT, FLANGE TO HOSE: 4 in. adapter and 4 in. flange
4730-00-034-2176	1 -ADAPTER ASSEMBLY, STRAIGHT, FLANGE TO HOSE: 4 in. adapter and 4 in. flange
4730 -00-705 -9536	2-ELBOW HOSE: used with 2 in. hose
5330-00-106-0671	AR-GASKET: 13/1 6 in. diameter
4720-00-253-5535	2-HOSE ASSEMBLY, NONMETALLIC: 25 ft lg, 2 in. diameter
4720-00-109-8145	2-HOSE ASSEMBLY NONMETALLIC: 50 ft lg. 2 in. diameter
4720-00-109-8146	6-HOSE ASSEMBLY, NONMETALLIC: 50 ft lg, 4 in. diameter
4930-00-930-5104	1 -MANIFOLD, DISPENSING
4930-00-051-3194	2-NOZZLE, FUEL AND OIL SERVICING: w/2 in. coupling half
	BEACH UNLOADING ASSEMBLY - 1 per system
4720-00-109-8146	2-HOSE ASSEMBLY, NONMETALLIC: 50 ft lg, 4 in. diameter
4930-01-271-7605	l-ADAPTER: 6 in. female split clamp to flange
4930-01-270-0827	1 -ADAPTER: 6 in. male camlock to flange
4720-00-109-8147	120-HOSE ASSEMBLY, NONMETALLIC: 50 ft lg 6 in diameter
4720-00-705-9542	13-HOSE ASSEMBLY, NONMETALLIC, SUCTION: 25 ft lg 4 in diameter
4930-00-438-9030	1 -MANIFOLD ASSEMBLY: flanged five way with three 6 in male coupling halves and two 6 in female coupling halves
4930-00-106-8672	l-METER ASSEMBLY, SKID MOUNTED: 3 in
4930-00-051-3193	3-NOZZLE, FUEL AND OIL SERVICING: 4 in coupling half
4930-01-103-7609	2-PUMP ASSEMBLY, TRAILER MOUNTED: 600 gpm
4730-00-068-0393	1 -REDUCER, QUICK DISCONNECT: 4x6 in size
4730-01-079-8234	1 -REDUCER, QUICK DISCONNECT: 6x4 in size
4930-00-738-5971	1 -STRAINER ASSEMBLY
5430-01-126-7623	2-TANK ASSEMBLY, FABRIC, COLLAPSIBLE: 20,000 gal capacity
4820-00-075-2404	2-VALVE, GATE: 4 in size
4730-00-705-9555	1 -WYE, QUICK DISCONNECT: 4 in male and 4 in female hose connection

NSN	QUANTITY AND ITEM IDENTIFICATION
	DRUM UNLOADING ASSEMBLY-1 per system
4330-00-177-8485	2-FILTER-SEPARATOR, LIQUID FUEL: 350 gpm
4720-00-109-8145	3-HOSE ASSEMBLY, NONMETALLIC: 50 ft lg 4 in diameter
4720-00-705-9541	6-HOSE ASSEMBLY, NONMETALLIC, SUCTION: 25 ft lg, 2 in diameter
4720-00-705-9542	3-HOSE ASSEMBLY, NONMETALLIC, SUCTION: 25 ft lg, 4 in diameter
4930-00-705-9547	1-MANIFOLD, DRUM UNLOADING
4930-01-103-7609	1 -PUMP ASSEMBLY, TRAILER MOUNTED: 600 gpm
4930-00-106-8671	6-VALVE, DRUM UNLOADING
4730-00-705-9556	1-WYE, QUICK DISCONNECT: type ACC
	FUEL DISPENSING ASSEMBLY -2 per system
4330-00-177-8485	1 -FILTER-SEPARATOR, LIQUID FUEL: 350 gpm
4720-00-253-5535	18-HOSE ASSEMBLY, NONMETALLIC: 25 ft lg, 2 in diameter
4720-00-109-8146	5-HOSE ASSEMBLY, NONMETALLIC: 50 ft Ig, 4 in diameter
4720-00-109-8147	10-HOSE ASSEM8LY, NONMETALLIC: 50 ft lg 6 in diameter
4930-00-903-5104	2-MANIFOLD, DISPENSING
4930-00-106-8672	I-METER ASSEMBLY, SKID MOUNTED: 3 in size
4930-00-106-8673	6-METER ASSEMBLY, FUEL: 2 in size
4930-00-106-8674	6-NOZZLE, FUEL AND OIL SERVICING
4930-00-106-8676	6-STAND ASSEMBLY, FUEL
4730-00-705-9555	1-WYE, QUICK DISCONNECT: type CAA
	PUMP, BOOSTER ASSEMBLY-2 per system
4720-00-109-8146	2-HOSE ASSEMBLY, NONMETALLIC: 50 ft lg 4 in diameter
4720-00-109-8147	120-HOSE ASSEMBLY, NONMETALLIC: 50 ft lg 6 in diameter
4720-00-705-9542	4-HOSE ASSEMBLY, NONMETALLIC: 25 ft lg 4 in diameter
4930-01-103-7609	1 -PUMP ASSEMBLY, TRAILER MOUNTED: 600 gpm
4730-00-068-0393	1 -REDUCER, QUICK DISCONNECT: 4x6 in size
4730-01-079-8234	1 -REDUCER, QUICK DISCONNECT: 6x4 in size
4930-00-106-8678	1 -REGULATOR, FUEL PRESSURE: 6 in size
5430-01-126-7623	2-TANK ASSEMBLY, FABRIC COLLAPSIBLE: 20,000 gal capacity
4820-00-075-2404	2-VALVE, GATE: 4 in size
4730-00-705-9555	1-WYE, QUICK DISCONNECT: type CAA

