PETROLEUM STORAGE TANKS
SUBCOURSE OVERVIEW

This subcourse is designed to teach you to select the correct type of storage tanks for a given set of conditions as well as how and when required maintenance is performed on petroleum storage tanks. The subcourse also provides instruction on the procedures for sampling and gagging petroleum storage tanks.

There are no prerequisites for this subcourse.

This subcourse reflects the doctrine which was current at the time that it was prepared. In your own work situation, always refer to the latest publications.

The words "he," "him," "his," and "men," when used in this publication, represent both the masculine and the feminine genders unless otherwise stated.

TERMINAL LEARNING OBJECTIVE

TASK: You will be able to identify bulk petroleum storage tanks, select the most appropriate type of tank for a given situation, and supervise tank preparation and maintenance.

CONDITIONS: You will have access to extracts from FM 10-18 and information from FM 10-20.

STANDARDS: You will select tanks and supervise all types of tank maintenance in accordance with FM 10-18 and FM 10-20.
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Use the above publication extracts to take this subcourse. These extracts may not be the most current. At the time this subcourse was written, these were the current publications. In your own work situation, always refer to the latest publications.

Passing score for ACCP material is 70%.
LESSON ONE

PETROLEUM TANKS AND MAINTENANCE PROCEDURES

MQS Manual Task: 03-5103.00-0028

OVERVIEW

TASK DESCRIPTION:

In this lesson you will learn to identify bulk petroleum tanks and their maintenance requirements and procedures.

LEARNING OBJECTIVE:

TASK: Select appropriate storage tanks and supervise their maintenance.

CONDITIONS: You will be given access to information from FM 10-18 and FM 10-20.

STANDARDS: Storage tank selection and maintenance procedures will be performed in accordance with FM 10-18 and FM 10-20.

REFERENCES: The material contained in this lesson was derived from the following publications:

FM 10-18
FM 10-20

INTRODUCTION

Upon completing this lesson, you will be able to identify types of petroleum storage tanks and select the appropriate tank for a given set of conditions. As a petroleum management officer, you must learn to supervise petroleum tank maintenance procedures, including tank cleaning, vapor freeing, and testing procedures.

PART A - TYPES AND USES OF PETROLEUM STORAGE TANKS

The principles of surface bulk storage for petroleum products are basically the same for the military as they are for the petroleum industry. The tanks in general commercial use have capacities of
1,000, 25,000, 30,000, 55,000, 82,000, and 120,000 barrels. The military forces most commonly use tanks that range in capacity from 100 to 50,000 barrels.

Surface tanks are usually constructed of steel plates. Normally, storage tanks are of welded construction. However, bolted steel tanks are available in sizes up to 10,000 barrels, and collapsible fuel tanks ranging in capacity from 3,000 gallons to 5,000 barrels (for storage in forward areas) are available.

Pressure and atmospheric tanks are the two main categories of storage tanks.

Pressure storage tanks are used to store products of a sufficiently high vapor pressure as to boil at normal atmospheric pressure. Use pressure tanks to store such products as natural petroleum gasoline and liquified petroleum gases (LPG) as well as some other volatile liquids, such as anhydrous ammonia. Pressure tanks are of various shapes, such as spheres, hemispheres, and cylinders. As it is unlikely that you will encounter these pressure storage tanks in the military petroleum field, they will not be further discussed in this subcourse.

Atmospheric tanks are commonly used for the storage of bulk petroleum products. Use these tanks for products that remain in the liquid form under normal atmospheric conditions.

Atmospheric tanks can be of any of the following types:

- Steel tanks.
- Concrete tanks.
- Collapsible tanks.
- Cone-roof tanks.
- Floating-roof tanks.
- Lifter-roof tanks.

1. Steel Tanks.

Unlined steel tanks are used for the storage of nearly every kind of petroleum product. Steel tanks in the smaller sizes (capacities of 500 or fewer barrels) may be horizontal or vertical. They may be installed either above or below ground.
a. **Riveted Tanks.** Prior to the development of effective welding techniques, all steel storage tanks were of riveted construction. This type of construction requires continual maintenance to prevent leakage. Riveted tanks are now usually assigned to the storage of nonvolatile
products because they are difficult to keep tight. Where there is a choice between welded and riveted tanks at a depot, use welded tanks to store volatile products.

b. Bolted Steel Tanks. For military use, bolted steel tanks are available in the following capacities: 100, 250, 500, 1,000, 3,000, and 10,000 barrels. A standard Army specification has been established which makes possible an interchangeability of tanks made by different manufacturers. Characteristics of these tanks are shown in Figure 1-1.

![Figure 1-1. Three-Ring, 10,000-Gallon Bolted Steel Tank.](image)

You can obtain bolted steel tanks through the military supply system. These tanks have the advantage of being easily assembled without the need of highly specialized personnel. You need less time to erect these tanks than you need to erect welded tanks. Another advantage is that you can disassemble, move, and reassemble the tank at a different location.
NOTE: Once a tank has been used, it is vital that you ensure that all parts are numbered during disassembly so that the tank is exactly as it was before it was disassembled. Otherwise, it will leak.

You should consider bolted steel tanks for use when better tanks are not available. Because of fund limitations, you will find them in use at many military installations as semipermanent storage tanks for all types of petroleum fuels.

c. **Welded Tanks.** At permanent installations, you should normally store petroleum products in welded steel tanks which may be installed above or below ground. Welded steel tanks are more expensive to construct than bolted steel tanks because construction must be done according to American Petroleum Institute (API) standards and by properly certified welders. However, tanks that are properly constructed, tested, and maintained remain free of leaks for a long time period.

2. **Concrete Tanks.**

The majority of concrete tanks at military installations are underground tanks having walls of prestressed concrete. Steel tension members are placed around the shell of the tank in a series of rings or in a continuous spiral. The tension members are stressed to a prescribed percentage of the metal's yield point. The exterior of the tank shell is then protected with a second pour of concrete or the entire surface of the shell is united.

When you are storing fuels which are heavier than diesel fuel, use concrete tanks that have been coated with a sodium silicate solution. Concrete tanks, used to store diesel and lighter fuels, have surfaces that are normally provided with a coating system.

Limit the temperature (or, more importantly, the rate of temperature change) of the concrete tank's contents to prevent excessive temperature differences between the inside wall surfaces and the outside steel bands. Remember that it is not safe to have the concrete at any time more than 75°F warmer than the steel bands. This is the uppermost limit and is much more than is desirable.

Be sure that the flow of oil into a cold, empty tank is started slowly when the temperature of the oil is more than 65°F warmer than the tank's temperature. Allow an underground tank to be heated slowly so that the steel and concrete temperatures will not differ greatly because of the insulating effect of the earthen fill that surrounds the tank. Limit the rate of heating the oil in storage to 4°F per
hour, and do not let the temperature of the oil be raised above the
top limit of 155°F. This limit is more than enough for all normal
depot operations except reclamation processes for which steel tanks
would be used instead of concrete ones.

Do not allow oil temperature in aboveground concrete tanks to exceed
the temperature of the air by more than 84°F. Locate pits containing
pumps and heaters alongside underground tanks. Replace ladders or
other means of access by stairs where this is feasible. Deep access
pits are considered unsafe because of vapor collection. Be sure to
provide adequate forced ventilation, which is necessary for all such
pits, especially when they are adjacent to gasoline and jet fuel
tanks.

3. **Collapsible Tanks.**

Collapsible tanks can be installed rapidly for emergency storage.
Such tanks are often used instead of bolted tanks and range in
capacity from 3,000 to 210,000 gallons. If permanence of storage is
expected to exceed one year, the tanks may be replaced with steel
tanks. Field conditions may dictate the use of the 500-gallon
collapsible drum for temporary storage.

Atmospheric tanks can be further classified according to the type of
the roof on the tank.

4. **Cone-Roof Tanks.**

The cone-roof tank is the most commonly used tank, primarily because
of its relatively low construction cost as compared to other designs.
This type of tank is subject to breathing and filling losses. Vapors
are forced out and air is sucked into the tank by expansion and
contraction caused by filling or issuing from the tank.

The roof is coned toward the center of the tank, and sufficient pitch
is allowed to provide adequate drainage, usually 3/4-inch pitch per
foot. You may use cone-roof tanks to store practically all grades of
petroleum products. Military services have adapted internal pan
floaters incone-roof tanks. This type of tank offers the
conservation and safe handling advantages of the standard floating
roof tank, but without the disadvantages associated with the
introduction of rain, snow, and sleet into the open-roof tank.

5. **Floating Roof Tank.**

The standard floating roof tanks are designed to permit the roof to
float on the surface of the liquid which rises or falls in accordance
with changes in product levels. There is no vapor space.
Consequently, with proper design of the deck and an efficient
closure (vapor seal) around the edge of the floating roof, breathing and filling losses are practically eliminated.

Fire hazards are eliminated because little, if any, vapor is present above the level of the product in the tank. The closure around the edge of the floating roof consists of a continuous gastight, weatherproof, synthetic-rubber-coated asbestos fabric attached to a sealing ring that slides along the face of the tank shell as the roof moves up and down. This sealing ring is maintained in close contact with the inside of the tank shell by means of counterweighted hangers or similar devices which exert constant pressure outward against the tank shell.

Two general types of floating-roof tanks are in use: the pontoon type and the double-deck type. In most military facilities, the floating-roof tanks without cone roofs are fitted with geodesic dome roofs for protection from rain, snow, and sleet. Floating-roof tanks are best suited for use in volatile product service where inventory turnover is rapid, such as airfield jet fuel tanks.

6. **Lifter Roof Tanks.**

The lifter roof is constructed to allow the roof to rise or fall as the pressure of vapor inside the tank increases or decreases. A trough is constructed around the upper part of the tank shell on the outside to hold a liquid seal in which a skirt plate attached to the roof is immersed. The liquid seal prevents the escape of vapors from inside the tank up to the maximum limit of travel for the tank roof. A control valve is provided to vent the excess volume of vapors or pressure as the roof rises to its extreme upper limits of travel.

When the roof comes downward as the tank's contents are removed and when the vacuum that is formed reaches 1-ounce-per-square-inch or more, a similar control valve allows air into the tank to prevent excessive vacuum. This latter condition usually only occurs while the roof rests on the roof rafters in its lowest position.

It is best to use the lifter-roof tank in volatile-product service in practically any climate in situations where the fuel will be kept in storage for relatively long time periods, as frequent emptying and filling would defeat the purpose of the lifter roof. Remove any excessive collection of ice and snow to prevent the excess weight from opening the control valve as a result of increased pressure inside the tank.

You may connect lifter roof tanks by vapor lines to one or more cone-roof tanks in the same product service to form a vapor conservation system. When this is done, use caution to make sure that the
cone-roof tanks in the system are gastight and capable of withstand ing the maximum pressure imposed on the system by the lifter roof tank. This type of interconnection is, of course, impossible with floating-roof tanks.

PART B - TANK ACCESSORIES AND MAINTENANCE

All storage tanks are equipped with a number of fittings and accessories which vary in accordance with the type of tank and the product to be stored. These accessories as well as the tanks themselves must be inspected and maintained to prevent product loss and to prevent fires and explosions.

1. **Steel Tank Exteriors**.

Check the outside of an aboveground steel tank every month for leaks. Be aware that seeping fuel discolors paint. Repair leaks if possible. Do not try to repair a leak on the bottom of a storage tank. First, determine how much fuel is being lost by checking the daily gauge. Then report the leak to support maintenance.

2. **Painted Surface**.

Look for rust and chipped paint on the sides of the tank every month. Check the paint on the roof every six months and spot paint if necessary. Do not paint the entire tank. Painting an entire tank is a support maintenance function. To spot paint areas of the tank:

- Clean the surface of the tank down to the bare metal with a wire brush.
- Paint the area with one coat of red lead primer (DOD-P-17545), and allow it to dry.
- Put two coats of rust-inhibiting semigloss enamel (Federal Specification TT-E-485) on the sides. Use white oil paint (Federal Specification TT-P-102) on the roof. If the tank has been camouflaged, use lusterless enamel (Federal Specifications TT-E-527) in black, brown, yellow, and sand.

3. **Floating Roof**.

Check the seal on a floating roof monthly. Make sure it is in good condition and tightly sealed. Report any damage to support maintenance. Check the roof daily during rainy, freezing, or snowy weather. If the seal has frozen to the tank's surface, free the seal before raising or lowering the roof. Remove snow by shoveling it over the side of the tank as soon as possible to prevent the roof from collapsing under the weight of the snow.
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4. **Swivel Joint Pipe Drain or Hose Drain.**

Drain the water off the roof daily by opening the roof drain valve located on the tank shell at the bottom. Clean the swivel joint pipe drain or hose and the sump. Keep the pipe drain free of water during freezing weather.

5. **Vents.**

Open vents may be used to provide venting for tanks in which fuel oils with a flashpoint of 100°F and above are stored. There is no reason to use anything more complex than an open vent pipe (protected with a hood and coarse screen to keep out rain, birds, and insects) on any underground tank assigned to store boiler or burner fuel. These products do not give off flammable vapors and are not appreciably affected by contact with the air.

Open vents are also suitable for aboveground tanks assigned to nonvolatile fuel storage, although under certain conditions breather valves may be justified in the latter service. Be sure to check the vents during nesting season to make sure that no birds have built nests in the vent openings. Remove the screens every six months and clean them with solvent. Check for corrosion and damage. Repair, repaint, or replace them if necessary.

6. **Pressure Vacuum Breather Valve.**

Breather valves are installed on aboveground gasoline or jet fuel storage tanks. They are also found on large underground tanks but are commonly omitted if the underground tank is less than 2,500 gallons in capacity.

Breather valves have weighted discs which open at preset pressure or vacuum levels. When the vapor pressure in the tank exceeds the settings (usually 1/2 ounce), the weighted disc is raised, allowing the pressure to escape. When a vacuum exists in the tank (either from removing fuel or because of a drop in temperature), the vacuum relief disc opens, allowing air to enter the tank.

Remove the valve every six months. Remove debris from the housing. Clean the screens with dry-cleaning solvent or compressed air. Clean pallets, guides, and seats with dry cleaning solvent or mild liquid metal polish. If you use metal polish be careful to remove the polish completely.

Lubricate the stems and the guides. Re grind corroded seats and pallets by placing fine grinding compound between the two parts and lightly moving the pallet back and forth on its seat. Then clean the parts as described above.
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7. Flame Arresters.

Flame arresters are installed on some storage tanks. Flame arresters are installed on tank vents to prevent fire from entering the tank through the vent. This is done by means of banks of box-shaped tubes made of flat and corrugated metal sheets.

Inspect the outside of flame arresters every six months. Clean and spot paint if necessary. Remove the tube banks every six, months and clean them with solvent or compressed air. Do not remove any of the metal sheets from a tube bank. To prevent damage to the tank during freezing weather, remove the entire flame arrester from the tank before the tube banks become clogged with ice and prevent air from circulating.

8. Gage and Thief Hatches.

On aboveground storage tanks, gauge hatches are located so that the gauger can gauge the tank while standing on the platform at the top of the tank ladder or stairway. This avoids the possibility of the man's weight affecting the height of the reference mark. Where this is impossible, the same man stands on the roof for both opening and closing gauges. The hatches are located so that gaging tapes are not fouled by obstructions inside the tank. Hatches must be closed immediately after use. Gage and thief (sample) hatches are normally the same opening.

Check the hatch cover for damage once a year. Replace the seal if necessary. To replace a damaged hatch cover, remove the pins and hatch cover, put a new cover in place, and replace the pins.

Check the seal on the cover once a year for cracks and damage. Replace the seal if necessary.


Normally, tanks have one or more manholes in the roof or side. The manholes are used mainly for access and ventilation prior to and during cleaning or repairing tasks. Manhole covers must be kept tightly closed to prevent vapors from escaping and to prevent product loss.

Check the manhole cover and gasket monthly. To replace a damaged cover or gasket on a hinged manhole cover (roof-type), remove the pins and washers on the hinge, remove the damaged cover or gasket, put the new cover or gasket in place, and replace the pins and washers. If the manhole cover on the side of the tank is damaged or leaking, the tank must be emptied, the bolts holding the manhole
cover on the tank must be removed, the damaged cover or gasket must be replaced, and the cover and the bolts must be replaced.
10. **Tank Outlets.**

The tank outlets on most storage tanks are normally pipe connections near the bottom of the tank and are equipped with a gate valve to allow the tank to be filled or emptied. Some tanks have been equipped with swing-line outlets—that is, with outlets which may be raised or lowered by means of a floating device attached to the free end of the line or a manually operated winch.

These swing lines are valuable in permitting a clean product to be drawn off in case the product in a tank has become stratified or contains wet oil emulsion or sludge in the lower levels. They are necessities in tanks used for settling and dehydrating wet or contaminated stock.

Sometimes, local regulations require the free end of swing lines to be raised above the oil level when the lines are not actually in use. In normal operation, if the free end of the swing line is kept at a high elevation, drawing only from the top layer of the product, the heavier parts of the product settle and accumulate on the tank's bottom. In the event that the free end of the swing line is constantly kept too low, you may draw off product of an unacceptable quality for issue.

The best operation results in a minimum of accumulation of settlings. The outflow opening on tanks which are not equipped with swing lines is usually about 10 to 18 inches above the tank's bottom. The line may come through the bottom of the tank, but on most tanks it comes through the tank shell. If the tank is used frequently, inspect the gate valve on the tank outlet frequently and lubricate it monthly.

On tanks that are used for long-term storage, check and lubricate the valve every six months. You can check swing lines only when the tank has been emptied and freed of vapor because the swing lines are located inside the tank. However, if the swing line has an external winch, inspect the winch and the exposed cable monthly and lubricate according to the manufacturer's directions.

11. **Water Drain Valves.**

Water drain valves are installed on aboveground tanks to drain accumulated water off the bottom of the storage tank. One or more of these valves may be installed on each tank. The valve is normally screwed into a threaded flange which is welded to the tank shell. The valve seat is arranged so that it is located inside the tank, thus helping to prevent freezing during cold weather. The valve is usually metal-to-metal with an O-ring seal. Some valves have a built-in check valve arrangement so that the valve seat may be removed for repairs.
10 QM4500
Check the manufacturer's maintenance procedures before removing any of these valves from the tank. Check the water valve weekly for leaks. At the same time, drain any water that has accumulated in the tank.

To repair a leak in a drain valve that has a check valve device, unscrew the valve from the threaded flange, replace the O-ring, and screw the valve back into place. If the valve does not have a check valve device, the tank must be emptied of product before the drain valve can be removed for repair. If replacing the O-ring does not stop the leak, then the entire water drain valve must be replaced.

12. **Roof Drains.**

Floating-roof tanks are equipped with roof drains to remove accumulated water from the floating roof. The roof drain assembly consists of a swing joint piping arrangement or hose drain line extending through the interior of the tank to an internal flange of the nozzle installed in the shell near the tank's bottom. A valve is installed on the exterior flange of the roof drain line. The drain opening on the top side of the roof deck is fitted with a short length of threaded pipe for engagement in the roof drain opening. A coarse-mesh screen is installed over the drain opening to prevent debris from entering the drain line.

