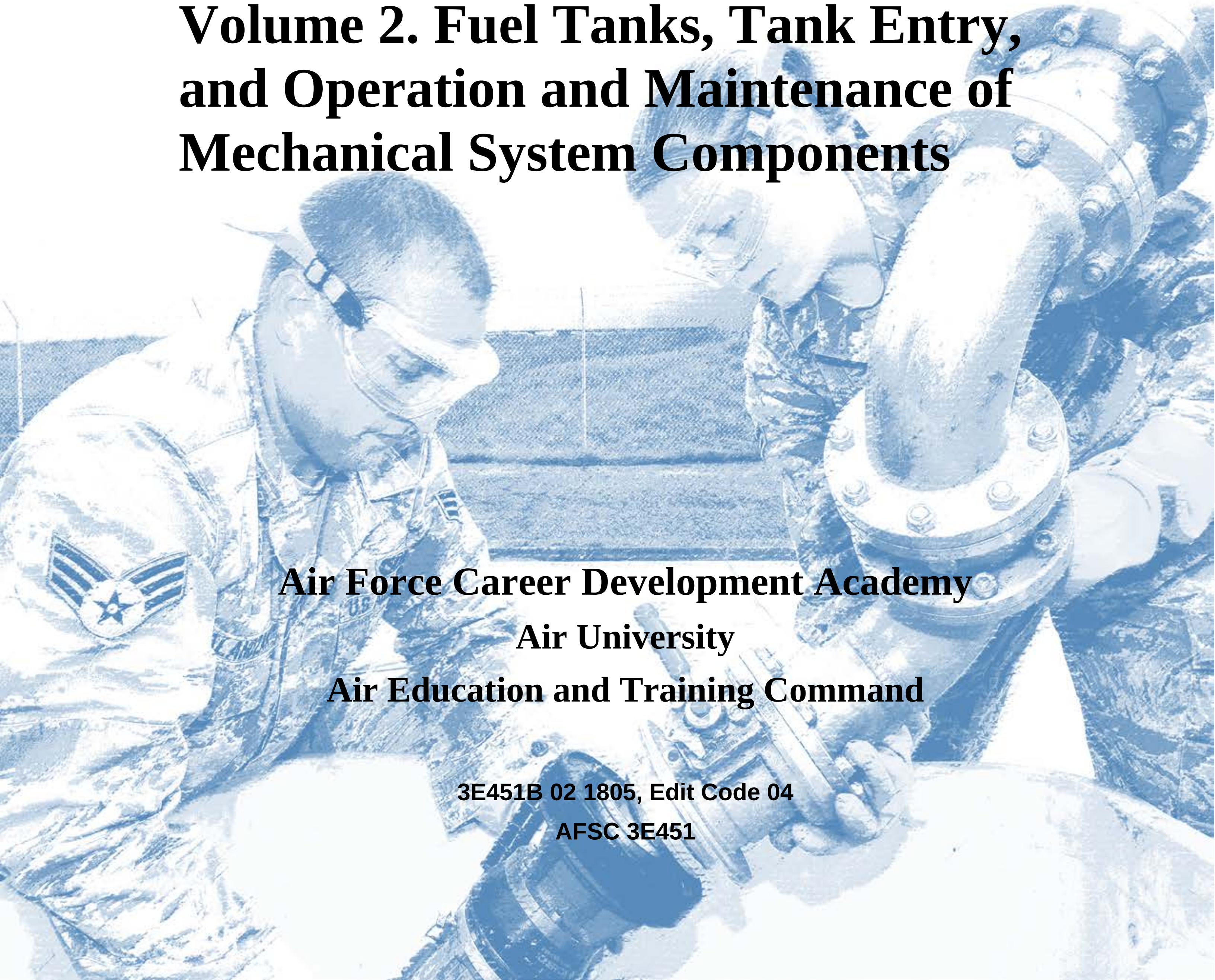
CDC 3E451B

Water and Fuel Systems Maintenance Journeyman

Volume 2. Fuel Tanks, Tank Entry, and Operation and Maintenance of Mechanical System Components



Air Force Career Development Academy

Air University

Air Education and Training Command

3E451B 02 1805, Edit Code 04

AFSC 3E451

Author: TSgt Roger Perez
MSgt Kevin Best
366th Training Squadron
AETC
366 TRS/TRR
727 Missile Road
Sheppard Air Force Base, Texas 76311–2254
DSN: 736–3411
E-mail address: roger.perez.1@us.af.mil

Instructional Systems Specialist: Timothy Sackie

Editor: Sherie A. Davis

Air Force Institute for Advanced Distributed Learning
Air University (AETC)
Maxwell Air Force Base, Gunter Annex, Alabama 36114–3107

Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For Weighted Airman Promotion System (WAPS) Specialty Knowledge Test (SKT) purposes, the examinee should check the *Enlisted Promotions References and Requirements Catalog* to determine the correct references to study.