NSN	QUANTITY AND ITEM IDENTIFICATION
4930-01-126-5366	**REPAIR KIT, GENERAL, BULK FUEL SYSTEM** -1 per system
	TANK FARM -5 per system
4720-00-109-8146	18-HOSE ASSEMBLY, NONMETALLIC: 25 ft lg
4720-00-705-9542	18-HOSE ASSEMBLY, NONMETALLIC: 25 ft lg, 4 in diameter
4930-00-903-0969	1-MANIFOLD ASSEMBLY, SKID MOUNTED: 4 in size
4930-01-103-7609	1-PUMP ASSEMBLY, TRAILER MOUNTED, 600 gpm
4730-00-068-0393	1-REDUCER, QUICK DISCONNECT: 4x6 in size
4730-01-079-8234	1-REDUCER, QUICK DISCONNECT: 6x4 in size
5430-01-126-7623	6-TANK ASSEMBLY, FABRIC, COLLAPSIBLE: 20,000 gal capacity
4820-00-075-2404	12-VALVE, GATE: 4 in size
4730-00-705-9555	3-WYE, QUICK DISCONNECT: 4 in size, type CAA
4730-00-705-9556	3-WYE, QUICK DISCONNECT: 4 in size, type ACC
	ACCESSORY EQUIPMENT
5180-00-606-3566	TOOL KIT, MECHANICS
4210-00-808-4545	EXTINGUISHER, FIRE, DRY CHEMICAL
4210-00-107-2082	EXTINGUISHER, FIRE, DRY CHEMICAL AND AQUEOUS FILM FORMING FOAM

NOTE: Refer to current SL-3 for inventory.

APPENDIX F

TACTICAL FUEL SYSTEM COMPONENTS FOR THE TACTICAL AIRFIELD FUEL DISPENSING SYSTEM (TAFDS) NSN 4930-01-094-0026

NSN	QUANTITY AND ITEM IDENTIFICATION
5120-00-710-6901	8-CLAMP, HOSE
4330-00-177-8485	6-FILTER-SEPARATOR, LIQUID FUEL: 350 GPM
4930-01-131-1917	6-FUEL MONITOR ASSEMBLY
4720-00-109-6145	36-HOSE ASSEMBLY, NONMETALLIC, 50 ft, Lg., 2 inch diameter
4720-00-706-9541	8-HOSE ASSEMBLY, NONMETALLIC, 25 ft. Lg., 2 inch diameter
4720-00-705-9542	19-HOSE ASSEMBLY, NONMETALLIC, 25 ft. Lg., 4 inch diamater
4720-00-109-6146	60-HOSE ASSEMBLY, NONMETALLIC, 50 ft. Lg., 4 inch diameter
4930-00-903-0969	1-MANIFOLD ASSEMBLY, SKID MOUNTED: 4 in. size
4930-00-903-5104	6-MANIFOLD, DISPENSING
4930-00-106-8672	8-MANIFOLD, DRUM UNLOADING
4930-00-106-8672	3-METER ASSEMBLY, SKID MOUNTED: 3 INCH
4930-00-106-8673	12-METER ASSEMBLY, FUEL
4930-00-051-3194	18-NOZZLE, FUEL AND OIL SERVICING, PRESSURE: 2 inch
4930-00-106-8674	12-NOZZLE, FUEL AND OIL SERVICING, GRAVITY: 2 inch
4710-00-273-1041	40-PIPE, CULVERT, METALLIC:1 2 in diameter
5306-00-884-8787	800-BOLT, MACHINE
5310-00-010-5606	800-NUT, PLAIN, SQUARE
4930-01-103-7609	3-PUMP ASSEMBLY, TRAILER-MOUNTED: 600 gpm
OR	
4320-00-987-8718	3-PUMP UNIT, CENTRIFUGAL: 350 gpm
4730-00-068-0393	3-REDUCER, QUICK DISCONNECT: 4 x 6 in size
4930-01-079-8234	3-REDUCER, QUICK DISCONNECT: 6 x 4 in size
4930-00-234-6032	12-REEL, STATIC DISCHARGE
4930-01-126-6366	1 -REPAIR KIT, GENERAL, BULK FUEL SYSTEM
4930-00-106-8678	12-STAND, FUEL NOZZLE
6430-01-126-7623	6-TANK ASSEMBLY, FABRIC, COLLAPSIBLE
4930-00-106-8671	6-VALVE, DRUM UNLOADING
4820-00-075-2404	30-VALVE, GATE: 4 inch
4730-00-706-9565	8-WYE, QUICK DISCONNECT: 4 inch, type CAA
4730-00-705-9556	12-WYE, QUICK DISCONNECT: 4 inch, type ACC