Check the screen after each time the roof is drained to make sure that the screen is not clogged. Make sure that the swing joint or hose drain is kept free of water during freezing weather. If the lines become frozen in water, damage occurs when the floating roof is raised. Repair the swing joint or hose drain only when the tank is drained of water and is free of vapor. Inspect this equipment during tank cleaning operations. Check the swing joint or hose drain for tightness by filling the line with water and looking for leaks. Replace defective swing joint gaskets and damaged or deteriorated hose.

13. **Liquid-Level Gage.**

Some storage tanks are equipped with a liquid-level gauge designed to indicate the level of product in the storage tank in feet and inches. The gauge head containing the counterbalancing mechanism and tape drum assembly is mounted near ground level on the exterior of the tank. A stainless steel graduated tape extends from the gauge head, through conduit and a series of pulleys, to the top of the tank and then to a float inside the tank. For cone roof and aboveground horizontal tanks, the float is contained by guide wires extending from the top to the bottom of the tank. For floating roof tanks, the float is contained in a gauge well in the roof of the tank.
The gauge is checked for accuracy when it is calibrated. Normally, this type of gauge requires little maintenance. The guide wires inside the tank are stainless steel, and the float is made from nonsinkable foam glass and has a stainless steel jacket.

Gages that do not have wiper blades in the sightglass form condensation on the glass, making it difficult to read the tape. Disassemble and clean the sightglass. If condensation frequently occurs on the sightglass. Install silica gel in the gauge head to absorb moisture. Do not use indicating liquid level gauges when accurate records of the receipt, storage, issue, and shipment of products are required.

Use hand gaging for accurate records.

14. **Fire Walls.**

Each aboveground tank must be surrounded by a fire wall (also called a berm or a dike) to provide a reservoir that will hold 100 percent of the tank's capacity and accommodate 1 foot of freeboard (empty space). The minimum height for a fire wall is 3 feet, and it must be at least 18 inches wide on top. The area that is enclosed by the fire wall should be graded to slope to a drain sump. The sump has a drainpipe which extends under the fire wall and is equipped with a valve or other device outside the fire wall.

Keep the valve closed except when it is being used to drain accumulated water. Do not allow water to accumulate in the fire wall area, the sump, or the pipe during freezing weather. Provide the drain sump with a grate to prevent debris from entering and clogging the drain.

You must perform recurring maintenance on earth fire walls to ensure proper drainage, to control erosion, and to eliminate fire hazards. Cover the fire wall with a 2-inch layer of crushed rock or gravel-aggregate which is resistant to disintegration by weathering. Apply a soil sterilant herbicide on fire walls with side slopes of a ratio of 1 1/2 horizontal to 1 vertical or steeper, in an area where rainfall does not support vegetative growth, or when the fire wall material is unproductive (sandy, gravel, or heavy clay).
12 QM4500
On side slopes with a ratio of two horizontal to one vertical and flatter and where rainfall supports vegetation, establish erosion-resisting grass. Grass on the fire wall and on the area outside and in the vicinity of the petroleum facility must be mowed as necessary to eliminate possible fire hazards. In all cases, keep the area inside the fire wall free of vegetation by applying a soil sterilant herbicide when authorized by local environmental regulations and unit Standing Operation Procedure (SOP).

15. Repair of Leaks in Welded Steel Tanks.

Repair a leaking system in a welded steel tank by rewelding the seam. Be sure that only skilled welders do this welding. (See TM 9-237.) The tank must first be drained, freed of vapor, and cleaned. After obtaining a permit from the safety officer to weld:

- Ensure that all welds are X-rayed and approved by the Contracting Officer prior to filling the tank.
- Move fire-fighting equipment near the tank.
- Make sure the welders wear protective clothing and shoes.
- Remove paint from the surface of the repair with a wire brush.
- Make sure the welders use the right size and type electrodes.
- Repaint the repair area after the leak is fixed.

16. Repair of Leaks in Bolted Steel Tanks.

Determine the method you use to repair a leak in a bolted steel tank by the size and location of the leak. In an emergency, you can stop a leak caused by a small hole in a stave by driving a wooden leak plug into the hole. You can also cover small holes with patch bolts, inserting them from the outside and tightening them with a wrench. Large leaks in the metal plate that require one or more staves are beyond the scope of organizational maintenance.

You can sometimes stop leaks at vertical seams by tightening the nuts at the leaking seam with a wrench. Usually you can repair leaks at the chimes (horizontal edges) by installing additional bolts or by replacing the gasket material.
To install additional using bolts, drill holes between the bolts of the leaking chime. Then use new washers, insert a bolt into each new hole, and securely tighten a nut on each bolt. To install new gasket material, take out enough bolts in the leaking chime to remove the leaking gasket at and around the leak. Then cut out the damaged section of the gasket material, and insert new gasket material. Overlap the edges of the old and new gasket material and caulk the area with putty. Using new gaskets and washers on the bolts, put the bolts back in and tighten the nuts.

NOTE: Before you can make many of the repairs, drain the tank to a level below the leak. If repairers must enter a tank to make repairs, the tank must be drained completely. No one should enter the tank until the fuel vapor level is below the explosive limit. They can then make small repairs which take a short time to complete, such as tightening a nut on a bolt. Repairers must wear protective clothing and respirators. The tank should be free of vapor for longer repairs.

17. Inspection and Maintenance of Collapsible Tanks.

Inspect collapsible tanks daily, and perform any necessary maintenance as soon as possible. Record service to collapsible tanks on DA Form 2404 (Equipment Inspection and Maintenance Worksheet). You will find detailed instructions on maintenance, troubleshooting, and repairs in TM 5-5430-210-12. Inspect and perform maintenance on the items listed below:

a. Surrounding Area. Check the ground around the tank. Remove sticks, rocks, and sharp objects that could damage the tank and cause a leak.

b. Tank Exterior. Check the tank for tears, holes, loose handles, and leaks. Make repairs if possible.

c. Fill and Discharge Parts. Check the fittings, elbows, and hoses for damage and signs of a leak. If necessary, clean the parts with dry-cleaning solvent. Replace worn gaskets and packing.

d. Vent Pipe. Check the coupling, dust cap, and vent pipe for damage. Look for signs of a leak. Replace worn gaskets. Clean all parts with dry-cleaning solvent. Make sure the dust cap can operate freely to relieve pressure.

e. Drain. The fitting is located on the bottom of the tank at the lower end. Check the fitting and hose for leaks. Replace worn packing, and clean all parts with dry-cleaning solvent.
f. **Control Valves.** Check the fill and discharge valves. Also, check the drain control valve. Look for leaks. To repair a leak, replace worn gaskets and packing. Clean all parts with dry-cleaning solvent. Look for bent stems. Repair or replace an entire valve if necessary.

g. **Tank Interior.** Sludge can build up in the bottom of a collapsible tank. Remove this sludge and clean the tank periodically to prevent fuel contamination. Also clean the tank before using it to store a different fuel. To clean the inside of a tank:

- Clear the fuel from the tank.
- Remove the access plate on the filler and discharge fitting.
- Dispose of sludge in a way that is not harmful to the environment (see paragraph 4 of Part F).
- Flush the tank with water.
- Replace the access plate.
- Open the drain and roll up the tank to remove as much water as possible.
- Unroll the tank, and close the drain.
- Pump in a few gallons of fuel and roll up the tank again to wet the walls with fuel, preventing cracking. Use the new fuel if service is being changed from one fuel to another.
- Unroll the tank, and put it back into use.

18. **Repair of Collapsible Tanks.**

The method that you use to repair a collapsible tank depends on the size of the hole or tear in the tank. Repair a collapsible tank with sealing plugs or clamps, whichever is called for, and then replace the tank as soon as possible if it requires permanent repair. Use a sealing plug to repair a hole up to 3/8 inch wide. Use a sealing clamp to repair holes larger than 3/8 inch and tears up to 7 inches. Two repair kits are issued with each collapsible tank. Repair kit type I (Figure 1-2) contains sealing plugs. Repair kit type II (also shown in Figure 1-2) contains sealing clamps and sealing plugs.
a. **Sealing Plug Repairs.** To repair a tank with a sealing plug:

- Put on the protective hood and rubber gloves.
- Put a wooden plug into the hole to stop the leak until repair materials are ready to use.
- Remove the wooden plug and use a rotary cutter to cut a clean edge around the hole.
- Push the cone-shaped end of the sealing plug through the hole.
- Pull the sealing plug up tight against the inside wall of the tank.
- Tighten the nut on the sealing plug with pliers, and cut off excess shank.
b. **Sealing Clamp Repairs.** To repair a tank with a sealing clamp:

- Put on the protective hood and rubber gloves.
- Put a wooden plug into the hole, if possible, to stop the leak until you select a sealing clamp.
- Select the correct size sealing clamp. The shorter side or width of the bottom plate of the clamp should fit through the hole or tear. It may be necessary to enlarge the hole or tear slightly by using a knife to insert the bottom plate (Figure 1-3).

![Diagram of Sealing Clamp Repairs](image)

**Figure 1-3. Reparing a Collapsible Tank.**

- Fold the hinged stud down, and put the bottom plate through the tear.
- Straighten the stud, and rotate the bottom plate so that the longer side or length of the bottom plate is in the same direction as the length of the tear.
- Slide the upper plate over the stud, and tighten the wing nut.
PART C - TANK CLEANING

You should not clean a tank unless it is absolutely necessary. You must drain, vapor free, and clean a tank for certain inspections and repairs, when fuel is being contaminated, when sludge has built up, and when there is a change in product or service.

1. **Responsibility for Cleaning a Tank.**

With two exceptions, vapor freeing, decontaminating, and cleaning tanks are organizational maintenance activities. It is the facilities engineer's responsibility to clean fixed tanks in order to apply rust proofing and rust coating. It is also the facilities engineer's responsibility to clean fixed tanks that are part of motor pools, service stations, and aircraft fueling systems.

2. **When to Clean a Tank.**

You should clean a tank only when it is absolutely necessary. Specifically, you should drain, vapor free, and clean a tank:

- For certain inspections.
- For certain repairs.
- When fuel is being contaminated.
- When sludge has built up.
- When there is a change of product.
- When there is a change of service.

  a. **Inspections.** MIL-STD-457 states that a storage tank must be inspected by physical entry (see Figure 1-4). This means that the inspectors must go inside the tank to carry out the inspection. Clean the tank before such an inspection takes place. When these inspections are made depends on whether or not the inside of the tank is coated and whether or not incoming fuel is pumped through a filter/separator. See Figure 1-4 for more information.

  b. **Repairs.** Drain, free of vapor, and clean a storage tank before making any repairs to the tank, inside or outside, that require welding or the use of tools that could ignite vapors. Clean the tank whenever it is necessary to enter the tank to make lengthy repairs.
c. **Fuel Contamination.** Clean a storage tank as often as necessary to maintain fuel quality. MIL-STD-457 states that a sample should be taken from an active stock tank at least every 30 days. Take a sample from a dormant stock tank every 180 days. If laboratory tests show that the fuel is being contaminated by rust and dirt in the tank, clean the tank. If tests show that the tank is being contaminated by bacteria, use fresh, clean water to flush the tank and lines. If bacteria reappear in later tests, clean the tank.

d. **Sludge Buildup.** Dirt, gum, waxes, and resins settle out of fuel in a storage tank. This sludge collects on the bottom of a storage tank. When the sludge hardens, it forms a heel which cannot be pumped out. This heel remains in the tank when the tank is emptied and filled. The heavier or the darker the fuel, the more sludge is left behind. Fuel pumped in on top of this layer of sludge can become contaminated. When bottom samples show fuel contamination or when gaging reveals that too much sludge has built up, the tank should be cleaned.

e. **Change of Product.** Use a tank to store only one kind of fuel so that quality can be maintained. If the service of a tank must be changed from one fuel to another, clean the tank before the new fuel is pumped into the tank.

f. **Removal of Tank from Service.** If a decision is made to take a tank out of service for longer than four months, take the following actions:

- Clean all concrete tanks.
- Clean steel tanks that are used to store fuel oil, diesel fuel, and lube oil. Then coat them with the same product they contained. This will preserve the metal.
Clean steel tanks used to store gasoline, jet fuel, and kerosene and then coat them with general purpose lubricating oil (Federal Specification VV-L-800) to preserve the metal.

Clean steel tanks that are to be dismantled with general purpose lubricating oil.

NOTE: It is not necessary to coat a tank that was taken down in order to move it to a new site for reassembly.

g. Reactivation of a Tank. If a decision is made to put an inactive tank back into service, take the following actions:

- Clean tanks that have stood empty for some time to remove the rust which may have formed on the inside.
- Clean tanks that were coated with lubricating oil before they are used to store gasoline, jet fuel, or kerosene.
- Clean inactive tanks that were ballasted with water or fuel to remove rust and sludge.

3. Duties of the Facilities Engineer.

When there is reason to justify cleaning a tank, notify the facilities engineer. It is the facilities engineer's duty to:

- Determine the need to enter any tank that has been used to store leaded fuel.
- Determine the need to enter any other tank that is capable of holding 1,000 or more barrels of fuel.
- Make sure that there is a safety equipment set available for use.
- Obtain the services of a safety engineer who is experienced in tank-cleaning safety. The safety engineer should be present when any tank containing leaded fuel is entered. The safety engineer should also be present when any tank capable of holding 1,000 or more barrels of fuel is entered.
- Request medical advice from the Surgeon General (AR 200-1), if necessary.
Obtain the services of a contractor to clean a tank if the local demand for tank cleaning is so infrequent that the local work force cannot maintain a level of expertise (AR 420-49). The contractor should be instructed to provide all the equipment and take all the precautions necessary to protect life, health, and property.

PART D - TANK-CLEANING PRECAUTIONS

During any fuel-handling operation, fuel vapors can accidentally ignite, causing a fire or an explosion. The risk of fire or an explosion is especially high when tanks are being cleaned. There are also other health and physical hazards besides fires and explosions which make tank cleaning dangerous work. However, the job can be performed without death, injury, or property damage if you plan the cleaning operation step by step and if members of the cleaning detail receive extensive training.

A working knowledge of the dangers involved and hands-on experience with the safety equipment is essential. At least two members of the cleaning detail must be trained and tested in first aid. The training must include cardiopulmonary resuscitation and treatment for vapor inhalation. You, the cleaning detail supervisor, must also prepare a fire plan for the tank in the event that vapors are ignited.

1. Fire Prevention.

The danger of fire and explosion during tank cleaning operations comes from the possible ignition of fuel vapors. Eliminate all sources of ignition, and reduce the concentration of vapors to a point at which they will not ignite.

a. Sources of Ignition. Do not open the tank for cleaning until the following sources of ignition are under control:

(1) Smoking. Do not allow smoking materials into the area. Collect matches, lighters, cigarettes, and other like material at a checkpoint. Return belongings to everyone when they leave the area.

(2) Static Electricity. Static electricity is impossible to prevent because it is produced by motion. However, it is not dangerous until it builds up a charge large enough to produce a spark. You can prevent this by making sure that the tank and any nearby equipment are well grounded and that the cleaning detail is given cotton clothing and rubber boots to wear.
(3) Electrical Equipment. Electric arcs and sparks produced during the operation of some pieces of electrical equipment can ignite fuel vapors. Overheated or short-circuited electrical equipment can cause vapors to ignite.

Prevent a fire or an explosion by avoiding the use of electrical equipment inside the tank until it has been freed of vapors. Use only dry-cell flashlights that have been approved by the Underwriter's Laboratory to provide light inside the tank. All other electrical equipment used in or around the tank must be explosion proof.

(4) Vehicles. Be sure that tank vehicles and vacuum trucks used to remove sludge from the tank are parked where fuel vapors cannot reach their internal combustion engines. It is best to locate them outside the fire wall on the windward side of the tank.

(5) Tool Sparks. Grinding and cutting tools produce sparks during operation. These sparks can ignite fuel vapors. Do not use grinding or cutting tools in or near a tank until it has been thoroughly cleaned, tested, and declared safe. Sparks can also be produced by friction when tools are struck together or when they strike another hard surface. Since nonsparking tools are no longer recommended for use, all tools must be handled carefully.

(6) Spontaneous Combustion. The two causes for spontaneous combustion in a tank are iron sulfide and oily rags.

(a) Iron Sulfide. A scale of iron sulfide forms when hydrogen sulfide corrodes the inside surface of a tank. Hydrogen sulfide is in crude oils with high sulfur content. Be careful when a crude oil tank is opened because the iron sulfide scale will oxidize rapidly when exposed to air. This process produces so much heat that the scale will glow. The iron sulfide scale can spontaneously combust at this point and ignite fuel vapors. To prevent this, use steam to free the tank of vapor. The steam will cover the iron oxide scale with condensation and prevent it from igniting. After the tank is vapor-free, knock down the scale by directing high-pressure hoses into the sludge. Keep the sludge wet until it is taken to a disposal area.

(b) Oily Rags. Fuel-soaked rags can ignite even though they have not been exposed to heat. Do not leave used cleaning rags in or around the tank. Place them in airtight metal containers until they can be disposed of permanently.
(7) **Electrical Storms.** Lightning can ignite fuel vapors. Never clean a storage tank during an electrical storm or when there is the threat of an electrical storm.

(8) **Welding.** The flame from a welding torch, the heat produced, and the flying slag can ignite fuel vapors. Never do any hot repair work on a storage tank until it has been thoroughly cleaned, tested, and declared vapor free.

b. **Concentration of Fuel Vapors.** Fuel vapors can be ignited when they come into contact with a source of ignition. This is possible only when a certain amount of fuel vapor has been combined with air. A mixture of 1 to 8 percent of fuel vapor and air will ignite at once when it comes into contact with a spark or flame.

The mixture will burn if it is ignited in an open area where the hot gases that are produced have room to expand. The mixture will explode if it has ignited in a closed space where the heat and gases have no place to go.

A mixture with less than 1 percent fuel vapor is too lean to ignite. A mixture with more than 8 percent fuel vapor is too rich to ignite. Care must be taken when opening a tank with a mixture that is too rich to ignite. The too-rich vapor could quickly change to an ignitable mixture after the tank is opened. The hydrogen sulfide vapors found in crude-oil tanks are also combustible. They can ignite when the hydrogen sulfide content of the tank is between 4.3 percent and 46 percent.

So that an explosion or a fire does not occur during tank cleaning operations, reduce the concentration of fuel and hydrogen sulfide vapors as quickly as possible to levels that will not ignite. The best way to reduce the concentration is to circulate air through the tank. The air weakens or dilutes the vapor concentration. Eventually, the air displaces the vapors completely.

Be careful to make sure the vapors are not allowed to collect in low areas outside the tank. These vapors could be ignited outside the tank, and the fire could spread back to the tank.