NSN	QUANTITY AND ITEM IDENTIFICATION
	ACCESSORY EQUIPMENT
6630-00-706-2302	1-DETECTOR, CONTAMINATED FUEL: Mark 3
4210-00-808-4545	15-EXTINGUISHER, FIRE, DRY CHEMICAL: portable
4210-00-107-2082	EXTINGUISHER, FIRE, DRY CHEMICAL: skid-mounted
6640-00-999-2786	1-VIEWER KIT, FREE WATER: Mark 1
5180-00-606-3566	1 -TOOL KIT, GENERAL MECHANICS

NOTE: Refer to current SL-3 for inventory.

APPENDIX G

TACTICAL FUEL SYSTEM COMPONENTS FOR THE HELICOPTER EXPEDIENT REFUELING SYSTEM (HERS) NSN 4930-01-114-9930

NSN	QUANTITY AND ITEM IDENTIFICATION
	8-ADAPTER, QUICK DISCONNECT
8110-00-965-2313	18-DRUM, FABRIC, COLLAPSIBLE: 500 gal
4930-00-369-4129	2-FILTER-SEPARATOR: 50 gpm
	or
4330-00-491-4957	2-FILTER-SEPARATOR, LIQUID FUEL: 100 gpm
4720-00-109-8145	B-HOSE ASSEMBLY, NONMETALLIC, 50 ft.lg., 2 inch diamatar
4720-00-893-4339	24-HOSE ASSEMBLY, NONMETALLIC, 120 in.lg., 2 inch diameter
4930-00-106-8673	4-METER ASSEMBLY, FUEL: 2 inch
4930-01-125-6032	2-MONITOR ASSEMBLY, FUEL: 100 gpm
4930-00-051-3194	4-NOZZLE, FUEL AND OIL SERVICING, PRESSURE: 2 inch
4930-00-106-8674	2-NOZZLE, FUEL AND OIL SERVICING, GRAVITY: 2 inch
4320-01 -298-393B	2-PUMP UNIT, CENTRIFUGAL: 125 gpm
	or
4320-00-427-0002	2-PUMP ASSEMBLY, FLAMMABLE LIQUID, BULK TRANSFER: 100 gpm
4930-00-234-6032	4-REEL, STATIC DISCHARGE
5975-01-050-5707	4-ROD, GROUND
4930-00-106-8676	2-STAND, FUEL NOZZLE
4820-00-887-9519	8-VALVE, ANGLE: 2 inch
4730-01-068-5070	2-WYE, QUICK DISCONNECT: 2 inch, CAA type
4930-00-559-7894	12-WYE, QUICK DISCONNECT: 2 inch, CCA type
5340-00-823-5318	2- CAP, PROTECTIVE, DUST AND MOISTURE SEAL
4730-00-079-1362	1 -COUPLING HALF, QUICK DISCONNECT: 2 inch
4730-00-649-9103	2-COUPLING HALF, QUICK DISCONNECT: 2 inch
4730-00-915-5127	l-PLUG, QUICK DISCONNECT
	ACCESSORY EQUIPMENT
5120-01-137-4513	BLADE, SOCKET, HEAD SCREW KEY
4210-00-808-4545	EXTINGUISHER, FIRE, DRY CHEMICAL: hand-type
5120-00-640-6364	WRENCH, TORQUE

NOTE: Refer to current SL-3 for inventory.