2. **Health Hazards.**

The atmosphere inside a tank that has been removed from service is hazardous to health. The danger lies in several areas, as described below.

a. **Presence of Fuel and Sludge.** Physical contact with fuel and sludge can cause serious damage to the skin. Fuel and sludge remove
natural oils, leaving the skin chapped and cracked. These cracks are avenues for disease and infection to enter the body.
Use soap and water to wash immediately areas of the skin which have come into contact with fuel or sludge. Make sure that the members of the cleaning detail wear white clothing so that fuel stains can be spotted easily. See that they also wear rubber gloves and boots to protect their hands and feet.

b. **Presence of Fuel Vapors.** Fuel vapors, especially gasoline and jet fuel vapors, are narcotic. Inhaling these vapors can slow the central nervous system to the point that breathing stops. In addition, inhaling even small amounts of these vapors can irritate the lungs and respiratory system, causing pneumonia or leaving a person open to other respiratory diseases. The poisonous or toxic limit is 500 parts per million. Be certain that the members of the cleaning detail wear respiratory equipment while working until testing of the fuel vapors produces a reading at or below that limit. Workers may then work in the tank up to eight hours without respiratory equipment. This does not apply to tanks that have been used to store leaded fuels.

c. **Presence of Tetraethyl Lead.** Contact with tetraethyl lead can result in poisoning. Therefore, great care must be taken when entering a tank that has been used to store leaded fuel. Inhaling the fuel vapors can be fatal. You must require cleaning details to wear respiratory equipment when working in leaded fuel storage tanks. The equipment must be used even after the tank has been tested and declared vapor free because inhaling dust particles from scale on the walls can also result in death. Require workers to avoid direct contact with leaded sludge since lethal amounts of lead can easily be absorbed through the skin. This sludge is dangerous even after it has been removed from the tank, so great care must be taken with its disposal. The tank is not safe until it has been cleaned down to the bare metal.

d. **Presence of Hydrogen Sulfide.** Exposure to hydrogen sulfide can cause death by paralyzing the respiratory system. Victims become unconscious and never regain consciousness. Mild exposure damages the eyes. Hydrogen sulfide, found in crude oils with a high sulfur content, can usually be detected by its rotten egg odor. Be cautious, however, never to use the sense of smell to determine whether or not hydrogen sulfide is present in a tank. Use a piece of moist lead acetate paper instead. If hydrogen sulfide is present in the tank, it will blacken the paper. The concentration of hydrogen sulfide vapor can be measured by a hydrogen sulfide detector. These detectors; are described in paragraph 5. The toxic level is 20 parts per million. It is not safe to work in a tank without respiratory equipment until readings are at or below that level.
3. **Physical Hazards.**

In addition to fire and health hazards, there are physical hazards involved in tank cleaning. Members of the cleaning detail must take precautions to avoid the following:

- Collapse of ladders, scaffolds, and stairways. Make sure they are in good condition and attached to the tank.
- Collapse of thin roof sections. Use wooden planks to distribute weight evenly when working on a roof.
- Accidental pumping of fuel into the tank. Make sure lines to the tank are blanked off with blind flanges or figure eight blinds. Do not depend on closed valves.
- Tools and objects dropped from above. Handle tools carefully. Do not throw them. Do not drop them through the roof manhole. Make sure fixtures inside the tank are securely attached to the tank and cannot be knocked down. Lower the swivel joint drain pipe to prevent accidental release during cleaning operations.
- Slipping on wet floors and tripping over hoses, pipes, and fittings. Use extreme caution when moving around inside the tank.
- Colliding with other workers or tank supports in a poorly lighted tank. Make sure lighting is adequate. Workers must wear white so they can be seen easily.

4. **Safety Equipment Set.**

The safety equipment set contains equipment necessary to provide physical and respiratory protection for two members of a cleaning detail. No one must enter a tank without having some experience in handling and operating the components of the set.
a. **Respirators and Air Hoses.** Two respirators and four air hoses are in the set. Respirators are face masks which attach to air hoses. The respirators must be approved by the Bureau of Mines. When
connected to a blower, respirators provide an independent supply of fresh air to the wearer. Be sure to wear them at all times inside tanks that were used to store leaded fuel. Wear them inside all other tanks until the tanks have been tested and found to be vapor free. Also, wear respirators inside clean tanks that have been closed for a long time. The following precautions must be taken with respirators and air hoses:

- Inspect respirators before each use. Also inspect them before they are stored.

- Make necessary repairs at once to be sure that the respirators are ready for use at all times.

- Test respirators before each use. To test a respirator, cut off the air supply to the mask for a few seconds by covering the end with the palm of the hand. If there are no leaks and the straps have been adjusted properly, the face piece will collapse against the face (see Figure 1-5).

![Figure 1-5. Testing a Respirator.](image)

- When attaching respirators to air hoses, make sure the connections are tight and that gaskets are being used to provide an airtight seal. Replace worn gaskets if necessary.
Never remove respirators while inside a tank. The tank may have been freed of vapors, but the facepieces could still be contaminated.

When entering a tank, lift the air hoses over the edge of the manhole. Pad the edge of the manhole to prevent damage to the hoses.

When a member of the cleaning detail enters the tank, assign someone to monitor the air hose and to keep the worker under observation at all times. The attendant must be dressed and outfitted to enter the tank to rescue an unconscious or injured worker.

Do not yank, twist, or step on an air hose.

When inside a tank, do not wrap air hoses and lifelines around anything that could make an emergency exit difficult.

Wash each face mask and air hose with soap and water at the end of each day and let them dry before storing.

b. **Hand-Operated Blower.** The blower is mounted inside one of the two carrying cases for the set. The detachable handle mounts on the outside of the case. The blower is operated with the lid closed. When the handle is turned, fresh air is fed through the air hoses to the respirators. The blower must be approved by the Bureau of Mines. The blower must be set up on the windward side of the tank to make sure that the cleaning detail is receiving fresh air. Be sure that the blower is monitored at all times while workers are wearing respirators.

c. **Leather Harnesses and Lifelines.** Two leather harnesses and lifelines are in the set. Your workers must wear harnesses into the tank when they wear respirators. The respirators attach to the backs of the harnesses. Assign the same workers who monitor the air hoses to monitor the lifelines. Lifelines are used to trace workers inside a tank and to pull unconscious workers to safety. Clean all harnesses and lifelines, and allow them to dry before storing them.

d. **Firemen's Boots and Rubber Gloves.** Four sets of boots and rubber gloves are provided with the safety equipment set. The boots and gloves are fuel resistant. The boots have reinforced toes and nonslip soles. Require boots and gloves to be worn in the tank at all times.
e. Explosimeter. One explosimeter (combustible gas indicator) (Figure 1-6), two sampling lines, and a probe are in the safety equipment set. An explosimeter is used to determine how explosive and toxic the atmosphere is inside a tank. The explosimeter must be approved by the Bureau of Mines.

![Explosimeter Diagram](image)

Figure 1-6. Explosimeter.

(1) Operation. Squeeze the rubber suction bulb to draw an air sample through a probe and sampling line to an analyzer unit. A filament inside the unit burns the fuel vapors in the sample. The flame that is produced is protected by a flame arrester so that the fuel vapors inside the tank are not ignited. The filament is part of an electrical circuit supplied with current by dry-cell batteries. Burning the fuel vapors increases the filament's temperature. As a result, there is an increase in the filament's electrical resistance. This increase in turn creates a voltage imbalance which moves the needle on the explosimeter—the greater the concentration of fuel vapors, the higher the reading.

(2) Meaning of the Readings. An explosimeter does not measure what percentage of a tank is made up of fuel vapors. It measures how explosive the contents are in a tank. A concentration of 1 percent fuel vapors is explosive. A reading of 100 percent on an explosimeter
means that at least 1 percent of the contents of a tank consists of
fuel vapors, making the contents 100 percent explosive. Do not allow
anyone to enter a tank when explosimeter readings are at or above 100
percent. A reading between 14 percent and 100 percent means that the
tank is not safe because of toxic vapors. Do not permit workers to
go into the tank unless they are wearing respirators.

A reading between 4 percent and 14 percent means that workers could
go into the tank without respiratory equipment but only for a very
short time. To be on the safe side, discourage such trips.

A reading of 4 percent on the explosimeter converts to approximately
500 parts per million, the toxic limit for fuel vapors.

Members of the cleaning detail can work in storage tanks for eight
hours at a time without respiratory equipment when the explosimeter
reading is 4 percent or less.

NOTE: This does not apply to tanks that have been used to
store leaded fuels.

(3) Directions for Use. To use an explosimeter:

- Obtain six fresh 1.5-volt dry-cell batteries and put
  them into the explosimeter.

- Turn on the explosimeter in a vapor-free area outside
  the tank.

- Flush the explosimeter with fresh air by squeezing the
  bulb five times. Add two squeezes for every 10 feet of
  line if a sampling line is being used.

- Move near the open manhole of the tank and take a
  sample of the air inside by squeezing the bulb until
  the reading on the explosimeter remains steady. Wear
  the proper protective equipment.

- Note the reading. It indicates the concentration of
  combustible vapors in the sample.

- Flush the explosimeter with fresh air after each use.

- Turn the explosimeter off and remove the batteries
  before storing the unit.
Service the unit, if necessary, by following the directions in the manufacturer's manual.

5. **Hydrogen Sulfide Detector.**

Have the cleaning detail determine what kind of fuel was stored in a tank before they start any cleaning operation. Test tanks that were used to store crude oils for the presence of hydrogen sulfide. If the cleaning detail is unable to determine what kind of fuel was stored in the tank, test the tank for hydrogen sulfide to be on the safe side. Require that respiratory equipment be worn during the test.

A hydrogen sulfide detector (Figure 1-7) consists of a suction bulb, a glass detector tube, and a frame with a scale.

![Figure 1-7. Hydrogen Sulfide Detector.](image)

To use a hydrogen sulfide detector, break off the ends of the glass detector tube and insert the tube into the frame. Squeeze the bulb 10 times to draw a sample into the tube. The reading on the scale is shown in percent.

A content of 4.3 percent to 46 percent hydrogen sulfide is explosive. The toxic limit is 20 parts per million or .002 percent. Members of the cleaning detail must not go into a tank until the percent of hydrogen sulfide is less than 4.3 percent.

They must not remove respirators until the tank is vapor free.

6. **Fire Extinguishers.**

A fire caused by ignited vapors is a Class B fire. Use a loaded stream, foam, carbon dioxide, or dry chemical fire extinguisher on a Class B fire. The extinguishers are available in hand and wheel units. Be certain that members of the cleaning detail know how to operate these fire extinguishers. Fire extinguishers are effective
only in the first stages of a fire, so train the cleaning detail to act quickly.
7. **Protective Clothing and Equipment.**

Require members of the cleaning detail to wear clean, white cotton overalls when they go inside a tank. White must be used because it is easily seen inside a dim tank, and it shows fuel stains easily. Cotton must be used because it cuts down on the generation of static electricity. Launder all protective clothing at the end of each work day. Require the team to wear safety helmets when it goes inside the tank to protect it from falling objects and debris. When respirators are no longer needed, be sure team members wear goggles to protect their eyes from loose scale and cleaning solvents in the tank.

**PART E - VAPOR-FREEING AND TESTING PROCEDURES**

1. **How to Blank Off a Tank.**

Before vapor-freeing and cleaning operations can begin, isolate a tank. In other words, cut it completely off from the rest of the terminal and pipeline system. There should be no way to accidentally pump fuel into the tank. There should also be no way for fuel vapors to drift back into the tank after it has been vapor freed. Use the following steps to isolate a tank:

- Use the lowest tank connection, and pump or drain as much fuel as possible out of the tank. If necessary, pump in enough water to cover the tank bottom. What fuel is left and the sludge that has not hardened will float on top of the water. Pump this liquid sludge to a tank vehicle and draw off the water. Do not allow oily water to spill on the ground. Be aware that some tanks, especially underground ones, may have permanently installed sump pumps for removing liquid sludge. Some may even have their own sludge disposal system to pipe sludge to a disposal area.

- Close the valves outside the fire wall on all lines going to and from the tank. Attach a sign to each one, warning workers not to open the valves.

- Drain and flush all lines into the tank.

- Break all lines, and remove the valves nearest to the tank. Replace the valves with either blind flanges or figure eight blinds. Figure 1-8 shows how to blank off a tank with either blind or figure eight flanges. Make sure the solid half of the figure eight blind is down in the line. If figure eight blind holders have already been permanently installed near the tank, it is not necessary to remove the valves. Reverse the blinds so that the solid half closes off the line. All blank ends and
lines should be strong enough to withstand any pressure that might be exerted on a line. Respirators should be worn when blanking lines to tanks which were used to store leaded fuels and crude oils.

![Diagram of blind flanges and figure eight blinds](image)

Figure 1-8. Blanking Off a Tank with Blind Flanges or Figure Eight Blinds.

2. **How to Vapor Free a Tank.**

Vapor freeing is actually the complete replacement of fuel vapors in a tank with fresh air, but a tank is usually considered vapor free when the concentration of fuel vapors is below the toxic and combustible levels.

Vapor freeing is a dangerous operation. Require workers who maintain the manholes and cleanout doors of leaded fuel or crude oil tanks to wear respirators. Allow no one in the area around the tank during vapor freeing except those who approach the tank from time to time to conduct vapor tests.

Several methods of vapor freeing a tank are used; some are better than others. The method that is used depends on the kind of tank that is being cleaned and the situation.

There are four ways by which to vapor free a tank:
a. **Natural Ventilation.** Natural ventilation, or airing, is the easiest method to use. Its main advantage is that it uses natural forces. Little or no equipment and no outside power source are required.

However, there are several disadvantages to this method. First, it takes longer than other methods. The concentration of vapors inside the tank is explosive and toxic for a longer period of time. Vapors may collect at ground level outside the tank, creating another hazard. Second, this method is not practical for underground tanks because of the lack of natural circulation.

To ventilate a tank naturally:

- Remove the manhole cover.
- Remove the tank shell manhole cover or cleanout door.
- Allow air to circulate freely through the tank.
- Take vapor readings periodically. Do not start sludge removal until the tank is at or below the toxic level of 4 percent.

b. **Forced Ventilation.** In using forced ventilation, you employ an outside force to direct the flow of air into the tank. By using such a force, you speed up the vapor-freeing process. You may use either of two methods to force ventilate a tank: the blower or fan method or the air injector or eductor method.

1. **Blower or Fan Method.** Use the blower or fan that is installed in the tank shell manhole or cleanout door, if one has been installed, to blow fresh air into the tank. Fuel vapors escape through the roof manhole. The blower or fan may be steamturbine, gasoline-engine, or electric-motor driven. Locate gasoline-powered units away from the tank on the windward side. Be sure that they are equipped with spark arresters. Canvas ducts carry the air to the tank. Make sure that electric-motor-driven units are explosion proof. To use a blower or a fan:

   - Open the tank shell manhole or cleanout door.

   - Set up gasoline-engine powered units away from the tank and lay canvas ducts on the ground to the tank opening. Mount other units in the tank opening. When you are using this method to vapor free underground units, attach the blowers to pipes leading to the tank bottom or to ducts or hose lines. These ducts or hose lines are fed through roof openings to the tank bottom.
o Remove the tank manhole cover.

o Start the blower and ventilate the tank until readings are in the safe zone.

(2) **Air Ejector or Educator Method.** Use an air ejector or educator, to draw fuel vapors out of a tank. Install the unit in the roof manhole. Allow fresh air to enter through the tank shell manhole or cleanout door. To use an air ejector or educator:

  o Open the roof manhole, and install the unit.

  o Operate the unit to create a pressure differential between the inside and the outside of the tank. Use the low setting at this point to avoid creating a vacuum.

  o Once you have established a pressure differential, open the tank shell manhole on cleanout door, allowing fresh air to be drawn into the tank. In underground tanks, open pipes leading to the bottom of the tank.

  o Operate the unit at full speed until the tank has been vapor freed.

c. **Steam Ventilation.** You may use steam to displace vapors, but this method is discouraged except in tanks in which iron sulfide is known to be present because of the following disadvantages:

  o It generates static electricity which could ignite vapors.

  o It is a slow method because producing enough steam to displace fuel vapors in a large tank is difficult.

  o The temperature must be at least 170°F to prevent condensation. This temperature is difficult to maintain in cold weather.

  o Steam damages the linings of coated tanks and causes cracks in concrete tanks. It should never be used to vapor free a concrete tank.

d. **Water Displacement.** In this method, you substitute water for fuel vapors in the tank. Fuel vapors exit as you overflow the tank with water. Treat the oily water that is produced by this process before you dispose of these oily waters. Use water displacement for small tanks only and in areas where water supplies are not limited.
**WARNING:** If samples are also being taken with a hydrogen sulfide detector, do not enter the tank until readings from the door are at or below the 4.3 percent explosive limit for hydrogen sulfide.

**PART F - TANK-CLEANING PROCEDURES**

1. **Duties of the Cleaning Detail Supervisor.**

The cleaning detail supervisor oversees all cleaning operations. The cleaning detail supervisor's duties are:

- Gather the following information:
  - Kind of fuel stored in the tank.
  - Reason for cleaning the tank.
  - Condition of the tank and any repairs to be made.
  - Amount of corrosion and sludge present in the tank.
  - Record the last date the tank was cleaned and how well it was cleaned.

- Train the cleaning detail. This training must include instruction on the dangers involved in tank cleaning, the use of the safety equipment set, and the safety precautions that apply to tank cleaning.

- Prepare a fire plan for the tank. Everyone should know what is expected of him or her in case of a fire or an explosion.

- Delegate various jobs to specific members of the cleaning detail.

- Make sure that at least two members of the cleaning detail have recently been trained in cardiopulmonary resuscitation.

- Determine whether or not every member of the detail is in good physical condition and capable of working in the tank. Workers who are tired or sick may develop problems inside the tank.

- Inspect all safety equipment to make sure it is in good condition and ready to use.

- Make sure that fire fighting equipment is nearby.
o Arrange for the safe disposal of sludge. (See AR 200-1.) 

o Contract, if necessary, the use of a vacuum truck to remove sludge and haul it to a disposal area.

o Furnish the environmental engineer with information on the tank and sludge disposal to obtain a safety permit.

o Examine the area around the tank to be sure that all sources of ignition have been removed.

o Make sure that the tank is isolated before starting cleaning operations.

o Be present during cleaning operations to provide instruction and guidance.

o Make sure that no one enters the tank until vapor readings are in the safe zone.

o Tell members of the cleaning detail to leave the tank if they smell fuel vapors.

2. **Tools Needed.**

In addition to the safety equipment and the clothing that has already been described, you will need to be sure that the following items are on hand before beginning cleaning operations:

- Blind flanges or figure eight blinds to provide positive shutoff to tank.
- Pump to move sludge from tank bottom to vehicle.
- Tank vehicle or vacuum truck to carry sludge to disposal site.
- Air educator or ejector to draw fuel vapors out of the tank.
- Blowers or fans to drive fuel vapors out of the tank.
- Shovels, scrapers, wire brushes, buckets, and wheelbarrows.
- Long-handled push brooms, scrub brushes, squeegees, and mops.
- Towels, washcloths, and bath soap for each member of the cleaning detail.
o Water hose and nozzle.

o Disinfectant for face masks.

o Clean rags and airtight metal cans to store oily rags until they can be destroyed.

o First aid kit.

o Wrenches and tools necessary to blank off the tank, enter the tank, and tighten tank accessories.

o Warning signs to post during tank cleaning.

o Sign-painting kit and yellow paint to stencil tank after cleaning.

o Ladders and scaffolding to reach upper areas of the tank shell.

o Detergents, cleaning solvents, and kerosene.

3. **Cleaning Operations.**

After declaring a tank to be vapor free, have members of a cleaning detail enter the tank to begin cleaning operations. It will not be possible to enter some underground tanks. Clean these tanks in the same way as tank cars and vehicles are cleaned. These methods are described in FM 10-20.

To clean tanks that allow entry:

- Stencil a warning sign near the tank's entrance if the tank was used to store leaded fuel. Wear respirators in the tank and use forced ventilation until the tank has been cleaned down to the bare metal.

- Before starting to work, inspect the inside of the tank for loose fixtures, and repair the tank if necessary. Lower the swivel joint drain pipe to the tank floor.

- Use a high-pressure water hose to dislodge sludge, loose rust, and scale.

- Continue to take vapor tests. Leave the tank if readings indicate the presence of toxic concentrations of fuel vapors. Since it takes more time to leave an underground tank than an aboveground tank, detect any increase in the concentration of fuel vapors as quickly as possible.
o Lay a suction hose in the tank, and use a pumping assembly to pump liquid sludge to a tank vehicle. If a vacuum truck is being used, you do not have to use the pumping assembly.

o Brush, sweep, or scrape the remaining sludge into piles, and shovel it into buckets or wheelbarrows.

o Use wire brushes and scrapers to remove rust and scale from the uncoated surface of the tank walls and floor. Use scaffolds and ladders to get to out-of-reach areas.

o Dispose of sludge and debris.

o Clean the tank, fixtures, and supports. If necessary, drill small holes at the bottom of hollow structures and supports. Flush them from the top, and allow them to drain.

o Scrub the walls and floors with kerosene, cleaning solvent, or detergents, if necessary. Do not damage tank coatings.

o Rinse the walls and floor with water. Mop up all water and mop dry with lint-free rags.

4. Sludge Disposal.

Arrange for the disposal of sludge. Coordinate all activities with the environmental engineer whose job it is to consider the effect or impact of the disposal of sludge on the environment. The method that you use to get rid of the sludge should not damage the environment or harm humans or animals. For these reasons, do not carelessly bury sludge or dump it on the ground.

   a. Unleaded or Nonhydrogen Sulfide Sludge. Dispose of sludge that does not contain lead, hydrogen sulfate, or other harmful chemicals by farming, controlled burning, and using specified disposal sites.

Sludge can be farmed at selected sites. Be sure that these sites are located away from populated areas, lakes, and streams. Make certain that the area is level, well-drained, well-ventilated, and sunny. Haul the sludge to the site, distribute it evenly on the ground, and plow it in with the topsoil. Later, the land can be used to grow crops.

NOTE: Farming is being eliminated due to Environmental Protection Agency (EPA) rules.
b. **Leaded or Hydrogen Sulfide Sludge.** Dispose of sludge that contains lead or hydrogen sulfide or other dangerous chemicals by burning it or depositing it at specified sites.

   1. **Controlled Burning.** Harmful sludge can be burned in high-intensity heat furnaces that do not give off close space emissions.

   2. **Disposal at Specific Sites.** Harmful sludge can be taken to hazardous-materials-disposal sites. These sites are specially designated areas which have been set aside permanently for the disposal of dangerous substances such as nuclear wastes and toxic chemicals.

5. **After-Cleaning Operations.**

After the cleaning detail has finished mopping up in the tank, complete these final tasks:

a. **Tools and Equipment.** Get rid of brooms and rags that were used to clean leaded fuel and crude oil storage tanks. Dispose of them with the sludge from the tanks. Thoroughly clean all other tools and equipment with soap and water. Use kerosene if necessary. Disinfect face masks. Allow all safety equipment set pieces to dry before storing them.

b. **Pumping Assembly.** To clean the pumping assembly:

   o Put the end of a suction hose into a barrel or drum of clean water, or attach the hose to a water faucet or couple the hose to a water hose.

   o Start the pump and, if necessary, turn on the water. Run the pump until the pump and the hoses have been thoroughly flushed with water. Drain the water from the pump and hoses.

   o Put the end of the suction hose into a drum or container of solvent. Flush the pump and the hoses with 1 or 2 gallons of solvent. Drain the solvent from the pump and hoses.

c. **Stenciled Sign.** Use yellow paint, to stencil the cleaning date on the tank near the tank shell manhole or cleanout door.

d. **Tank Ballast.** Ballast or weight steel tanks that are being taken out of service in hurricane areas to prevent them from being blown away. Ballast empty steel tanks in flood areas to prevent them from floating away.
NOTE: Ballasting is not a common practice. Do it only if past experience has shown it to be necessary. Use light fuels or water with a rust inhibitor for ballast. Do not use water as ballast in areas where there is a chance that the water might freeze. Also, if other ballast is available, do not pump water into tanks which will be used to store gasoline, jet fuel, or kerosene.

e. **Hygiene.** At the end of each work day and at the end of the job, make sure that all members of the cleaning detail bathe with soap and water and change to clean clothes.

f. **Documentation.** Complete a DA Form 4177. Enter the cleaning date and any other important facts.
LESSON ONE

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answers with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

Situation: You are the petroleum management officer. You are responsible for the use and maintenance of petroleum storage tanks. For the purpose of this exercise, assume that you will perform each task yourself. In actuality, you will most likely delegate many of these tasks.

1. Which is the most common storage tank?
   A. Cone roof.
   B. Floating roof.
   C. Lifter roof.
   D. Underground.

2. How often do you check the shell of steel, aboveground storage tanks?
   A. Daily.
   B. Weekly.
   C. Monthly.
   D. Yearly.

3. What do you do to a pressure relief valve twice yearly?
   A. Inspect it.
   B. Remove and clean it.
   C. Test it.
   D. Replace it.

4. How do you repair a small leak in a stave of a bolted steel tank in an emergency?
   A. Use epoxy patching compound.
   B. Repair it with sealing plugs and clamps.
   C. Drive a wooden leak plug into the hole.
   D. Apply a canvas/neoprene patch over the hole.
5. What do you do with a collapsible fabric tank that needs permanent repairs?

A. Refer the tank to the maintenance officer to arrange for repairs.
B. Repair the tank with sealing plugs or clamps and then replace the tank as soon as possible.
C. Apply a canvas/neoprene patch over the damaged area.
D. Repair the damaged area by sewing with dacron cord and coating the seam with epoxy.

6. Which of the following is a reason for cleaning a storage tank?

A. During the routine annual cleaning cycle.
B. When the tank has been emptied and is to be refilled.
C. When the fuel in the tank has been contaminated.
D. When you are training new personnel in cleaning procedures.

7. How often do you take a sample from an active tank?

A. Daily.
B. Weekly.
C. Monthly.
D. Quarterly.

8. What is the toxic limit for fuel vapors?

A. 20 parts per million.
B. 40 parts per million.
C. 100 parts per million.
D. 500 parts per million.

9. When preparing to use an explosimeter, how do you flush it with fresh air?

A. Squeeze the rubber suction bulb five times.
B. Blow it out with compressed air.
C. Allow it to stand in fresh air for 15 minutes.
D. Rinse it with fresh water and let it air dry.

10. Iron sulfide vapor is present in a tank. Which method of vapor freeing do you use to vapor free the tank?

A. Natural ventilation.
B. Steam ventilation.
C. Air eductor.
D. Forced ventilation.
11. A petroleum storage tank is being cleaned and you are the cleaning detail supervisor. One of the workers reports that he smells fuel vapors. What is your FIRST step?

A. Vapor test the tank.
B. Provide forced ventilation by using a blower.
C. Have all workers wear respirators.
D. Have all workers leave the tank.

12. Which method of disposal can you use to dispose of sludge that contains lead?

A. Controlled burning.
B. Farming.
C. Weathering.
D. Burying.
## LESSON ONE

### PRACTICE EXERCISE

### ANSWER KEY AND FEEDBACK

<table>
<thead>
<tr>
<th>Item</th>
<th>Correct Answer and Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A. Cone roof.</td>
</tr>
<tr>
<td></td>
<td>The cone roof is the most commonly used, primarily because of its relatively low cost. (Page 5, para 4)</td>
</tr>
<tr>
<td>2.</td>
<td>C. Monthly.</td>
</tr>
<tr>
<td></td>
<td>The outside of aboveground steel tanks must be checked monthly; remember that seeping fuel discolors paint. (Page 7, para 1)</td>
</tr>
<tr>
<td>3.</td>
<td>B. Remove and clean it.</td>
</tr>
<tr>
<td></td>
<td>Cleaning is required every six months. Corroded seats might need to be reground at the same time. (Page 8, para 6)</td>
</tr>
<tr>
<td>4.</td>
<td>C. Drive a wooden leak plug into the hole.</td>
</tr>
<tr>
<td></td>
<td>This is done in an emergency and is only a temporary repair. (Page 13, para 16)</td>
</tr>
<tr>
<td>5.</td>
<td>B. Repair the tank with sealing plugs or clamps and then replace the tank as soon as possible.</td>
</tr>
<tr>
<td></td>
<td>Permanent repairs are not made to collapsible tanks. (Page 15, para 18)</td>
</tr>
<tr>
<td>6.</td>
<td>C. When the fuel in the tank has been contaminated.</td>
</tr>
<tr>
<td></td>
<td>Tanks should be cleaned when necessary, such as when the fuel has been contaminated. (Page 18, para 2)</td>
</tr>
<tr>
<td>7.</td>
<td>C. Monthly.</td>
</tr>
<tr>
<td></td>
<td>MIL-STD-457 requires that a sample be taken every 30 days from active tanks. If the tank is contaminating the product that is stored in it, the tank must be drained and cleaned. (Page 19, para 2c)</td>
</tr>
</tbody>
</table>
8. D. 500 parts per million.

Workers must wear respirators until vapors test below 500 parts per million. (Page 24, para 2b)

9. A. Squeeze the rubber suction bulb five times.

This pumps fresh air into the explosimeter. Add two squeezes of the bulb for every 10 feet of line if a sampling line is used. (Page 29, para 4e(3))

10. B. Steam ventilation.

Because of several disadvantages, steam is only used when iron sulfide is present. (Page 34, para 2c)

11. D. Have all workers leave the tank.

This is the first step. You will then take other appropriate measures. (Page 37, para 3)

12. A. Controlled burning.

Sludge that contains lead, hydrogen sulfide, or other harmful chemicals can be disposed of by controlled burning. Other methods of disposal might cause damage to the environment. (Page 39, para 4b)
LESSON TWO

SAMPLING AND GAGING PETROLEUM STORAGE TANKS

MQS Manual Task: 03-5103.00-0077

OVERVIEW

TASK DESCRIPTION:

In this lesson, you will learn the procedures for sampling and gaging petroleum tanks.

LEARNING OBJECTIVE:

TASKS: Determine the correct sampling and gaging procedures and supervise their performance.

CONDITIONS: You will be given access to information and extracts from FM 10-18.

STANDARDS: Sampling and gaging procedures will be performed in accordance with FM 10-18.

REFERENCES: The material contained in this lesson was derived from the following publication:

FM 10-18

INTRODUCTION

Upon the completion of this lesson, you will be able to identify the different sampling and gaging procedures and determine appropriate procedures for various situations. As a petroleum management officer, you must learn to supervise the sampling and gaging of various petroleum products.

PART A - SAMPLING

1. General.

Samples are important because they are used to determine the quality of petroleum products. A sample is a small amount of petroleum which represents the whole product.
Appendix A shows the requirements for testing and sampling petroleum products, including the minimum frequency for such testing according to the product's bulk and packaging. As the appendix points out, a product should also be tested and sampled whenever it is suspected of being off specification, using test type A or test type B-2. (See Appendix A.)

NOTE: After sampling equipment has been used to obtain representative samples of different petroleum products from various petroleum containers, these samples must be inspected and tested by personnel operating a base laboratory, a mobile laboratory, or a petroleum testing kit to determine whether or not the products meet specifications.

2. Types of Samples.

a. **Top.** Use a bottle or a beaker sampler to take a sample about 6 inches below the surface of a tank's contents.

b. **Upper.** Use a bottle or a beaker sampler to take an upper sample from the middle of the top third of the product.

c. **Middle.** Use a bottle or a beaker sampler to take a middle sample from the middle of the product.

d. **Lower.** Use a bottle or a beaker sampler to take a lower sample from the middle of the bottom third of the product.

e. **Bottom.** Use a Bacon bomb thief sampler to take a bottom sample from material or product on the bottom of the tank.

f. **All-Levels.** To take an all-levels sample, submerge a closed bottle or beaker sampler as close as possible to the bottom of a tank or a container. The sampler is then opened and raised at a uniform rate so that it is 75 to 85 percent full when it comes out of the liquid.

g. **Spot.** Take a spot sample at a specific place in the tank.

h. **Composite.** A composite sample combines individual samples that represent the bulk from which they were taken. The samples can be a single-tank or a multiple-tank composite sample.

i. **Single-Tank Composite.** A single-tank composite sample is a blend of the upper, middle, and lower samples of the tank's contents. The blend has equal parts of the three cross sections from a tank with uniform cross sections. An upright cylindrical
tank has uniform cross sections.
j. **Multiple-Tank Composite.** A multiple-tank composite sample is a blend of single, all-levels samples taken from tanker or barge compartments that contain the same product. The sample consists of parts in proportion to the volume of product in each compartment sampled.

k. **Outlet.** Use a bottle or a beaker sampler to take an outlet sample at the level of a tank outlet, whether fixed or swing line.

l. **Drain.** Take a drain sample from the drawoff discharge valve.

m. **Continuous.** Take a continuous sample from a pipeline while allowing the product to collect slowly in a sampler during the entire flow time. A continuous sample represents the stream of the product during the period that it was sampled.

3. **Sampling Procedures.**

You must obtain a sample that represents the entire quantity of the product. Otherwise, an analysis of your sample will reflect the quality of only a portion of the whole substance, and the quality that is thus reflected may be better or worse than the true quality of the product as a whole.

Normally, you should collect a 1-gallon sample for a liquid product and a 5-pound sample for a semisolid product. Collect a 5-gallon sample for a specialty sample or a gasoline sample to be used to test the performance number by the supercharger method. Also collect a 5-gallon sample of jet fuel to be sampled for thermal stability.

Use a standard sampler like those described in paragraph 4 (below) and the one that is best suited for the product and its container or carrier. You can use an improvised sampler in cases in which a standard sampler is not suitable because of the existence of a small opening through which the sample must be taken. In any case, be sure that the sampler is clean and made of material that cannot contaminate the sample. (Samplers will be described later in this lesson.)

Clean the sampler and the sample container by rinsing them with the product that is being sampled. However, do not rinse these items with the product if you are taking samples for a particulate contaminant (sediment).

Protect the samples for shipment. Protect gasoline, jet fuel, and kerosene samples from direct sunlight by using brown bottles or cans or by covering clear bottles with paper or foil. Keep samples of gasoline and JP-4 cool (30°F to 40°F), if possible, to prevent
the loss of light ends. Protect samples which contain lead additives from sunlight.

Assign a serial number to each sample, and enter this number on the sample log. This number is made up of the last two digits of the calendar year and the sample number for that year. For example, the first sample from an activity for 1988 is number 88-1. Likewise, the next sample would be numbered as 88-2. A station log is kept with a record of samples submitted to the designated testing laboratory.

Maintain a laboratory log as a permanent record of samples which have been received for testing. Enter on the log:

- The date of receipt.
- The type of product.
- The unit sample number.
- The source of the sample.
- The quantity that the sample represents.
- The sampler's name.
- The date of the sample.
- The date of the completion of the test.

4. **Sampling Equipment.**

Four types of samplers (shown in Figure 2-1) are used to obtain samples of liquid petroleum products: the weighted beaker, the drum thief, the Bacon bomb, and the weighted bottle.

a. **The Weighted Beaker.** The weighted beaker (weighted copper beaker sampler) consists of a copper bottle that is permanently attached to a lead base. A drop cord is attached through the stoppers so that, with a quick jerk, you can open the sampler at any point beneath the surface of the product. Use this sampler to obtain a top, an upper, a middle, a lower, or an all-levels sample of liquid petroleum products from tank cars, tank trucks, barges, ship tanks, or shore storage tanks.

b. **Drum Thief.** The drum thief (plastic cylinder) tube-type sampler is commonly known as the drum thief. It consists of a two piece, plastic tube which is 39 1/2 inches long and 1 1/2 inches in diameter. The tube is fitted with two finger-rings at the upper end
and may have three supporting legs at the bottom. Both ends are tapered and have openings. Close the top opening with your thumb.
until the sampler is submerged in the liquid. Then remove the thumb from the opening, allowing the liquid to fill the sampler. The drum thief is used in drums and cans.

![Diagram of petroleum product samplers](image)

**Figure 2-1. Petroleum Product Samplers.**

c. **Bacon Bomb Thief.** The Bacon bomb thief (tank car thief) is a nickel-plated brass cylinder fitted with an internal plunger valve that opens automatically when the sampler strikes the bottom of a container and closes when it is lifted. You may attach a trip cord to make it possible to open the cylinder at any level.

d. **Weighted Bottle.** The weighted bottle (glass cylinder) sampler consists of a glass bottle within a square, weighted metal holder. It is used in the same manner and for the same purpose as the weighted beaker sampler. It is used for all vapor pressure and oxidation stability samples.

5. **Portable Petroleum Testing and Measuring Kit.**

The portable petroleum sampling and gaging kit (shown in Figure 2-2) is used at bulk storage facilities. It is used to:

  o Gage tanks.
51  QM4500
- Measure product temperature.
- Detect bottom sediment and water.
- Make volume calculations.
- Sample fuels.

Figure 2-2. Portable Petroleum Sampling and Gaging Kit.

The kit is referenced in the Supply Catalog (SC) 6680-90-CL-N01. It weighs 22 pounds. The kit consists of an aluminum carrying case fitted with measuring and sampling equipment. The major parts of the kit are:

- Olive-drab, aluminum carrying case.
- Cup-case thermometer, 0° to 180° F range.
- Innage tape and bob.
- Hydrometers, ranging from 19° to 81° American Petroleum Institute (API) gravity.
- Hydrometer cylinder with removable base.
- Weighted beaker sampler.
- Wide-mouthed sampling bottle.
- Brass-coated chain.
- Gasoline-indicating paste.
- Water-indicating paste.
- Cheesecloth.
- Gravity computer with case.
- American Society for Testing Materials (ASTM) pamphlets.