APPENDIX H

TACTICAL FUEL SYSTEM COMPONENTS FOR THE EXPEDIENT REFUELER PUMP ASSEMBLY SYSTEMS (ERS)

NSN	QUANTITY AND ITEM IDENTIFICATION
ERS 4320-01-113-7146	
4730-00-231-5634	1 -ELBOW, PIPE TO TUBE
4720-00-705-9541	1 -HOSE ASSEMBLY, NONMETALLIC, 25 ft. lg. 2 in. id.
4720-00-253-5535	1 -HOSE ASSEMBLY, NONMETALLIC, 25 ft. lg. 2 in. id.
4720-00-455-2821	1 -HOSE ASSEMBLY, SUCTIONAL, 25 ft. lg 2 in. id.
4930-00-051-3194	2-NOZZLE, FUEL AND OIL SERVICING
4930-00-106-8674	2-NOZZLE, FUEL AND OIL SERVICING
3990-00-271-1879	PALLET, MATERIAL HANDLING
4320-00-427-0002	PUMPING ASSEMBLY, 100 GPM
2910-00-066-1235	1 -ADAPTER
7240-00-222-3088	1 -CAN, GASOLINE, MILITARY
4720-00-298-6927	1 -HOSE ASSEMBLY, NONMETALLIC, 1/4 in. id.
4730-00-842-2201	l-ADAPTER, STRAIGHT, TUBE TO HOSE
4720-00-289-9197	3- HOSE, NONMETALLIC, 1/4 in. id.
2990-00-961-3692	l-STARTER ROPE, ENGINE
5340-00-914-7303	1 -STRAP, WEBBING
4730-01-009-1735	1 -ADAPTER, QUICK DISCONNECT
5975-00-878-3791	l-GROUND ROD
5999-00-186-3912	1 -CLAMP. ELECTRICAL
5975-00-794-2523	2-COUPLING, GROUND ROD
5975-00-924-9927	1 -DRIVE HEAD
5975-01-143-7340	3-ROD, GROUND
5940-00-112-5218	1 -TERMINAL LUG
6145-00-189-6695	6-WIRE, ELECTRICAL
4620-00-887-9519	1 -VALVE, ANGLE
4730-01-068-5070	1 -WYE, QUICK DISCONNECT
5120-00-640-6324	WRENCH TORQUE
ERS 4930-01-182-5028	
4720-00-705-9541	1 -HOSE ASSEMBLY, NONMETALLIC, (suction) 2 in. id.
4720-00-253-5535	3-HOSE ASSEMBLY, NONMETALLIC, (discharge) 2 in. id.
	or
4720-00-455-2821	1 -HOSE ASSEMBLY, (discharge) 2 in. id.
4930-00-051-3194	1 -NOZZLE, FUEL AND OIL SERVICING
4930-00-106-6674	2-NOZZLE, FUEL AND OIL SERVICING

NSN	QUANTITY AND ITEM IDENTIFICATION
ERS 4930-01-182-5028 (Continued)	
3990-00-271-1879	1 -PALLET, MATERIAL HANDLING
4320-01-313-9442	1 -PUMP UNIT, CENTRIFUGAL, 125 GPM
4730-01-009-1735	1-NIPPLE, QUICK DISCONNECT
4730-01-064-0560	1 -REDUCER, QUICK DISCONNECT
4930-00-106-8676	1-STAND ASSEMBLY, FUEL
5340-00-914-7303	2-STRAP, WEBBING
4820-00-887-9517	1 -VALVE, ANGLE
4730-01-068-5070	1 -WYE, QUICK DISCONNECT, AAC type
4930-00-559-7894	1 -WYE, QUICK DISCONNECT, CCA type
	ACCESSORY EQUIPMENT
4210-00-808-4545	2-EXTINGUISHER, FIRE, DRY CHEMICAL

NOTE: Refer to current SL-3 for inventory.

APPENDIX

CONVERSION CHARTS

AREA

To convert	To	Multiply by
care s	Square feet	43,560
	Square yards	4,840
	Square miles	0.0015625
	Square meters	4,046.873
	Hectares	0.4046873
Hectares	Square yards	11,959.85
	Acres	2.47104
	Square miles	0.003861
	Square meters	10,000
	Square kilometers	0.01
	Square feet	107,600
Square centimeters	Square feet	0.001076
	Square inches	0.1550
	Square meters	0.0001
	Square miles	3.861 X 10"
	Square millimeters	100
	Square yards	0.000196
Square feet	Acres	0.0000296
	Square centimeters	929.0
	Square meters	0.09290
	Square inches	144.0
	Square yards	0.11111
	Square miles	3.587×10^{8}
	Square millimeters	9.29×10^{4}
Square inches	Square centimeters	6.452
	Square feet	0.6944
	Square millimeters	645.2
	Square yards	0.000716
Square kilometers	Acres	247.1
	Square centimeters	,010
	Square fact	10.76×10^{6}
	Square inches	$1.550 \times \times 10^{9}$
	Square meters	106
	Square miles	0.3861
	Square yards	1.196×10^{6}
Square meters	Acres	0.0002471
	Square centimeters	10,000
	Square feet	10.76
	Square inches	1,550
	Square miles	3.861×10^{7}
	Square millimeters	106
	Square yards	1.196