6. **Sampling and Testing Requirements.**

The minimum sampling and testing requirements for determining the quality of petroleum and related products are outlined in MIL-HDBK-200.

It is your responsibility, as the cognizant petroleum officer, to maintain strict quality surveillance; the frequency of testing may be increased as required.

Conditions of storage, age of stock, and type of product are considerations concerning whether increased testing conditions are warranted.

The types of tests used to test petroleum products stored in bulk and at installations and depots are:

- Type A
- B-1
- B-2
- B-3
- C
- Solids (Millipore)
Refer to the publication extracts in the appendix. Table A-1 (on page 114) displays the minimum frequency for testing various petroleum products. For example, the Table shows that, for dormant bulk and packaged diesel fuels, testing is required every 12 months. Table A-2 in the appendix provides information about the types of samples required, when the sampling is done, and the type of test to be performed. The final page of Table A-2 briefly describes each type of test and provides additional information.

Use whatever type of test is appropriate to test a petroleum product when it is stipulated that the product must be inspected at least annually or at the discretion of the owning or inspection authority having regard to the type of product, age of stock, and conditions of storage.

PART B - GAGING

1. **General.**

Gaging is measuring the height of liquid level above the bottom of a tank (innage) or the height of a tank reference mark above the liquid level (outage) as part of determining the volume of the contents of the tank. You will often handle bulk petroleum products many times before you use them. Make sure that they are rigidly accounted for throughout this handling and that you maintain accurate records at all times. For accounting purposes, make sure that the products are gauged periodically to determine the quantity on hand, to verify the quantities issued or received, to detect leaks, and to determine the terminal capacity for receiving shipments.

2. **Gaging Terms.**

The following terms are used in discussing gaging:

- Innage
- Outage
- Reference mark
- Datum plate
- Reference height
- Innage tape and bob
a. **Innage**. Innage is the depth (height of volume) of product in a tank measured or gauged from the surface of the product to the bottom of the tank.

b. **Outage (Ullage)**. The outage (ullage) is a measurement of the free space above the surface of the product in a tank extending to the reference mark.

c. **Reference Mark**. The reference mark is a horizontal line put in the rim of the gaging hatch on a tank representing a fixed point from which measurements are made.

d. **Datum Plate**. The datum plate is a level metal plate at the tank bottom, directly under the reference mark. This plate provides a smooth, level surface for the innage bob to rest upon when an innage gauge is being taken.

e. **Reference Height**. The reference height is the distance from the reference mark to the top of the datum plate. After the reference height is established, stencil it in a conspicuous place adjacent to the gaging hatch.

f. **Tape Cut**. The tape cut is the line made on the tape measuring scale by the product being measured.

g. **Bob Cut**. The bob cut is the line made on the bob by bottom sediment and water (BS&W) being measured.

h. **Opening Gage**. The opening gauge is the gauge of a product taken before the delivery, issue, or receipt of a product.

i. **Closing Gage**. The closing gauge is the gauge of a product taken after its delivery, issue, or receipt.

j. **Total Measured Quantity**. The total measured quantity is the volume of the product and the BS&W in a tank at the observed temperature of the product at the time of gaging. It is usually obtained from the tank's capacity table or strapping chart.

k. **Gross Quantity of Product**. The total measured quantity minus the BS&W is the gross quantity of product.

3. **Gaging Equipment**.

This paragraph describes the special equipment needed to measure bulk petroleum.

a. **Innage Tape and Bob**. The innage tape and bob is a steel tape graduated to 1/8 inch and the first whole number on the tape is 9 or
10. Consequently, from the pointed tip of the conical bob to the first number on the tape is 9 or 10 inches. From the tip of the
bob to the top of the eyelet is 6.6 inches. The bob is made of nonsparking metal and the zero point is at the bob's tip. Refer to Figure 2-3 for an illustration of an innage tape and bob.

![Figure 2-3. Innage Tape and Bob.](image)

b. Outage Tape and Bob. The outage tape and bob, shown in Figure 2-4, is similar to the innage tape except that the readings begin at the 3-inch level on the tape. The zero reference is where the harness snap connects to the bob. The rectangular bob is 6 inches long, but the 1/8-inch graduations start with the 6-inch mark at the bottom and are read upward to 1 inch as the last whole number on the top. The outage bob has a flat nose and is made of nonsparking metal.

c. Fuel-Indicating Paste. Fuel-indicating paste is a chemical paste used in measuring the amount of liquid petroleum in a storage tank. It changes color when it comes into contact with a petroleum product.

d. Water-Indicating Paste. Water-indicating paste is a chemical paste used to differentiate between liquid petroleum products and water. The paste changes color when it comes into contact with water but is not affected by petroleum products.
4. **Gaging Precautions and Procedures**.

Tanks must be gauged according to AR 710-2. Certain gaging precautions and procedures must be observed during gaging.

a. **Gaging Precautions**. Follow these precautions in gaging a tank:

- Ground the static electricity by touching a bare hand to the tank shell or handrail before climbing a tank to perform a task.

- Perform the gauge from the side of the gaging hatch which has the wind to your back, if possible. Be careful not to breathe vapors from the contents of the tank.

- Never perform gaging during an electrical storm.

- Require the gaging personnel to stand at the same location on the roof for both the opening and the closing gauges if the gauge must be performed standing on the tank's roof.
Perform and record the gaging to the nearest 1/8 inch.

Repeat the gaging until two readings are identical.

Be certain that the tape touches the rim of the gaging hatch at all times to ground static electricity during the gaging process.

Wipe the tape clean and dry after every use.

Let the product stand for at least 30 minutes after it has been discharged into a tank to eliminate all static electricity before gaging it.

Take the product temperature reading for volume correction before or after volumes of 3,500 gallons or more have been received or issued.

Use the same tape and bob for opening and closing gauges.

b. Innage Gaging. Follow these steps to obtain an innage gauge, using an innage tape and bob:

Direct the innage method of gaging for atmospheric and other nonpressure tanks.

Raise the appropriate hatch cover and locate the reference point (shown in Figure 2-5 as point A).

Apply the water-indicating paste to the bob and apply the product-indicating paste to the tape at the level of the product in the tank. Apply the paste thinly and to the graduated side of the tape.

Ensure that the ungraded side of the tape is held in contact with the metal rim of the gaging hatch at the reference point as you lower the tape into the tank.

Lower the bob and tape into the tank until the tip of the bob just touches the tank bottom or datum plate (the horizontal plane at the level of point C). If you lower the tape too far, the bob tilts and an incorrect gauge reading is obtained. Compare the tape reading at the reference point (point A in Figure 2-5) to the reference height (the
distance from point A to point C in Figure 2-5) of the container to make sure that the gauge is accurate.

Figure 2-5. Taking an Innage Reading.

- Withdraw the tape after 30 seconds (at most) and read and record the product cut on the tape as the innage gauge. Read and record the water cut on the bob as the bottom sediment and water (BS&W) cut.

- Ensure that two identical readings are obtained to get an accurate measurement. Use the same gaging equipment and gaging hatches in obtaining both the opening and the closing gauges and be sure that the tape is lowered to the same depth for both gauges.

C. **Outage Method.** Use the outage method when gaging barges and tankers. Use all safety precautions. You may use this method on storage tanks when necessary.

To get an outage or ullage using an outage tape and bob, follow these steps:
Ensure that product-indicating paste is applied to the length of the bob.

Hold the unmarked side of the tape against the metal rim of the gaging hatch at the reference point (Point A in Figure 2-6).

Lower the tape and bob into the tank until the bob touches the surface of the product (Point B in Figure 2-6).

Wait until the bob is motionless. Lower the tape slowly until the bottom of the bob is 2 or 3 inches below the product's surface (Point B represents the product's surface in Figure 2-6). Record the reading on the tape at the reference point (Point A in Figure 2-6) as the tape reading.

Withdraw the tape quickly. Record the product cut on the bob as the bob reading. Read the scale to the nearest 1/8 inch unless 1/4-inch readings are applicable. If the product cut is hard to read, put product-indicating paste on the bob and gauge the tank again.

Add the bob reading to the tape reading to get the outage gauge.

Subtract the outage gauge from the reference height of the tank to convert outage gauge to innage gauge. The following example shows how to perform this step:

EXAMPLE:

NOTE: Use 1/4-inch readings.

Tape reading at reference point: 21 feet, 6 inches
Bob reading: + 3 3/4 inches
Outage gauge: 21 feet, 9 3/4 inches

NOTE: An outage gauge can be converted to an innage gauge if the tank being gauged is calibrated only in innage measurements. The procedure is as follows:
Figure 2-6. Outage Gaging.
Use the outage gauge above (21 feet, 9 3/4 inches) and an assumed reference height of 50 feet. (In actual practice, use the reference height of the tank you are gaging.)

The outage gauge is 21 feet, 9 3/4 inches (point A to point B). The reference height is 50 feet (point A to point C). The innage gauge is the distance from point B to point C.

To convert outage to innage, simply subtract the outage from the reference height. An example of the procedure is given below:

**EXAMPLE:**

Height - Distance = Innage gauge
50 feet. - 21 feet., 9 3/4 inches. = 28 feet., 2 1/4 inches.

Perform bob cuts for BS&W in the outage method as described for the innage method. Use an innage bob, if available, for water. Otherwise, use the outage bob.

5. **Bottom Sediment and Water (BS&W) Measurements.**

You must measure storage tanks containing liquid petroleum products for bottom sediment and water each time you gauge them to determine the actual amount of product. Figure 2-7 shows how to take BS&W measurements. Bottom sediment and water often accumulate in different parts of a tank bottom. They usually accumulate on the side opposite a filling line or on either side of an outlet. When the tank has several hatches, take gauges from each hatch. Average them to get one bottom sediment and water gauge for the whole tank. Follow these steps to measure the height of bottom sediment and water:

- Use water-indicating paste to determine the water cut. Put a thin, even coat of paste on the part of the bob that will be at the point where water and product meet. Be careful not to put so much paste on the bob that it will cause a false reading. If the depth of the water is greater than the length of the innage bob, use a water gauge bar to measure water in the tank.

- Hold the side of the tape against the metal rim of the gaging hatch at the reference point.
Lower the tape and bob into the tank until the bob is a short distance from the bottom. Determine this by comparing the length of the unwound tape to the reference height of the tank.

Unwind the tape slowly until the tip of the bob touches the tank bottom or datum plate. Do not let the bob rest on a rivet or other obstruction. Do not lower the tape so far into the tank that the bob tilts and causes an incorrect reading.

Keep the tape and bob in the gaging position for 5 to 10 seconds for kerosene, gasoline, and other light products. Keep it in position 15 to 30 seconds for heavier products.

Remove the tape and bob from the tank. No paste should be left on the portion of the bob that was in the water or the paste should be discolored. Record the water cut as bottom sediment and water (BS&W).

Figure 2-7. Taking Bottom Sediment and Water Measurement.
6. **Temperature Measurements.**

Because the volume of petroleum products increases or decreases with temperature changes, you must take an accurate measurement or the temperature of a product when you gauge it. You then correct the measured quantity to the standard temperature of 60°F for volumes over 3,500 gallons. When gauging large quantities, you must take temperature readings at various levels and average them to determine the true temperature of the product. Figure 2-8 shows the number of readings necessary and the levels at which to place the tank thermometers.

<table>
<thead>
<tr>
<th>DEPTH OF PRODUCT</th>
<th>MINIMUM NUMBER OF TEMPERATURE MEASUREMENTS</th>
<th>MEASUREMENT LEVELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 15 feet</td>
<td>3</td>
<td>3 feet below top surface of product, middle of product, and 3 feet above bottom.</td>
</tr>
<tr>
<td>10 to 15 feet</td>
<td>2</td>
<td>3 feet below top surface of product, and 3 feet above bottom.</td>
</tr>
<tr>
<td>Less than 10 feet</td>
<td>1</td>
<td>Middle of product.</td>
</tr>
</tbody>
</table>

Figure 2-8. Petroleum Product Temperature Measurements.

Be sure that the cup-case thermometer (Figure 2-9) is used to measure the temperature of a product in a storage tank. The thermometer is attached to a hardwood backing with the base of liquid under measurement, the cup-case minimizes fluctuations of the reading when you suddenly withdraw the thermometer from the tank. Figure 2-10 shows the minimum immersion times for various fuels.

**NOTE:** To avoid long immersion times in measuring heavy petroleum fuels, leave the thermometers suspended in the tanks at all times.

Follow these procedures when you are measuring temperatures:

- Examine the mercury column for each cup-case thermometer for separations. Replace any thermometer having a faulty column. Mercury separations cause incorrect readings.

- Inspect the thermometers for accuracy. Expose them as a group to the same atmospheric temperature and compare the readings. Replace any thermometer with a reading that differs from the group by 1°F or more. Prove all tank thermometers against a reference standard each year.
Use Figure 2-8 to determine the minimum number of readings and the measurement levels required for the operation. Do this to find the true average temperature of the product.

Figure 2-9. Cup-Case Thermometer.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>TIME (MINUTES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive gasoline (MOGAS), aviation gasoline (AVGAS), kerosene, diesel fuel, jet fuel, and grades 1 and 2 burner fuel oil</td>
<td>5</td>
</tr>
<tr>
<td>Grades 4, 5, 6, and Navy Special burner fuel oil</td>
<td>15</td>
</tr>
</tbody>
</table>

NOTE: This conforms to Table IV, Minimum Immersion Time for Cup-Case Assembly, API Standard 2543, ASTM Designation D 1086. Product listings are not comprehensive.

Figure 2-10. Minimum Immersion Times for the Cup-Case Thermometer.
o Attach the thermometer to the end of a gauge tape, brass coated chain, or cord. If a cord is used, tie knots in the cord so that the knots will show when the thermometer reaches the required level.

o Lower the thermometer to the required level and leave it there for at least as long as is shown in Figure 2-10.

o Take the thermometer out of the tank and read it at once.

o Shelter the cup below the hatch to reduce temperature changes caused by wind or atmosphere. Withdraw a full cup of product from the tank when taking the reading. Do not spill it. Record the temperature to the nearest degree Fahrenheit.

o When you take readings from more than one level, add all the readings and divide the sum by the number of readings in order to get the true average temperature of the product. For example, assume a tank contains 20 feet of product. Temperatures are taken at 17 feet, 10 feet, and 3 feet or 3 feet below the top of the surface of the product, at the middle of the product, and at three feet above the bottom. Assume that readings of 82°F, 81°F, and 80°F are obtained. Add these readings and divide by three (the number of readings taken) to get the average true temperature of the product:

\[
82°F + 81°F + 80°F = 243°F \div 3 = 81°F
\]

81°F is the true average temperature of the product in the example.

7. **Volume Corrections.**

The volume of liquid petroleum products changes because of changes in temperature. When the temperature of the product increases, the volume of the product increases. When the temperature of the product decreases, the volume of the product decreases. Therefore, you must correct gauged volumes in excess of 3,500 gallons to account for this change of volume.

The standard temperature for volume measurements of petroleum products is 60°F. When you measure petroleum products in volumes exceeding 3,500 gallons, you must correct the measurement to what it would have been at 60°F. For example, when the temperature is greater than 60°F, your measurement will show more product than it would at 60°F. Therefore, you must adjust your measurement accordingly. Likewise, if the temperature is less than 60°F, you will measure less product than if the temperature were at: the
standard 60°F temperature and you must adjust the reading to that standard.
a. **Procedure for Corrections.** Follow these steps to make volume corrections:

**NOTE:** Gross volume is the quantity of the petroleum product and bottom sediment and water (BS&W) in a tank. Net uncorrected volume is the measured quantity of the product minus the BS&W at the observed temperature (before it is converted to the equivalent quantity at 60°F (15°C)).

- Make sure all tanks have individual strapping charts or calibration tables showing the volume of product in the tank per foot, inch, and even fractions of an inch (usually 1/8 inch). Determine the total measured quantity in the tank (product and BS&W).

- Using the same strapping chart, be certain that the gauge determines the volume of water in the tank. The volume, and only the volume, of the petroleum product is left. Remember that volume must be subtracted from volume, never inches from inches. The resulting figure is at the observed temperature and is ready to be corrected to volume at 60°F. To determine the multiplier necessary to convert the volume at observed temperature to the volume at 60°F, you need an average tank temperature and the API gravity of the product.

b. Example, use the following as an example for making volume corrections (innage gauge):

- **Tank capacity:** 500 barrels (BBL)
- **Tape reading:** 6 feet, 3 1/4 inches
- **Bob reading:** 0 feet, 1 inch
- **Measured tank temperature:** 67.5°F
- **API gravity at 60°F:** 56.3 (JP-4)

- Convert gauge readings to gallons.

- Refer to Figure 2-11 to convert the bob cut of 0 feet, 1 inch to 5.41 bbls. There are 42 gallons per bbl. To calculate the number of gallons, multiply 5.41 by 42. The result is 227.22 gallons.

**NOTE:** In actual practice, refer to the chart for the specific tank being gauged.
Refer to Figure 2-11 to convert the tape cut of 6 feet, 3 1/4 inches to 17,096.52 gallons. Since the Figure does not list 6 feet, 3 1/4 inches, you must read the quantities for 6 feet, then for 3 inches, and finally for 1/4 inch. Then add all the quantities together. Figure 2-11 shows 389.48 bbls for 6 feet, 16.23 bbls for 3 inches, and 1.35 bbls for 1/4 inch. The sum of these measurements is 407.06 bbls or 17,096.52 gallons. (Again, in actual practice, you would use the chart for the particular tank being measured, not Figure 2-11.)