AREA

To convert	To	Multiply by
Square miles	Acres	640.00
	Square feet	27.88×10^6
	Square kilometers	2.590
	Square meters	2.590×10^6
	Square yards	3.098×10^6
Square yards	Acres	0.0002066
	Square centimeters	8,361
	Square feet	9.0
	Square inches	1,296
	Square meters	0.8361
	Square miles	3.228×10^7
	Square millimeters	8.361×10^5

LENGTH

To convert	To	Multiply By
Centimeters	Feet	0.03281
	Inches	0.3937
	Kilometers	1×10^5
	Maters	0.01
	Miles	6.214×10^6
	Millimeters	10.0
	Mils	393.7
	Yards	0.01094
	Microns	10,000
Feet . . . . . .,	Centimeters	30.48
	Kilometers	0.0003048
	Meters	0.3048
	Miles (Nautical)	0.0001645
	Miles (Statute)	0.0001894
	Millimeters	304.6
	Mils	12,000
	Microns	30,480.0
Kilometers	Centimeters	1×10^5
	Feet	3,281
	Inches	39,370.0
	Meters	1,000.0
	Miles	0.6214
	Millimeters	$1O^6$
	Yards	1,094
eagle	Miles	3
Meter	Centimeters	100
	Feet	3.281
	Inches	39.37
	Kilometers	0.001
	Miles (Nautical)	0.0005396
	Miles (Statute)	0.0006214
	Millimeters	1,000.0
	Yards	1.094
	Microns	1×10^6

LENGTH

To convert	To	Multiply by
Miles (Nautical)	Feet	6,080.27
	Kilometers	1.853
	Meters	1,853.0
	Miles (Statute)	1.1516
	Yards	2,027
Miles (Statue) , ...	Centimeters	1.609×10^5
	Feet	5,280
	Inches	63,360.0
	Kilometer	1.609
	Meters	1,609.0
	Miles (Nautical)	0.8684
	Yards	1,760
Millimeters	Centimeters	0.1
	Feet	0.003281
	Inches	0.03937
	Kilometers	10^6
	Meters	0.001
	Miles	6.214×10^7
	Mils	39.37
	Yards	0,001094
	Microns	1,000
Microns	Centimeters	1×10^4
	Inches	3.937×10^5
	Meters	1×10^6
Yard	Centimeters	91.4402
	Fathoms	0.03
	Feet	3
	Inches	36
	Meters	0.9144
	Miles	5.68182×10^4

FLOW

To convert	To	Multiply by
Barrels/day	Gallons/hour	1.75
	Gallons/minute	0.0292
Barrels/hour	Cubic feet/minute	0.0936
	Gallons/minute	0.7
Gallons/hour	Cubic feet/hour	0.1337
	Cubic feat/minute	0.002228
	Gallons/minute	0.016667
Gallons/minute	Barrels/day	34.257
	Barrels/hour	1.4266
	Barrels/minute	0.02381
	cubic feet/day	192.50
	Cubic feet/minute	0.1337
	Gallon/day	1,440.0
	Liters/second	0.6308
	Cubic feet/second	0.002228
Cubic feet/minute	Gallons/second	0.1247
	Liters/second	0.4720
	Cubic centimeters/second	472.0
Cubic feet/second	Million gallons/day	0.646317
	Gallons/minute	448.831
Cubic yards/minute	Cubic feet/second	0.45
	Gallons/second	3.367
	Liters/second	12.74
iters/minute..	Cubic feet/second	0.0005886
	Gallons/second	0.004403

WEIGHTS

To convert	To	Multiply by
Pounds (avoirdupois)	Grams	453.59
	Kilogram	.45359
	Ounces (avoirdupois)	16
	Ounces (troy]	14.5833
Pounds (avoirdupois)	Long tons	$4.4643 \times 10^{}$
	Short tons	5×10^{4}
Short tons.....	Kilograms	907.186
	Long tons	.892857
	Metric tons	.907185
	Pounds	2,000.00
Kilograms . ., . ., ...	Pounds	2.20462
	Short tons	0.0011023
	Metric tons	0,001
	Long tons	$9.842 \times 10^{}$
Long tons	Kilogram	1,016.05
	Metric tons	1.01605
	Pounds	2,240
	Short tons	1.12
Metric tons	Kilogram	1,000
	Long tons	0.98421
	Pounds	2,204.6
	Short tons	1.10231