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>100 bbls</th>
<th>250 bbls</th>
<th>500 bbls</th>
<th>1,000 bbls or 3,000 bbls</th>
<th>10,000 bbls</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 in</td>
<td>0.24</td>
<td>0.69</td>
<td>1.35</td>
<td>2.57</td>
<td>8.81</td>
</tr>
<tr>
<td>1/2 in</td>
<td>0.49</td>
<td>1.38</td>
<td>2.70</td>
<td>5.15</td>
<td>17.62</td>
</tr>
<tr>
<td>3/4 in</td>
<td>0.73</td>
<td>2.07</td>
<td>4.06</td>
<td>7.72</td>
<td>26.43</td>
</tr>
<tr>
<td>1 in</td>
<td>0.98</td>
<td>2.76</td>
<td>5.41</td>
<td>10.30</td>
<td>35.23</td>
</tr>
<tr>
<td>2 in</td>
<td>1.97</td>
<td>5.52</td>
<td>10.82</td>
<td>20.59</td>
<td>70.47</td>
</tr>
<tr>
<td>3 in</td>
<td>2.96</td>
<td>8.28</td>
<td>16.23</td>
<td>30.89</td>
<td>105.70</td>
</tr>
<tr>
<td>4 in</td>
<td>3.95</td>
<td>11.04</td>
<td>21.64</td>
<td>41.18</td>
<td>140.94</td>
</tr>
<tr>
<td>5 in</td>
<td>4.94</td>
<td>13.80</td>
<td>27.05</td>
<td>51.48</td>
<td>176.17</td>
</tr>
<tr>
<td>6 in</td>
<td>5.93</td>
<td>16.56</td>
<td>32.46</td>
<td>61.77</td>
<td>211.41</td>
</tr>
<tr>
<td>7 in</td>
<td>6.92</td>
<td>19.32</td>
<td>37.87</td>
<td>72.07</td>
<td>246.64</td>
</tr>
<tr>
<td>8 in</td>
<td>7.91</td>
<td>22.07</td>
<td>43.28</td>
<td>82.36</td>
<td>281.88</td>
</tr>
<tr>
<td>9 in</td>
<td>8.90</td>
<td>24.83</td>
<td>48.68</td>
<td>92.66</td>
<td>317.11</td>
</tr>
<tr>
<td>10 in</td>
<td>9.89</td>
<td>27.59</td>
<td>54.09</td>
<td>102.96</td>
<td>352.25</td>
</tr>
<tr>
<td>11 in</td>
<td>10.88</td>
<td>30.35</td>
<td>59.50</td>
<td>113.25</td>
<td>387.58</td>
</tr>
<tr>
<td>1 ft 0 in</td>
<td>11.87</td>
<td>33.11</td>
<td>64.91</td>
<td>123.56</td>
<td>422.82</td>
</tr>
<tr>
<td>2 ft 0 in</td>
<td>23.76</td>
<td>66.22</td>
<td>129.83</td>
<td>247.09</td>
<td>845.64</td>
</tr>
<tr>
<td>3 ft 0 in</td>
<td>35.66</td>
<td>99.34</td>
<td>194.74</td>
<td>370.64</td>
<td>1,268.46</td>
</tr>
<tr>
<td>4 ft 0 in</td>
<td>47.54</td>
<td>132.45</td>
<td>259.65</td>
<td>494.19</td>
<td>1,691.28</td>
</tr>
<tr>
<td>5 ft 0 in</td>
<td>59.43</td>
<td>165.56</td>
<td>324.56</td>
<td>617.74</td>
<td>2,114.09</td>
</tr>
<tr>
<td>6 ft 0 in</td>
<td>71.32</td>
<td>198.67</td>
<td>389.48</td>
<td>741.28</td>
<td>2,536.91</td>
</tr>
<tr>
<td>7 ft 0 in</td>
<td>83.21</td>
<td>231.79</td>
<td>454.39</td>
<td>864.38</td>
<td>2,959.73</td>
</tr>
<tr>
<td>8 ft 0 in</td>
<td>95.10</td>
<td>264.90</td>
<td>519.30</td>
<td>988.38</td>
<td>3,382.55</td>
</tr>
<tr>
<td>9 ft 0 in</td>
<td>106.99</td>
<td>298.01</td>
<td>584.22</td>
<td>1,111.93</td>
<td>3,805.37</td>
</tr>
<tr>
<td>10 ft 0 in</td>
<td>118.88</td>
<td>331.12</td>
<td>649.13</td>
<td>1,235.47</td>
<td>4,228.19</td>
</tr>
<tr>
<td>11 ft 0 in</td>
<td>130.77</td>
<td>364.24</td>
<td>714.04</td>
<td>1,359.02</td>
<td>4,651.01</td>
</tr>
<tr>
<td>12 ft 0 in</td>
<td>142.66</td>
<td>397.35</td>
<td>778.96</td>
<td>1,482.57</td>
<td>5,073.83</td>
</tr>
<tr>
<td>13 ft 0 in</td>
<td>154.55</td>
<td>430.46</td>
<td>843.87</td>
<td>1,606.12</td>
<td>5,496.64</td>
</tr>
<tr>
<td>14 ft 0 in</td>
<td>166.44</td>
<td>463.57</td>
<td>908.78</td>
<td>1,729.66</td>
<td>5,919.46</td>
</tr>
<tr>
<td>15 ft 0 in</td>
<td>178.33</td>
<td>496.69</td>
<td>973.69</td>
<td>1,853.29</td>
<td>6,342.28</td>
</tr>
<tr>
<td>16 ft 0 in</td>
<td>190.22</td>
<td>529.80</td>
<td>1,038.61</td>
<td>1,976.76</td>
<td>6,765.10</td>
</tr>
</tbody>
</table>

Figure 2-11. Gage Data for Military Tanks.
68 QM4500
Now that you have determined the uncorrected volume of the tank, you must find the tank's corrected volume. Find the volume correction factor in Figure 2-12. In order to use this factor, you must know the API gravity of your product at 60°F. (Round off to the nearest .5°F). In this problem, the API gravity is 56.3°F. Round off this figure to 56.5°F. You also need the measured tank temperature, which is 67.5°F in this problem.

- Locate the tank temperature of 67.5°F in the lefthand column of the volume correction table (Figure 2-12).
- Go across from 67.5° to the rounded API gravity measure of 56.5°.
- Read the volume correction factor from the table (at the point at which the temperature line and the API gravity column intersect).
- The volume correction factor is .9950.

![Figure 2-12. Volume Correction to 60°F.](image-url)
Subtract the volume of BS&W (227.22) from the gross volume (17,096.52) to obtain the net uncorrected volume:

17,096.52   Gross Volume
   -227.22   BS&W
   16,869.30   Net Uncorrected Volume

Multiply the net volume, uncorrected (16,869.30), by the volume correction factor (.9950):

16,869.30 x .9950 = 16,784.953

Round off to the nearest gallon and report 16,785 gallons as the corrected volume.
QM4500
The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answers with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

**Situation.** You are the petroleum management officer. You are responsible for sampling and gaging petroleum storage tanks. For the purpose of this exercise, assume that you will perform each task yourself. In actuality, you will most likely delegate many of these tasks.

1. What is the name of a small portion of a substance which you use to inspect or to determine the quality of the total substance?
   
   A. Sample.  
   B. Gage.  
   C. BS&W.  
   D. Sludge.

2. How often do you test bulk dormant stocks of diesel fuels?
   
   A. Every 6 months.  
   B. Every 12 months.  
   C. Every 24 months.  
   D. Every 36 months.

3. Which type of sampler do you use to take a bottom sample from a storage tank?
   
   A. Weighted beaker.  
   B. Drum thief.  
   C. Bacon bomb thief.  
   D. Weighted bottle.

4. In a storage tank, when you measure the depth of the product from the product's surface to the tank's datum plate, what are you measuring?
   
   A. Overage.  
   B. Outage (ullage).  
   C. Innage.  
   D. Actual product on hand.
5. When performing an innage gauge, how do you use the datum plate?
   A. Read data from it for use in calculating innage.
   B. Stand on it while taking measurements.
   C. Put water-indicating paste on it to show the water level.
   D. Lower the innage bob to rest on it while taking the innage gauge.

6. The measurement of a product taken before delivery, issue, or receipt is a/an
   A. opening gauge.
   B. closing gauge.
   C. net quality gauge.
   D. gross quantity gauge.

7. How do you ground static electricity before gaging a tank?
   A. Connect a grounding strap to the tank.
   B. Use a static compressor.
   C. Ground the tank using an approved grounding rod.
   D. Touch a bare hand to the tank shell or handrail.

8. When taking an innage measurement, how many times must you repeat the measurement?
   A. Until you get two identical measurements.
   B. Until you get three identical measurements.
   C. Until you get two measurements within 1/8 inch of each other.
   D. Until you get three measurements within 1/8 inch of each other.

9. If the depth of the product in a tank is 10 to 15 feet, how many temperature measurements must you take?
   A. One.
   B. Two.
   C. Three.
   D. Four.
Figure 2-13. Volume Corrections to 60 Degrees Fahrenheit.

10. Refer to Figure 2-13. If the API gravity for a fuel is 58.4 at 60° Fahrenheit and the actual temperature is 68.7 °Fahrenheit, what is the volume correction factor?

A. 0.9923.
B. 0.9937.
C. 0.9939.
D. 0.9942.
<table>
<thead>
<tr>
<th>Item</th>
<th>Correct Answer and Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A. Sample.</td>
</tr>
<tr>
<td></td>
<td>The sample is used to test the substance or to inspect it. (Page 46, para 1)</td>
</tr>
<tr>
<td>2.</td>
<td>B. Every 12 months.</td>
</tr>
<tr>
<td></td>
<td>According to Table A-1 (Appendix) bulk diesel fuels are tested every 12 months. (Page 114)</td>
</tr>
<tr>
<td>3.</td>
<td>C. Bacon bomb thief.</td>
</tr>
<tr>
<td></td>
<td>The Bacon bomb thief has an internal plunger valve that opens automatically when the sampler strikes the bottom of the tank and closes when the sampler is lifted. (Page 47, para 2e)</td>
</tr>
<tr>
<td>4.</td>
<td>C. Innage.</td>
</tr>
<tr>
<td></td>
<td>The depth of the product from the surface of the product to the tank bottom is the innage. This is a measurement of the amount of product in the tank. (Page 54, para 2a)</td>
</tr>
<tr>
<td>5.</td>
<td>D. Lower the innage bob to rest on it while taking an innage gauge.</td>
</tr>
<tr>
<td></td>
<td>The datum plate is a level metal plate at the bottom of the tank, directly under the reference mark. (Page 54, para 2d)</td>
</tr>
<tr>
<td>6.</td>
<td>A. Opening gauge.</td>
</tr>
<tr>
<td></td>
<td>The opening gauge is taken before delivery, issue, or receipt of a product, and the closing gauge is taken after delivery, issue, or receipt of a product. (Page 54, para 2h)</td>
</tr>
<tr>
<td>Item</td>
<td>Correct Answer and Feedback</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>7.</td>
<td>D. Touch a bare hand to the tank shell or handrail. You cannot prevent static electricity, but you can dissipate it before it becomes dangerous. Touching a bare hand to the handrail or the tank dissipates any static buildup. Other techniques are used during the gaging process. (Page 56, para 4a)</td>
</tr>
<tr>
<td>8.</td>
<td>A. Until you get two identical measurements. Two identical measurements are required for a product depth of 10-15 feet. (Page 58, para 4b)</td>
</tr>
<tr>
<td>9.</td>
<td>B. 2. Figure 2-8 shows that two measurements are required for a product depth of 10-15 feet. (Page 63, Figure 2-8)</td>
</tr>
<tr>
<td>10.</td>
<td>D. 0.9942. Use Figure 2-13. Round off 58.4 to 58.5 and 68.7 to 68.5 degrees. Locate the point where 58.5 degrees API gravity and 68.5 degrees Fahrenheit intersect and read the correction factor off the chart. (Page 69, para 7b)</td>
</tr>
</tbody>
</table>
LESSON THREE

STORAGE TANK CALIBRATION

MQS Manual Tasks: 03-5103.00-0077

OVERVIEW

TASK DESCRIPTION:

In this lesson, you will learn to perform and supervise petroleum tank calibration.

LEARNING OBJECTIVE:

TASKS: Calibrate storage tanks and identify the devices used to calibrate storage tanks.

CONDITIONS: You will be given information from FM 10-18.

STANDARDS: Storage tank calibration will be performed in accordance with FM 10-18.

REFERENCES: The material contained in this lesson was derived from the following publication:

FM 10-18

INTRODUCTION

Upon completion of this lesson, you will be able to identify methods of strapping and calibrating storage tanks, compute essential data, use conversion formulas, and perform calibration of horizontal cylindrical tanks. You will also be able to compute volume in spherical tanks and oblate spheroid tanks. As a petroleum management officer, you must learn to supervise strapping crews.

PART A - METHODS OF STRAPPING AND CALIBRATING

1. Strapping Defined.

"Strapping" is a term used for mathematically determining the volume capacity of a storage tank at intervals of 1/8 inch depth by carefully measuring it and allowing for lost or gained volume from deadwood. It is necessary that you strap a tank to prepare accurate tank tables
used to determine true tank innage or outage (tank gaging). As a rule, you prepare a strapping chart for each storage tank because tanks of the same size may vary in capacity. Before you can strap or calibrate storage tanks, you must fill them. The walls of storage tanks contract as the tanks empty.

General tank strapping includes measuring and recording deadwood, length, breadth, circumference, thickness of tank walls, and pipe connections.

2. **All-Rings Method.**

The all-rings method of tank strapping is very accurate. There is only a .02 percent error. Follow these steps to use this method:

- Measure the outside circumference of each ring of the tank.
- Measure the height of each ring of the tank.
- Compute the inside diameter of each ring of the tank.
- Compute the volume of the tank.

3. **One-Ring Method.**

The one-ring method of tank strapping is also very accurate, having a percent of error of only .1 percent. Follow these steps to use this method:

- Measure the diameter of the second or third ring of the tank.
- Measure the total height of the tank.
- Compute the inside diameter of the tank.
- Compute the volume of the tank.

4. **Average Circumference Method.**

The average circumference method is less accurate than the all-rings method and the one-ring method, having a percent of error of .2 percent. To use this method of tank strapping, follow these steps:

- Measure the outside circumference of all rings of the tank, and average these measurements.
- Compute the diameter from the circumference average.
o Measure the total height of the tank.

o Compute the inside diameter of the tank.

o Compute the volume of the tank.

5. **Strapping Crew, Tools, and Components.**

Generally, a minimum crew of three people is enough for strapping most tanks. The time required to perform a strapping operation depends on the size of the tank, operating conditions, and the experience of the personnel.

**PART B - ESSENTIAL DATA (MEASUREMENTS)**

1. **Terminology.**

The following terms are used in describing tank strapping procedures:

a. **Internal Deadwood.** Internal deadwood is any part of the interior of the tank that reduces the volume. Such items as ladders, supports, bolts, nuts, and channels are deadwood in the tank.

b. **External Deadwood.** External deadwood is any object that projects outside the tank shell that will increase the capacity of the tank (pipe connections, manholes, and cleanout openings).

c. **Depth or Tank Height.** Depth or tank height is the vertical distance from the top of the stave, shell, or top angleiron to the inside bottom surface or datum plate.

d. **Product Height.** Product height is the highest point to which the tank can be filled without overflowing. The product’s height may be the same as the tank height or it may be below the top because of connections, overflow lines, or vent lines.

**NOTE:** Each individual tank has both a total tank capacity (the maximum amount of product that the tank can hold without overflowing) and a normal fill capacity (a quantity of product less than the total tank capacity). A tank is filled to its total tank capacity only when the tank is being strapped. Otherwise, the tank is filled to its normal fill capacity.
2. **Measurement Techniques.**

   a. **Deadwood Measurements.** Deadwood measurements include measuring and recording deadwood length, breadth, and thickness in order to compute the volume of fluid that will be displaced by any object within the tank shell after it is filled and computing the added volume outside of the shell because of projections.

   b. **Depth or Tank Height Measurements.** You usually take depth or tank height measurements on the outside of the tank and then compare them to measurements taken inside the tank through the gauge hatch to determine if cement or other materials have been placed on the tank bottom. If cement or other materials are present on the tank bottom, measure and record the depth at three places as illustrated in Figure 3-1. Use the three measurements to compute the average depth of the tank. The average depth is recorded in feet, tenths, and hundredths.

   c. **Circumference Measurements.** Take circumference measurements on each ring at points located by measuring down from the top and up from the bottom of each ring 1/4 the height of the ring. Since these tanks usually have 8-foot rings, you should take measurements at 2, 6, 10, 14, 18, and 22 feet above the tank bottom. If bolts prevent the close contact of the tape with the tank's shell at the vertical joints, you may loosen one or more nuts to allow the tape to lie flat. However, if this is not practical, use dividers to span such obstructions. Consider each course or ring in a cylindrical tank a true cylinder. Use the ring measurements to compute the average circumference of the tank. The average circumference is recorded in feet, tenths, and hundredths.

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**PART C - COMPUTING TANK VOLUME**

1. **Measurements.**

   Obtain tank and deadwood dimensions before computing tank volume. You must know the mathematics of volume calculations to do the job. The mathematics of volume calculations include computing metal thickness, outside diameter, inside diameter, and radius.

   Be sure that all measurements are in feet before using them in the formulas. Convert inches to feet by dividing by 12.

2. **Computation Information.**

   There are three major steps in computing tank volume:

   o Compute the uncorrected tank volume.

   o Convert the volume to gallons or barrels.
o Subtract internal deadwood and add external deadwood.

Figure 3-1. Tank Measuring Techniques.

Detailed information on these steps follows.

You must be familiar with the following to compute the uncorrected volume of a cylindrical tank:

\[ n = 3.1416 \]

\[ t = \text{shell thickness} \]

\[ c = \text{circumference} \]

\[ d = \text{diameter} \]
R = radius
H = height
L = length
W = width
D = depth
id = inside diameter
od = outside diameter

To convert area volume to liquid volume:

1 cubic foot = 7.48 gallons or 0.178 barrels (bbl).

To compute the volume of a cylindrical tank, you must first find the uncorrected volume of the tank. Do this with the following formula:

\[ \pi R^2 H \text{ or } \pi D^2 H/4 \]

Next, convert the volume to either gallons or barrels using the conversion factor.

3. **Computations.**

   a. **Sample Problem--Cylindrical Tanks.** Find the uncorrected volume in gallons for a storage tank 20 feet high with an outside circumference of 55 feet and a shell thickness of 1/2 inch (Figures 3-2 and 3-3 show these dimensions of the tank).

   o First, find the outside diameter of the tank by dividing the circumference by \( r \) (3.1416):

   \[ \text{od} = \frac{c}{\pi} = \frac{55}{3.1416} = 17.51 \text{ feet} \]

   o To find the inside diameter, subtract two times the shell thickness (\( t \)): \( \text{id} = \text{od} - 2t \). Since the shell thickness is given in inches, first convert it to feet before deducting it:

   \[ .5'' = .04 \text{ feet}; \ 2t = .08 \text{ feet} \]

   \[ 12 \]

   \[ \text{id} = \text{od} - 2t \text{ or } \text{id} = 17.51 \text{ feet} - .08 \text{ feet} \]

   \[ \text{or } \text{id} = 17.43 \text{ feet} \]
To find the volume \((V)\) of the tank:

\[
V = \pi d^2 H \text{ or } V = 3.1416 \times 17.43^2 \text{ feet} \times 20 \text{ feet}
\]
\[ V = 3.1416 \times \left( \frac{17.43 \text{ feet} \times 17.43 \text{ feet}}{4} \right) \times 20 \text{ feet} \]

\[ V = 3.1416 \times (303.80) \times 20 \text{ feet} \]

\[ V = 3.1416 \times 75.95 \text{ feet} \times 20 \text{ feet} \]

\[ V = 4,772.09 \text{ cubic feet (feet}^3) \]

- To convert the volume from cubic feet to gallons, multiply by 7.48:

\[ V = 4,772.09 \text{ feet}^3 \times 7.48 \]

\[ V = 35,695.23 \text{ gallons} \]

To do this using the formula \( \pi R^2 H \), convert the diameter to the radius by dividing the diameter by two. The formula is \( R = \frac{1}{2}d \).

- The next step is to subtract the volume of internal deadwood, and add the volume of external deadwood. Follow this procedure:

Make separate computations for the volumes of internal and external deadwood. Since the volume of deadwood either adds to or subtracts from the total volume of a storage tank, deadwood is referred to as being, respectively, either positive or negative deadwood. Positive deadwood, is any fixture which adds volume to the tank, such as a cleanout door or a pipe connection. Negative deadwood is anything that takes up room in the tank and must be subtracted from the total volume of the tank. To find the corrected volume of a tank, first add the volume of positive deadwood, and then subtract the volume of negative deadwood. Here is an example:

The tank in the sample problem has a roof support which is the same height as the tank and is 6 inches in diameter. The tank is equipped with a rectangular cleanout door 3 feet high and 2 feet wide; the cleanout door extends 6 inches from the side of the tank (inside dimensions). The tank also has a 2-foot pipe connection with an inside diameter of 8 inches. (See Figure 3-3.) Find the corrected volume of the tank.
Solution: First compute the volume of positive deadwood. There are two items of positive deadwood: the pipe connection and the cleanout door.

To find the volume of the pipe connection, use the same formula as for the tank:

\[ V = \frac{\pi d^2 H}{4} \]

(in this case, the length of the pipe is used for H).

\[ V = 3.1416 \times \frac{d^2 \times 2}{4} \]

Since the diameter of the pipe is in inches, you must convert it into feet:

\[ d = \frac{8 \text{ inches}}{12} = 0.66 \text{ feet} \]

\[ V = 3.1416 \times \left( \frac{0.66 \text{ feet} \times 0.66 \text{ feet}}{4} \right) \times 2 \text{ feet} \]

\[ V = 3.1416 \times \frac{0.4356 \text{ feet} \times 2 \text{ feet}}{4} \]

\[ V = 3.1416 \times 0.1089 \text{ feet} \times 2 \text{ feet} \]

\[ V = 0.68 \text{ feet}^3 \]

Convert to gallons: 0.68 feet^3 \times 7.48 = 5.09 gallons

To compute the volume of the cleanout door, multiply the length times the width times the depth:

\[ V = L \times W \times D \]

First, convert the depth to feet:

\[ 6 \text{ inches} = \frac{0.5 \text{ feet}}{12} \]

\[ V = 3 \times 2 \times 0.5 \]

\[ V = 3 \text{ feet}^3 \]
To convert to gallons, multiply by 7.48:

3 feet$^3$ x 7.48 = 22.44 gallons

The total amount of positive deadwood is:

Pipe Connection 5.09 gallons
+ Cleanout Door 22.49 gallons
Total 27.58 gallons

To compute the volume of the negative deadwood which is the roof support:

d = $\frac{6 \text{ inches}}{12} = 0.5 \text{ feet}$; $R = \frac{1}{2} d$ or 0.25 feet

\[ V = \frac{\pi D^2 H}{4} \]

\[ V = \frac{3.1416 \times 0.5^2 \text{ feet} \times 20 \text{ feet}}{4} \]

\[ V = \frac{3.1416 \times (0.5 \text{ feet} \times 0.5 \text{ feet}) \times 20 \text{ feet}}{4} \]

\[ V = \frac{3.1416 \times 0.25 \text{ feet}^2 \times 20 \text{ feet}}{4} \]

\[ V = 15.708 \]

\[ V = 3.927 \text{ feet}^3 \]

\[ V = 3.927 \text{ feet}^3 \times 7.48 \text{ (convert to gallons)} \]

\[ V = 29.37 \text{ gallons} \]

To find the corrected volume of the tank, first add the volume of positive deadwood to the uncorrected volume and then subtract the volume of the negative deadwood:

Uncorrected Volume 35,695.23 gallons
Positive Deadwood + 27.58 gallons
35,722.81 gallons
Negative Deadwood - 29.37 gallons
Corrected Volume 35,693.44 gallons

If you desire the results in barrels, use 0.178 to convert feet$^3$ to barrels or divide gallons by 42.
NOTE: You may use either the formula

\[ V = \frac{\pi D^2 H}{4} \]

or the formula

\[ V = \pi R^2 H \]

to compute the volume of negative deadwood. You have just seen how to use the first formula to compute the volume of negative deadwood. To show you that you can use the second formula to obtain the same results, the volume of negative deadwood is again calculated below, using the second formula.

\[ V = \pi R^2 H \]

\[ V = 3.1416 \times (.25 \text{ feet} \times .25 \text{ feet}) \times 20 \text{ feet} \]

\[ V = 3.1416 \times .0625 \text{ feet} \times 20 \text{ feet} \]

\[ V = 0.19635 \text{ feet}^2 \times 20 \text{ feet} \]

\[ V = 3.927 \text{ feet}^3 \]

\[ V = 3.927 \text{ feet}^3 \times 7.48 \text{ (convert to gallons)} \]

\[ V = 29.37 \text{ gallons} \]

b. Sample Problem--Spherical Tanks. Use this formula to find the capacity of a spherical tank:

\[ V = 4.189R^3 \]

where \( V \) = volume,
\( R \) = radius of the sphere,
and \( 4.189 = \frac{4}{3} \pi \)

Problem: Find the capacity of a spherical tank with a radius of 9 feet. Assume 0.178 barrel per cubic foot.

\[ V = 4.189 \times (9)^3 \]

\[ = 3,054 \text{ cubic feet} \]

Tank capacity = 544 BBL (3,054 x 0.178)
c. Sample Problem--Oblate Spheroid Tank. Use the following formula to determine the capacity of an oblate spheroid tank:

\[ V = 4.189a^2b \]

where \( V \) = volume of the tank, 
\( a \) = major semiaxis of the tank, and 
\( b \) = minor semiaxis of the tank.

Problem: Find the capacity of a tank which is an oblate spheroid 20 feet wide and 10 feet high. Assume 0.178 barrel per cubic foot. Refer to Figure 3-4.

![Figure 3-4. Oblate Spheroid Tank.](image)

The major semiaxis, \( a = 1/2 \) width (20 feet) = 10 feet

The minor semiaxis, \( b = 1/2 \) height (10 feet) = 5 feet

\[ V = 4.189 \times (10)^2 \times 5 \]

\[ = 2,094.5 \text{ cubic feet} \]

Tank capacity = 373 BBL (2,094.5 x 0.178)

d. Gaging Tables. Subtract internal deadwood and add external deadwood to the unadjusted volume to get the actual volume of a storage tank. To make a gaging table, compute volume as described for every 1/8-inch depth from the inside floor or datum plate of the tank to the reference mark at the top of the tank. Once the rated volumes of a tank are tabled, gaging personnel can calculate actual volumes of liquid contained in the tank according to the height of the liquid in the tank.
1. **General**

There are numerous occasions in which the rated capacity of tank cars and horizontal tanks varies widely from actual capacity. When a cylindrical tank is in a horizontal position, it is very difficult to determine the amount of product it contains, particularly if the tank is partially filled. The American Petroleum Institute indicates three strapping/calibration methods of determining the capacity of cylindrical tanks/tank cars: the water gauge plant method, the water weighing method, and the strapping method.

2. **Water Gage Plant Method**

To perform the water gage plant method, fill the tank with a quantity of water that is measured by a discharge from a calibrated tank or tanks. This procedure is recommended as the most accurate.

3. **Water Weighing Method**

To perform the water weighing method, fill the tank with water and weigh the tank before and after it is filled. The scale must be sensitive in order to respond quickly and accurately to small changes in weight. In addition, the tank must be level. This method is not as accurate as the water gauge plant method.

4. **Strapping Method**

To perform the strapping method, measure the tank car and deduct the thickness of walls and lap plates. This method is the least accurate because of human error, and it is very time consuming.

5. **Obtaining Volume of Liquid in Partially Filled Tanks**

The American Petroleum Institute recommends two methods for obtaining the capacities of partially filled tanks: the percentage method and the length-of-tank method.

   a. **Percentage Method.** Use the percentage method to compute the capacities of partially filled horizontal tanks. The volume of liquid as a percentage of the total capacity is related to the depth of the liquid as a percentage of total depth. Here it must be assumed that the given rated capacity is correct (see Figure 3-5, which shows the capacities of partially filled horizontal tanks.)
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Figure 3-5. Capacities of Partially Filled Horizontal Tanks.
b. **Length of Tank Method.** The length of tank method computes the diameter and the length of the tank in feet. Figures 3-6 and 3-7 provide factors corresponding to the diameter and innage. These factors represent the volume of liquid for 1 foot of length for the particular diameter and innage. To obtain the total volume of liquid, multiply the factor by the length of the tank. The advantage of determining actual volumes of contained liquids by this method is that the process can be applied to rating the total capacity of the tank. When the depth of the tank is considered to be the diameter and the length (inside) to be the height, the total capacity of the tank can be determined by the formula: $v = (\pi R^2 H)7.48$ with account made for deadwood.

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<td>47.09</td>
<td>55.00</td>
<td>61.81</td>
<td>67.90</td>
</tr>
<tr>
<td>2 3/4</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>50.76</td>
<td>60.66</td>
<td>68.91</td>
<td>76.18</td>
</tr>
<tr>
<td>3</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>52.88</td>
<td>65.66</td>
<td>75.63</td>
<td>84.26</td>
</tr>
<tr>
<td>3 1/4</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>69.69</td>
<td>81.81</td>
<td>92.01</td>
</tr>
<tr>
<td>3 1/2</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>71.97</td>
<td>87.23</td>
<td>99.30</td>
</tr>
<tr>
<td>3 3/4</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>91.56</td>
<td>105.94</td>
</tr>
<tr>
<td>4</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>116.38</td>
</tr>
<tr>
<td>4 1/4</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>118.98</td>
</tr>
</tbody>
</table>

Figure 3-6. Capacities of 1-4 1/2-Inch-Diameter Horizontal Cylindrical Tanks.
Figure 3-7. Capacities of Horizontal Cylindrical Tanks
(5-9 Feet in Diameter)

Example: You measure the liquid in a horizontal cylindrical tank to be 3 feet. The diameter of the tank is 6 feet. Refer to Figure 3-7. Find 3 feet in the left-hand column and go across to the right until you intersect the column representing the tank diameter of 6 feet. Read 105.76 gallons per foot of length of tank. Now, compute the total capacity of the tank by using the formula $V = \pi R^2 H$ (7.48). Assume a length of 10 feet.

$$V = 3.1416 \times (3)^2 \times 10 \times 7.48$$

$$V = 3.1416 \times (9) \times 7.48 \times 10$$

$$V = 2,115 \text{ gallons}$$
LESSON THREE

PRACTICE EXERCISE

The following items will test your knowledge of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answers with the answer key that follows. If you answer any item incorrectly, then study again that part of the lesson which contains the portion involved.

1. When you strap a tank, you mathematically determine the volume capacity of the tank at intervals of
   A. 1/8 inch.
   B. 1/3 inch.
   C. 1/2 inch.
   D. 1 inch.

2. Before you can strap a tank, you must
   A. fill it to 25% of fill capacity.
   B. fill it to 50% of fill capacity.
   C. fill it to 75% of fill capacity.
   D. fill it to 100% of fill capacity.

3. You are strapping a tank that has a cement cap on the bottom. You measure and record the depth
   A. once.
   B. in two different places.
   C. in three different places.
   D. in four different places.

4. What is the outside diameter (od) of a cylindrical tank that has a circumference of 25 feet?
   A. 6.25 feet.
   B. 7.33 feet.
   C. 7.96 feet.
   D. 8.25 feet.

5. What is the inside diameter (id) of a cylindrical tank that has an outside diameter of 15 feet and a shell thickness (t) of 1/2 inch?
   A. 14.5 feet.
   B. 14.92 feet.
   C. 15.08 feet.
   D. 15.26 feet.
6. What is the volume of a cylindrical tank with an inside diameter (id) of 18 feet and a height of 22 feet?

A. 5,598.33 gallons.
B. 17,587.7 gallons.
C. 41,875.5 gallons.
D. 52,473.8 gallons.

7. A cylindrical tank has an external cleanout door that is 4 feet high, 2 feet wide, and extends 4 inches from the side of the tank. It also has an external 3-foot pipe connection with an inside diameter of 6 inches. What is the external (positive) deadwood?

A. 20.00 gallons.
B. 24.34 gallons.
C. 32.42 gallons.
D. 65.40 gallons.

**Situation:** A cylindrical tank has the following measurements and deadwood:

- Outside circumference = 42 feet
- Shell thickness = 1 inch
- Height = 25 feet
- Pipe connection (positive deadwood) = 4 feet long, 6 inches inside diameter
- Cleanout door (positive diameter) = 4 feet by 3 feet by 1 foot
- Roof support (negative deadwood) = 6 inches in diameter

8. In the situation above, what is the corrected volume of the tank in gallons?

A. 3,421.1 gallons.
B. 14,293.61 gallons
C. 25,649.51 gallons
D. 52,686.21 gallons.

9. A spherical tank has a radius of 11 feet. What is the capacity?

A. 41,705.2 gallons.
B. 55,755.6 gallons.
C. 60,276.8 gallons.
D. 63,475.9 gallons.
10. An oblate spheroid tank is 22 feet wide and 9 feet high. What is the volume?

A. 41 bbl.
B. 406 bbl.
C. 1,623 bbl.
D. 2,281 bbl.
LESSON THREE
PRACTICE EXERCISE
ANSWER KEY AND FEEDBACK

<table>
<thead>
<tr>
<th>Item</th>
<th>Correct Answer and Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A. 1/8 inch. This allows the amount of product to be easily determined by measuring its depth. (Page 77, para 1)</td>
</tr>
<tr>
<td>2.</td>
<td>D. Fill it to 100% of fill capacity. The walls of a tank contract when it is emptied, causing the calculations to be inaccurate. (Page 78, para 1)</td>
</tr>
<tr>
<td>3.</td>
<td>C. In three different places. Use three measurements to compute the average depth. (Page 80, para 2b)</td>
</tr>
<tr>
<td>4.</td>
<td>C. 7.96 feet. Use the formula: ( \text{od} = \frac{c}{n} ) (Page 82, para 3a)</td>
</tr>
<tr>
<td>5.</td>
<td>B. 14.92 feet. Use the formula: ( \text{id} = \text{od} - 2t ). (Page 82, para 3a)</td>
</tr>
<tr>
<td>6.</td>
<td>C. 41,875.5 gallons. Use the formula: ( V = \frac{n d^2 H}{4} ) Convert to gallons by multiplying by 7.48. (Page 83, para 3a)</td>
</tr>
</tbody>
</table>
7. B. 24.34 gallons.

Calculate volume of the pipe connection using the formula:

\[ V = \frac{\pi d^2 H}{4} \]

\[ \pi = 3.1416 \]

Since the diameter of the pipe is in inches, convert it into feet by dividing 6 inches by 12 inches:

\[ \frac{6}{12} = 0.5 \text{ feet} \]

Use the length of the pipe (3 feet) for H.

The equation now reads:

\[ V = \frac{3.1416 \times (0.5 \times 0.5) \times 3}{4} \]

\[ V = \frac{3.1416 \times 0.25 \times 3}{4} \]

\[ V = 3.1416 \times 0.0625 \times 3 \]

\[ V = 0.589 \text{ feet} \]

Now, convert 0.589 feet to gallons by multiplying 0.589 by 7.48:

\[ 0.589 \times 7.48 = 4.405 \text{ (Round to 4.41)} \]

Next, calculate volume of the cleanout door using the formula: \( V = L \times W \times D \).

Since the depth of the cleanout door is in inches, you must divide by 12 to convert inches to feet:

\[ \frac{8}{12} = 0.333 \text{ feet} \]

\[ V = 4 \text{ feet} \times 2 \text{ feet} \times 0.333 \text{ feet} \]

\[ V = 2.664 \text{ feet} \]
Multiply 2.664 by 7.48 to convert feet to gallons:

\[ V = 2.664 \text{ feet} \times 7.48 \]

\[ V = 19.926 \text{ (Round to 19.93)} \]

Finally, add the gallons of positive deadwood represented by the pipe connection (4.41) and the gallons of positive deadwood represented by the cleanout door to obtain the total volume of positive (external) deadwood:

\[ 4.41 + 19.93 = 24.34 \text{ gallons} \]

(Page 82, para 3a)

8. C. 25,649.51 gallons.

Compute the volume of the tank. Compute positive deadwood. Compute negative deadwood. Add positive deadwood, subtract negative deadwood.

(Page 84, para 3a)

9. A. 41,705.2 gallons.

Use the following formula:

\[ V = 4.189R^3 \]

where \( V \) = volume  
\( R \) = radius of the sphere  
and \( 4.189 = \frac{4}{3} \pi \)

\[ V = 4.189 \times (11)^3 \]

\[ V = 4.189 \times (11 \times 11 \times 11) \]

\[ V = 4.189 \times 1,331 \]

\[ V = 5,575.559 \text{ (Round to 5,575.56) cubic feet} \]

Convert to gallons:  
\[ 7.48 \times 5,575.56 = 41,705.2 \text{ gallons} \]

(page 87, para 3b)
10. B. 406 bbl.

Use the formula: \( V = 4.189a^2b \)

\[ V = 4.189 \]

where \( V \) = volume of the tank  
\( a \) = major semiaxis of the tank  
\( b \) = minor semiaxis of the tank

\( a = \frac{1}{2} \) width (22 feet) = 11 feet  
\( b = \frac{1}{2} \) height (9 feet) = 4.5 feet

\[ V = 4.189 \times (11)^2 \times 4.5 \]

\[ V = 4.189 \times 121 \times 4.5 \]

\[ V = 2,280.91 \text{ feet} \]

Convert feet to barrels by multiplying by 0.178:  
2,280.91 feet \times 0.178 = 406 barrels

(Page 88, para 3c)
APPENDIX

PUBLICATION EXTRACTS

FM 10-18, December 1986.

Use the above publication extracts to take this subcourse. At the time that this subcourse was written, this was the most current publication. In your own work situation, always refer to the latest publications.
### Table A-1. Minimum frequency for testing petroleum products

At the minimum frequency indicated below or whenever they are suspected of being off specification, dormant stocks of products will be sampled and checked by type A and type B-2 tests.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>BULK</th>
<th>PACKAGED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aviation gasolines</td>
<td>6 months</td>
<td>6 months</td>
</tr>
<tr>
<td>Automotive gasolines</td>
<td>12 months</td>
<td>12 months</td>
</tr>
<tr>
<td>Aviation turbine fuels</td>
<td>12 months</td>
<td>12 months</td>
</tr>
<tr>
<td>Diesel fuels</td>
<td>12 months</td>
<td>12 months</td>
</tr>
<tr>
<td>Kerosene, burner fuels, Navy</td>
<td>24 months, visual check—</td>
<td>36 months, visual check—</td>
</tr>
<tr>
<td>distillate, fog oils</td>
<td>12 months</td>
<td>12 months</td>
</tr>
<tr>
<td>Dry cleaning solvents</td>
<td></td>
<td>36 months, visual check—</td>
</tr>
<tr>
<td>Internal combustion engine oils</td>
<td></td>
<td>12 months</td>
</tr>
<tr>
<td>(including multigrade oils)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aircraft petroleum base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal combustion engine oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extreme pressure gear-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lubricating oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open gear lubricants,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>compounded lubricating oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic type oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery, railway axle, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>graphited lubricating oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic fluids/oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(petroleum base)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic fluids/oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(nonpetroleum base)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preservative oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulating oils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutting fluids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protective compounds</td>
<td></td>
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</tr>
</tbody>
</table>

114  
QM 4500
Table A-1. Minimum frequency for testing petroleum products (continued)

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>BULK</th>
<th>PACKAGED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialty products, antifreeze fluids, coolants, thrust augmentation fluids (nonhermetically sealed containers)</td>
<td>24 months, visual check— 6 months</td>
<td></td>
</tr>
<tr>
<td>Specialty products, antifreeze fluids, coolants, thrust augmentation fluids (hermetically sealed containers)</td>
<td>36 months, visual check—12 months</td>
<td></td>
</tr>
</tbody>
</table>

NOTES: Fuel and lubricants subjected to sustained conditions of arctic storage must be inspected every three years.