VOLUME

To convert	To	Multiply by
Barrels (US)	US gallons	42
	Cubic inches	9,702
	Cubic feet	5.6146
	Imperial gallons	34.9726
	Liters	158.984
	Cubic meters	0.15899
Cubic centimeters	Cubic feet	3.531×10^{6}
	Cubic inches	0.06102
	Cubic meters	10^{6}
	Cubic yards	$1,308 \times 10^{6}$
	Gallons (US liquid)	0.0002642
	Liters	0.001
	Pints	0.002113
	Quarts (US liquid)	0.001057
Cubic feet	Cubic centimeters	28,320.00
	Cubic inches	1,728.00
	Cubic meters	0.02832
	Cubic yards	0.03704
Cubic feet	Gallons (US liquid)	7.48052
	Liters	28.32
	Pints (US liquid)	59.84
	Quarts (US liquid)	29.92
Cubic inches	Cubic centimeters	16.39
	Cubic feet	5.787 X 10”
	Cubic meters	1.639×10^{6}
	Cubic yards	2.143×10^{6}
	Cubic gallons	0.004329
	Liters	0.01639
	Mil feet	1.061×10^{5}
	Pints (US liquid)	0.03463
	Quarts (US liquid)	0.01732
Cubic meters	Bushels (dry)	28.38
	Cubic centimeters	1×10^{6}
	Cubic feet	35.31
	Cubic inches	61.023
Cubic meters	Cubic yards	1.308
	Gallons (US liquid	264.2
	Liters	1,000
	Pints (US liquid)	2,113.0
	Quarts (US liquid	1 ,057.0
Cubic yards	Cubic centimeters	7.646×10^{5}
	Cubic feet	27.0
	Cubic inches	46,656
	Cubic meters	0.7646
	Cubic gallons	202.0
	Liters	764.6
	Pints (US liquid)	1,615.9
	Quarts (US liquid)	807.9

VOLUME

To convert	To	Multiply by
Gallons (Imperial)	Cubic inches	277.42
	Cubic feet	0.160544
	US gallons	1.20094
	US barrels	0.028594
	Liters	4.54596
	Cubic maters	0.004546
Gallons (US)	Cubic centimeters	3785.0
	Cubic feet	0.1337
	Cubic inches	231.0
	Cubic meters	0.003785
	Cubic yards	0.004951
	Liters	3.785
	Pints	8.0
	Quarts	4.0
Gills	Liters	0.1183
	Pints (liquid)	0.25
biters	Bushels (US dry)	0.02836
	Cubic centimeters	1,000.0
	Cubic feat	0.03531
	Cubic inches	61.02
	Cubic meters	0.001
	Cubic yards	0.001308
	Gallons (US liquid)	0.2642
	Pints (US liquid)	2.113
	Quarts (US liquid)	1.057

FORCE

To convert	To	Multiply by
Pounds/square inch	Kilogrsms/square mater	703.06687
	Inch of mercury	2.036009
	Feet of Water	2.306009
	Atmospheres	.0680457
	Kilograma/square centimeter	.07036
Kilograms/square meter	Pounds/square inch	.00142234
	Pounds/square foot	.2048169
	Inches of mercury	.0028959
	Feet of water	.003280833

APPENDIX J

API GRAVITY TABLES

Table J-1. API Gravity Charts. Corresponding Specific Gravity, Weights, and Pressures at 60°F

API GRAVITY	SPECIFIC GRAVITY	POUNDS PER CU FT	FEET PER PSI	PSI PER FOOT
10	1.0000	62.30	2.31	,433
15	.9659	60.17	2.39	.418
20	.9340	58.18	2.48	.404
25	.9042	56.32	2.56	.391
26	.8984	55.96	2.57	.389
27	.8927	55.61	2.59	.386
28	.8871	55.26	2.61	.384
29	.8816	54.92	2.62	.381
30	.8762	54.58	2.64	.379
31	.8708	54.24	2.66	.377
32	.8654	53.90	2.67	.374
33	,8602	53.58	2.69	.372
34	.8550	53.25	2.70	.370
35	.8498	52.93	2.72	.368
36	.8448	52.62	2.74	.365
37	,8398	52.31	2.75	.363
38	.8348	52.00	2.77	.361
39	.8299	51.69	2.79	.359
40	.8251	51.39	2.80	.357
41	.8203	51.09	2.82	.355
42	.8155	50.79	2.84	.353
43	.8109	50.51	2.85	.351
44	.8063	50.22	2.87	,349
45	.8017	49.93	2.88	.347
46	.7972	49.65	2.90	.345
47	.7927	49.37	2.92	.343
48	.7883	49.10	2.93	.341
49	.7839	48.82	2.95	,339
50	.7796	48.55	2.97	.337
51	.7753	48.29	2.98	.335
52	.7711	48.02	3.00	.334
53	.7669	47.76	3.02	,332
54	.7628	47.50	3.03	.330
55	,7587	47.25	3.05	.328
56	.7547	47.00	3.06	.326
57	.7507	46.75	3.08	.325
58	.7467	46.50	3.10	.323
59	,7428	46.26	3.11	.321

Table J-1. API Gravity Charts, Corresponding Specific Gravity, Weights, and Pressures of 600 F - Continued

API GRAVITY	SPECIFIC GRAVITY	POUNDS PER CU FT	FEET PER PSI	PSI PER FOOT
60	.7389	46.01	3.13	.320
61	.7351	45.77	3.15	.318
62	.7313	45.53	3.16	.316
63	.7275	45.30	3.18	.315
64	.7238	45.07	3.19	.313
65	.7201	44.84	3.21	.311
66	.7165	44.61	3.22	.310
67	.7128	44.39	3.24	.306
68	.7093	44.16	3.26	.307
69	.7057	43.94	3.27	.305
70	.7022	43.72	3.29	.304
71	.6988	43.51	3.30	.302
72	.6953	43.30	3.32	.301
73	.6919	43.08	3.34	.299
74	.68B6	42.87	3.35	.298
75	.6852	42.66	3.37	.296

Table 1-7. API Gravity Equivalents at 60°F

API GRAVITY	SPECIFIC GRAVITY	POUNDS PER			BARRELS PER		
		us GALLON	IMPERIAL GALLON	BARREL	LONG TON	METRIC TON	SHORT TON
1	1.0679	8.895	10.683	373.59	5.996	5.901	5.353
2	1.0599	8.828	10.602	370.78	6.041	5.946	5.394
3	1.0520	8.762	10.523	368.00	6.087	5.991	5.435
4	1.0443	8.697	10.446	365.32	6,132	6.035	5.475
5	1.0368	8.634	10.369	362.63	6.177	6.080	5.516
6	1.0291	8.571	10.294	359.98	6.223	6.124	5.556
7	1.0217	8.509	10.219	357.38	6.268	6.169	5.596
8	1.0143	8.448	10.146	354.82	6.313	6.213	5.637
9	1.0071	6.388	10.074	352.30	6.359	6.258	5.677
10	1.0000	6.328	10.002	349.78	6.404	6.303	5.716
11	0.9930	8.270	9.932	347.34	6.449	6.347	5.758
12	0.9861	8.212	9.863	344.90	6.495	6.392	5.799
13	0.9792	8.155	9.794	342.51	6.540	6.437	5.839
14	0.9725	8.099	9.727	340.16	6.585	6.481	5.880
15	0.9659	8.044	9.661	337.85	6.630	6.525	5.920
16	0.9593	7.989	9.595	335.54	6.676	6.570	5.961
1 7	0.9529	7,935	9.530	333.27	6,721	6.615	6.001
18	0.9465	7.862	9.466	331.04	6.766	6.660	6.042
19	0.9402	7.830	9.404	326.86	6.812	6.704	6.082
20	0.9340	7.778	9.341	326.68	6.857	6.749	6.122
21	0.9279	7.727	9.260	324.53	6.902	6.793	6.163
22	0.9218	7.676	9.219	322.39	6.948	6.838	6.204
23	0.9169	7.627	9.160	320.33	6.993	6.882	6.244
24	0,9100	7.578	9.101	318.28	7.038	6.927	6.284
25	0.9042	7.529	9.042	316.22	7.084	6.972	6.325
26	0.8984	7.481	8.985	314.20	7.129	7.017	6.365
27	0.8927	7.434	8.928	312.23	7.174	7.061	6.406
28	0.8871	7.387	8.872	310.25	7,220	7.106	6.446
29	0.8816	7.341	8.817	308.32	7.265	7.150	6.487
30	0.8762	7.296	8.762	306.43	7.310	7.194	6.527
31	0.8708	7.251	8.708	304.54	7.356	7.239	6.568
32	0.8654	7.206	8.654	302.65	7.401	7.284	6.603
33	0.8602	7.162	8.603	300.85	7.446	7.328	6.648
34	0.8550	7.119	8.550	299.00	7.492	7.373	6.689
35	0.8499	7.076	8.498	297.19	7.537	7.418	6.730
36	0.8448	7.034	8.448	295.43	7,582	7.462	6.770
37	0.6398	6.992	8.399	293.71	7.628	7.506	6.810
36	0.8348	6.951	8.348	291.94	7.673	7.552	6.851
39	0.8299	6.910	8.299	290.22	7.718	7.597	6.891