Product must be visually inspected by type C test. At the same time, the container must be inspected internally and externally. Composite samples may be prepared from not more than three source samples for each.

Hermetically sealed products are liable to deteriorate after they are opened. Once they are opened, they must be inspected and used at once or disposed of as authorized.

MIL-G-6032D type I products must be examined visually for hardening every six months.
<table>
<thead>
<tr>
<th>SERIAL</th>
<th>LOCATION OF STOCK</th>
<th>TYPE OF STORAGE</th>
<th>WHEN SAMPLED</th>
<th>TYPE OF SAMPLE (SEE NOTE 2)</th>
<th>TYPE OF TEST REQUIRED</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AT REFINERIES, BLENDING INSTALLATIONS ETC., ON PROCUREMENT, AND AT MAIN INSTALLATIONS, INCLUDING NATIONAL DEPOTS AND OCEAN-IMPORTING POINTS ON ESTABLISHMENT OF NEW BATCHES.</td>
<td>BULK</td>
<td>BEFORE ACCEPTANCE OF NEW MATERIAL AND AFTER ESTABLISHMENT OF NEW BATCH.</td>
<td>UPPER, MIDDLE AND LOWER SAMPLES, OR COMPOSITE OF ALL-LEVELS, SAMPLES AS CONDITIONS PRESCRIBE</td>
<td>TYPE A</td>
<td>U.S. QUALITY ASSURANCE POLICIES AND PROCEDURES FOR PROCUREMENT ARE GOVERNED BY DIAM 4155-1</td>
</tr>
<tr>
<td>2</td>
<td>SHORE TANKS AND PIPELINE MAIN DEPOT RECEIVING TANKS.</td>
<td>BULK</td>
<td>BEFORE LOADING DISCHARGE</td>
<td>AS FOR SERIAL 1</td>
<td>TYPE B-2</td>
<td>STOCKS IN TANKS WHICH HAVE BEEN TESTED PREVIOUSLY, AND WHICH ARE STILL WITHIN THE REQUISITE &quot;TEST&quot; PERIOD (TABLE II) NEED NOT BE TESTED, BUT A REFEREE SAMPLE IS TO BE TAKEN</td>
</tr>
<tr>
<td>3a</td>
<td>TANKERS AND BARGES</td>
<td>BULK</td>
<td>AFTER LOADING</td>
<td>ALL-LEVELS SAMPLE FROM EACH TANK, COMPOSITE SAMPLE OF SHIP OR BARGE TANKS</td>
<td>TYPE C</td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>YARD OILERS</td>
<td>BULK</td>
<td>AFTER LOADING</td>
<td>ALL-LEVELS SAMPLE FROM EACH TANK</td>
<td>TYPE B-1</td>
<td>NORMALLY YARD OILERS ARE IN DEDICATED SERVICE AND CARRY SHIP PROPULSION FUELS</td>
</tr>
<tr>
<td>4a</td>
<td>TANKERS &amp; BARGES (MULTI-PRODUCT CARGO)</td>
<td>BULK</td>
<td>BEFORE DISCHARGING</td>
<td>ALL-LEVEL SAMPLE FROM EACH TANK</td>
<td>TYPE C (SEE NOTE 6)</td>
<td>DISCHARGE OF VESSEL IS AUTHORIZED AFTER CONFORMANCE WITH TYPE C TESTS AND THE PROVISIONS OF PARAGRAPH 7-16.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>COMPOSITE SAMPLE OF TANKS</td>
<td>TYPE B-1</td>
<td>THESE TESTS WILL BE PERFORMED PRIOR TO OR DURING DISCHARGE OF CARGO. IN THE EVENT THE CAPABILITY FOR TESTING DOES NOT EXIST AT THE DISCHARGE POINT, A COMPOSITE SAMPLE FROM THE VESSEL WILL BE RETAINED AND TYPE B-1 TESTS PERFORMED ON A ALL-LEVEL SAMPLE TAKEN FROM THE RECEIVING TANK IF RECEIVING</td>
</tr>
<tr>
<td>SERIAL</td>
<td>LOCATION OF STOCK</td>
<td>TYPE OF STORAGE</td>
<td>WHEN SAMPLED</td>
<td>TYPE OF SAMPLE (SEE NOTE 2)</td>
<td>TYPE OF TEST REQUIRED</td>
<td>REMARKS</td>
</tr>
<tr>
<td>--------</td>
<td>------------------</td>
<td>-----------------</td>
<td>--------------</td>
<td>-----------------------------</td>
<td>-----------------------</td>
<td>---------</td>
</tr>
<tr>
<td>4b</td>
<td>TANKERS &amp; BARGES (SINGLE PRODUCT CARGO)</td>
<td>BULK</td>
<td>BEFORE DISCHARGE</td>
<td>COMPOSITE SAMPLE OF SHIP OR BARGE TANKS.</td>
<td>TYPE C</td>
<td>TANK PRODUCT FAILS SPECIFICATION REQUIREMENTS, TYPE B-1 TESTS WILL BE PERFORMED ON THE RETAINED COMPOSITE SAMPLE TO HELP DETERMINE THE CAUSE OF THE OFF SPECIFICATION PROBLEM.</td>
</tr>
<tr>
<td>117</td>
<td></td>
<td></td>
<td>DURING DISCHARGE APPLICABLE TO SERIAL 4(a)</td>
<td>FOR AVIATION FUELS ONLY, A ONE GALLON SAMPLE AT THE DOCK HEADER OBTAINED IN ACCORDANCE WITH APPENDIX METHOD A1 OR A2 OF ASTM D2276, TAKEN ONE-HALF HOUR AFTER START OF DISCHARGE A SECOND SAMPLE AT MID-POINT AND A THIRD SAMPLE ONE-HALF HOUR BEFORE COMPLETION OF DISCHARGE.</td>
<td>SOLIDS (MILLIPORE)</td>
<td>DISCHARGE OF VESSEL IS AUTHORIZED AFTER CONFORMANCE WITH TYPE C TESTS AND THE PROVISIONS OF PARAGRAPH 7.1.6 COMPOSITE SAMPLE WILL BE RETAINED UNTIL RECEIVING TANK ANALYSIS IS COMPLETE. IF RECEIVING TANK PRODUCT FAILS SPECIFICATION REQUIREMENTS, TYPE B-1 TESTS WILL BE PERFORMED ON THE RETAINED COMPOSITE SAMPLE TO HELP DETERMINE CAUSE OF OFF-SPECIFICATION PROBLEM.</td>
</tr>
<tr>
<td>QM 4500</td>
<td></td>
<td></td>
<td>DURING DISCHARGE APPLICABLE TO SERIAL 4(a) AT</td>
<td>FOR SPLIT CARGO DISCHARGES WHERE ONE PRODUCT IS JP-5, JP-8</td>
<td>FLASH POINT OR EXPLOSIVITY</td>
<td>SEE NOTE 5</td>
</tr>
</tbody>
</table>

Table A.2. Minimum sampling and testing requirements for petroleum products as extracted from Military Handbook 200F, Table III (continued)
<table>
<thead>
<tr>
<th>SERIAL</th>
<th>LOCATION OF STOCK</th>
<th>TYPE OF STORAGE</th>
<th>WHEN SAMPLED</th>
<th>TYPE OF SAMPLE (SEE NOTE 2)</th>
<th>TYPE OF TEST REQUIRED</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>TRANSFERS FROM MAIN INSTALLATIONS (SEE SERIAL 1 TO OTHER INSTALLATIONS)</td>
<td></td>
<td>NAVY TERMINALS ONLY</td>
<td>OR DFM AND OTHER PRODUCT IS JP-4, MOGAS OR AVGAS A DOCK HEADER SAMPLE WILL BE TAKEN DURING DISCHARGE OF THE JP-5, JP-8 OR DFM ONE-HALF HOUR AFTER START OF DISCHARGE AND HOURLY THEREAFTER</td>
<td>TYPE B-1</td>
<td>PROVIDED COMPLETE INSPECTION REPORT IS FURNISHED AND AVAILABLE FROM ORIGIN OF SHIPMENT, OTHERWISE TYPE A TESTS WILL BE REQUIRED.</td>
</tr>
<tr>
<td>5a</td>
<td>AFTER RECEIPT OF FUEL BY PIPELINE SYSTEMS USED FOR MORE THAN ONE PRODUCT.</td>
<td>BULK</td>
<td>AFTER RECEIPT OF FUEL</td>
<td>AS FOR SERIAL 1 (FROM EACH STORAGE TANK)</td>
<td>TYPE B-3</td>
<td></td>
</tr>
<tr>
<td>5b</td>
<td>AFTER RECEIPT OF FUEL BY WATERBORNE TRANSPORT.</td>
<td>BULK</td>
<td>AFTER RECEIPT OF FUEL</td>
<td>AS FOR SERIAL 1 (FROM EACH STORAGE TANK)</td>
<td>TYPE B-3</td>
<td>A COPPER STRIP CORROSION TEST EVERY 6 MONTHS IS RECOMMENDED SAMPLES WILL BE RETAINED FOR 2 MONTHS FOR REFEREE PURPOSES</td>
</tr>
<tr>
<td>5c</td>
<td>AFTER RECEIPT OF FUEL THROUGH A FULLY SEGREGATED SYSTEM.</td>
<td>BULK</td>
<td>AFTER RECEIPT OF FUEL</td>
<td>AS FOR SERIAL 1 (FROM EACH STORAGE TANK)</td>
<td>TYPE B-3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>TRANSFERS WITHIN INSTALLATION OR DEPOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6a</td>
<td>BATCHES PREPARED FROM APPROVED BATCHES CONSOLIDATED BY TRANSFER THROUGH A FULLY SEGREGATED SYSTEM</td>
<td>IN-STALLATIONS AND DEPOTS</td>
<td>AFTER RECEIPT OF FUEL</td>
<td>AS FOR SERIAL 1</td>
<td>NO TEST REQUIRED</td>
<td>SAMPLES WILL BE RETAINED FOR 2 MONTHS FOR REFEREE PURPOSES</td>
</tr>
</tbody>
</table>

Table A.2. Minimum sampling and testing requirements for petroleum products as extracted from Military Handbook 2904, Table III (continued)
<table>
<thead>
<tr>
<th>SERIAL</th>
<th>TYPE OF STORAGE</th>
<th>LOCATION OF STOCK</th>
<th>WHEN SAMPLED</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>6b</td>
<td>IN-STATIONS AND DEPOTS</td>
<td>Batches prepared by transfer of approved batches from consolidated through a non-segregated systems</td>
<td>After receipt of fuel</td>
<td>Type A</td>
</tr>
<tr>
<td>6c</td>
<td>IN-STATIONS AND DEPOTS</td>
<td>Batches segregated to a full segregated tank for road or rail loading service</td>
<td>Periodically as required by Table II</td>
<td>Type B</td>
</tr>
<tr>
<td>7</td>
<td>BULK</td>
<td>Dormant stocks wherever located.</td>
<td>Before filling, commences and changeover to fresh feed</td>
<td>Type C</td>
</tr>
<tr>
<td>8</td>
<td>BULK</td>
<td>Filling points for road and rail tank car containers or other equipment</td>
<td>Both after loading and before discharge</td>
<td>Type C</td>
</tr>
<tr>
<td>9</td>
<td>BULK</td>
<td>In rail tank cars and road tank vehicles and refueling and in over the road transport.</td>
<td>After passage of interface</td>
<td>Type C</td>
</tr>
<tr>
<td>10</td>
<td>BULK</td>
<td>Transfers by pipeline</td>
<td>Before re-injection</td>
<td>Type C</td>
</tr>
<tr>
<td>11</td>
<td>BULK</td>
<td>Tanks containing interface mixtures from pipeline for re-injection</td>
<td>Periodically as required by Table II</td>
<td>Type C</td>
</tr>
<tr>
<td>12</td>
<td>PACKAGED PETROLEUM STOCKS WHEREVER LOCATED</td>
<td></td>
<td></td>
<td>Type B</td>
</tr>
</tbody>
</table>

**Table A-2. Minimum sampling and testing requirements for petroleum products as extracted from Military Handbook 200F, Table III (continued)**

- **Type B-3**: Rejection of interface products is to be under the technical control of the pipeline authority. Where an aggressive inspection period has not been established, **Type B-2A** as required by Table II.
- **Type C**: Visual check on the samples taken to determine the degree of contamination.
- **Type A**: Appearance, water, and sediment.
- **Type B**: Sampling and testing to establish homogeneity if not visually acceptable.
<table>
<thead>
<tr>
<th>Type of Test Required</th>
<th>Type of Sample (See Note 2)</th>
<th>When Sampled</th>
<th>Type of Storage</th>
<th>Location of Stock</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) (2) When Contamination or Detection of Product or Component of Product Is Suspected</td>
<td>Line Sample</td>
<td>(1) Daily (2) Monthly</td>
<td>Bulk</td>
<td>Refueler Trucks Skid Mounted Refuelers or Other Dispensing Equipment</td>
<td>(1) Visual Check for Appearance, Water, and Sediment. (2) Lab Analysis for Water and Sediment.</td>
</tr>
<tr>
<td>(b) At the Discretion of the Owning or Inspecting Authority</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) Visual Check for Appearance, Water, and Sediment. (2) Lab Analysis for Water and Sediment.</td>
</tr>
<tr>
<td>(c) Annual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) Visual Check for Appearance, Water, and Sediment. (2) Lab Analysis for Water and Sediment.</td>
</tr>
<tr>
<td>(d) Every 5 Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) Visual Check for Appearance, Water, and Sediment. (2) Lab Analysis for Water and Sediment.</td>
</tr>
<tr>
<td>Appropriate: (See Remark b) and Note 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) Visual Check for Appearance, Water, and Sediment. (2) Lab Analysis for Water and Sediment.</td>
</tr>
</tbody>
</table>
LEGEND

TYPE "A" TEST COMPLETE SPECIFICATION INSPECTION TESTS.
TYPE "B-1" TEST PARTIAL ANALYSIS COMPRISING THE CHECKING OF PRINCIPAL CHARACTERISTICS MOST LIKELY TO HAVE BEEN
AFFECTED IN THE COURSE OF MOVING THE PRODUCT.
TYPE "B-2" TEST PARTIAL ANALYSIS TO VERIFY CHARACTERISTICS SUSCEPTIBLE TO DETERIORATION BECAUSE OF AGE.
TYPE "B-3" TEST PARTIAL ANALYSIS FOR CONTAMINATION, IN PARTICULAR, FOR CONTROLLING THE RE-INJECTION OF PIPELINE
INTERFACE PRODUCTS.
TYPE "C" TEST SPECIFIC GRAVITY, COLOR, AND APPEARANCE, INCLUDING VISIBLE SEDIMENT AND WATER.

NOTE (1): FOR FURTHER DETAILS, SEE THE TABLES FOR THE TYPES OF TEST REQUIRED ON THE VARIOUS PRODUCTS. (TABLE IV)
NOTE (2): THE METHODS OF SAMPLING TO BE USED ARE THOSE PRESCRIBED BY THE ASTM (SEE CHAPTER 5).
NOTE (3): WHEN LABORATORY TESTS OF MATERIAL FROM DISPENSING AND HANDLING EQUIPMENT EVIDENCE FREE WATER OR A
SEDIMENT LEVEL EXCEEDING 1.0 MILLIGRAMS PER LITER OF FUELS, THAT EQUIPMENT SHALL BE RESAMPLED AND
DEADLINED PENDING LABORATORY CONFIRMATION OF THE INITIAL RESULTS. IF THE SECOND LABORATORY ANALYSIS
CONFIRMS THE PRESENCE OF FREE WATER OR A SEDIMENT CONTENT EXCEEDING 1.0 MILLIGRAMS PER LITER,
IMPROVEMENT IN FUEL QUALITY MUST BE MADE (FOR THE NAVY, 2.0 MILLIGRAMS PER LITER APPLIES)
NOTE (4): NO RECEIVING TESTS ARE NECESSARY ON PACKAGED PRODUCTS PROVIDED THE CONTAINERS ARE INTACT AND
MARKINGS ADEQUATELY IDENTIFY THE PRODUCT.
NOTE (5): THE AVERAGE PARTICULATE CONTENT OF THE 3 FUEL SAMPLES SHOULD NOT EXCEED 8 mg/gal. HOWEVER, THE FIRST
AND LAST SAMPLES ARE OBTAINED UNDER SEVERE DISCHARGE CONDITIONS AND MAY SHOW HIGH PARTICULATE
CONTENT. SOLID CONTAMINATION WHILE EXTREMELY OBJECTIONABLE IS A PHYSICAL CONTAMINANT WHICH CAN BE
REMOVED UNDER PROPER CONDITIONS WITH PROPER EQUIPMENT AND SINCE THE PRODUCT AT THIS POINT IS
GOVERNMENT-OWNED, DISCHARGE OPERATIONS WILL NOT BE DISCONTINUED FOR THIS REASON. THE CONTRACTING
OFFICER, DEFENSE FUEL SUPPLY CENTER AND THE QUALITY ASSURANCE REPRESENTATIVE AT THE LOADING POINT
WILL BE ADVISED HOWEVER OF ANY HIGH PARTICULATE RESULTS OBTAINED, FOR FUTURE PLANNING PURPOSES AND
POSSIBLE CLEANING ACTION NECESSARY TO THE VESSEL INVOLVED. THIS NOTE IS NOT APPLICABLE TO INTERNAL
NAVY TRANSFERS.
NOTE (6): WHERE FLASH POINT TESTS ARE REQUIRED, A VESSEL COMPOSITE(S) SHALL BE RUN IN LIEU OF EACH INDIVIDUAL TANK.
FOR EACH SHORE TANK RECEIVING PRODUCT, A COMPOSITE SAMPLE WILL BE MADE CONTAINING PRODUCT FROM
EACH TANKER/BARGE COMPARTMENT DISCHARGING INTO THE SHORE TANK.