Table J-2. API Gravity Equivalents et 600 F - Continued

API GRAVITY	SPECIFIC GRAVITY	POUNDS PER			BARRELS PER		
		us GALLON	IMPERIAL GALLON	BARREL	LONG TON	METRIC TON	SHORT TON
40	0.8251	6.870	8.251	288.54	7.764	7.641	6.931
41	0.8203	6.830	8.203	286.86	7.809	7.686	6.972
42	0.8156	6.790	8.155	285.18	7.854	7.731	7.013
43	0.8109	6.751	8.109	283.58	7.900	7.774	7.053
44	0.8063	6.713	8.062	281.95	7,945	7.819	7,093
45	0.8017	6.675	8,017	280.35	7.990	7.864	7.134
46	0.7972	6.637	7.971	278.75	8.036	7.909	7.175
47	0.7927	6.600	7.927	277.20	8.081	7.953	7.215
48	0.7883	6.563	7.882	275.65	8.126	7,998	7.256
49	0.7839	6.527	7.838	274.09	8.172	8.043	7.297
50	0.7796	6.491	7.794	272,58	8.217	8.088	7.337
51	0.7753	6.455	7.752	271.11	8.262	8.132	7.377
52	0.7711	6.420	7.710	269.64	8.308	8.176	7.477
53	0.7669	6.385	7.668	268,17	8.353	8.221	7.458
54	0.7628	6.350	7,626	266.70	8.398	8.266	7.499
5 5	0.7587	6.316	7.586	285.27	8.444	8.310	7.539
56	0.7547	6.283	7.546	263.89	8.489	8.354	7.579
57	0.7507	6.249	7.505	262.46	8.534	8.400	7.620
58	0.7467	6.216	7.465	261.07	8.580	8.444	7.661
59	0.7428	6.183	7.427	259.73	8.625	8.488	7.700
60	0.7389	6.151	7.387	258.34	8.670	8.534	7.742
61	0.7351	6.119	7.349	257.00	8.716	8.578	7.782
62	0.7313	6.087	7.310	255.65	8.761	8.623	7.823
63	0.7275	6.056	7.273	254.35	8.807	8.668	7.863
64	0.7238	6.025	7.236	253.05	8.852	8.712	7.904
65	0.7201	5.994	7,199	251.75	8.897	8.757	7,944
66	0.7165	5.964	7.163	250.49	8.943	8.801	7.984
67	0.7128	5.934	7.127	249.23	8.988	8.846	8.025
68	0.7093	5.904	7.091	247.97	9.033	8.891	8.065
69	0.7057	5.875	7.055	246.71	9.079	8.936	8.107
70	0.7022	5.845	7.020	245.49	9.125	8.980	8.147
71	0.6988	5.816	6.986	244.31	9.169	9.024	8.187
72	0.6953	5.786	6.951	243.10	9.215	9.069	8.227
73	0.6919	5.759	6.917	241,88	9.260	9.114	8,269
74	0.6886	5.731	6.883	240,70	9,305	9.159	8.309
75	0.6852	5.704	6.849	239.53	9.351	9.204	8.350
76	0.6819	5.676	6.817	238.39	9.396	9.248	8.390
77	0.6787	5.649	6.784	237.26	9.442	9.292	8.430
78	0.6754	5.622	6.752	236.12	9.487	9.337	8.470
79	0.6722	5.595	6.720	234.99	9.532	9.382	8.511

Table J-2. API Gravity Equivalents at 60°F - Continued

		POUNDS PER			BARRELS PER		
API GRAVITY	SPECIFIC GRAVITY	us GALLON	IMPERIAL GALLON	BARREL	LONG TON	METRIC TON	SHORT TON
80	0.6690	5.569	6.687	238.86	9.578	9.427	8.552
81	0.6659	5.542	6.656	232.76	9.623	9.472	8.593
82	0.6628	5.516	6.624	231.67	9.668	9.516	8.633
83	0.6597	5.490	6.595	230.62	9.714	9.559	8.672
84	0.6566	5.465	6.563	229.53	9.759	9.605	8.713
85	0.6536	5.440	6.533	228.48	9.805	9.649	8.754
86	0.6506	5.415	6.503	227.43	9.850	9.694	8.794
87	0.6476	5.390	6.473	226.38	9.695	9.738	8.835
88	0.6446	5.365	6.443	225.33	9.941	9.784	8.876
8 9 . . . , ...	0.6417	5.341	6.415	224.32	9.986	9.828	8.916
90	0.6388	5.317	6.385	223.27	10.031	9.874	8.967
91	0.6360	5.293	6.357	222.31	10.077	9.917	8.996
92	0.6331	5.269	6.328	221,30	10.122	9,962	9,038
93	0.6303	5.245	6.300	220.33	10.168	10.006	9.077
94	0.6276	5.222	6.273	219.37	10.213	10.050	9.117

*Water (H_2O at 60°F).

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* u.s. GOVERNMENT PRINTING OFFICE: 1995-633-163/00376