OUR GOAL in this second volume of career development course (CDC) 3E451B, *Water and Fuel Systems Maintenance Journeyman*, is to provide you with the knowledge about tank construction and tank entry as well as how to maintain the equipment normally found in fuels related mechanical systems. Many of these components are also found at the bulk storage areas and in the immediate storage area of the hydrant systems.

This volume contains five units; unit 1 covers tank construction, tank entry and fuel support equipment, unit 2 covers filter/separators and strainers, unit 3 deals with meters and gauges, unit 4 explains the truck and tank car loading/offloading facilities and pipelines, and unit 5 contains lessons on the operation and maintenance of automotive dispensing systems.

As you complete this course, you'll gain the knowledge that if applied with on-the-job training will give you the skills required to advance beyond the apprentice level. Read and study each lesson, do the self-test questions and complete the mentioned training qualification packages, and you will master the contents of this course.

Code numbers on figures are for preparing agency identification only.

The use of a name of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

To get a response to your questions concerning subject matter in this course, or to point out technical errors in the text, unit review exercises, or course examination, call or write the author using the contact information on the inside front cover of this volume.

NOTE: Do not use Air Force Instruction (AFI) 38-402, *Airmen Powered by Innovation*, to submit corrections for printing or typographical errors. For Air National Guard (ANG) members, do not use Air National Guard Instruction (ANGI) 38-401, *Suggestion Program*.

If you have questions that your supervisor, training manager, or education/training office cannot answer regarding course enrollment, course material, or administrative issues, please contact Air University Educational Support Services at http://www.aueducationsupport.com. Be sure your request includes your name, the last four digits of your Social Security number, address, and course/volume number.

This volume is valued at 18 hours and 6 points.

Acknowledgment

PREPARATION of this volume was aided through the cooperation and courtesy of the Cla-Val Company; FMC Technologies; IDEX Corporation; Brodie Meter Co., LLC; Gammon Technical Products, Inc.; Argo-Tech; OPW, A Dover Company; Gasboy® Corporation; and Danaher Corporation, who furnished technical materials for this water and fuel systems volume. Permission to use this material is gratefully acknowledged.

Title	Company	CDC Figure Number
40AF–2A, fuel discharge valve (refueling).	Cla-Val Company	2–8
40AF–2A, fuel discharge valve (ball float in the top position).	Cla-Val Company	2–9
40AF–2A valve components.	Cla-Val Company	2–10
40AF–2C, Fuel discharge valve.	Cla-Val Company	2–11
102B–1, Three-way hytrol 1/8-inch orifice.	Cla-Val Company	2–13
CFF21 flanged float control.	Cla-Val Company	2–16
Smith meter.	FMC Technologies	3–2
Smith meter calibration.	FMC Technologies	3–3
Liquid control meter.	IDEX Corporation	3–4
Liquid control calibration	IDEX Corporation	3–5
Brodie meter.	Brodie Meter Co., LLC	3–6
Brodie meter calibration.	Brodie Meter Co., LLC	3–7
Gammon model GTP–534 differential pressure gauge.	Gammon Technical Products, Inc.	3–13
J.C. Carter single-point nozzle.	Argo-Tech.	4–2
Cla-Val single-point nozzle.	Cla-Val Co.	4–3
OPW swivel joint.	OPW, A Dover Company	4–4
Internal gear pump and air eliminator.	Gasboy® Corporation	5–7
Self-contained pump dispenser fuel flow.	Gasboy® Corporation	5–8
Pumping unit surge check valve.	Gasboy® Corporation	5–9
Measuring unit.	Gasboy® Corporation	5–10
Register.	Gasboy® Corporation	5–11
Vacuum and pressure test.	Gasboy® Corporation	5–13
Red Jacket XLD diaphragm leak detection.	Danaher Corporation	5–15

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Page

Unit 1. Tank Construction, Tank Entry, and Fuel Support Equipment

IN ADDITION TO providing first-rate maintenance on water systems, Water and Fuel Systems Maintenance (WFSM) has the only personnel within the base civil engineering (BCE) squadron that has a direct effect on the flying mission. We ensure that the aircraft receives clean, dry fuel. This means we have to be experts at the fuel systems maintenance side of our job as well. Our job begins when the fuel is received on base and does not end until the fuel reaches an aircraft. Having a thorough familiarization with your base's systems and components is paramount to keep them operating properly and the aircraft flying. The base fuels management office, also known as petroleum, oils and lubricants (POL), is responsible for the installation's fuel accounting and fuel systems operations, while we are the maintainers of those systems.

Since World War II, our forces needed large quantities of fuel to supply our aircraft and ground vehicles. Over the next 60 years, the Department of Defense (DOD) has combined the practices of the private sector with military needs to provide the most efficient means to construct and maintain the infrastructure to meet our fuel requirements. In this unit, we will discuss fuel storage tanks and their components and other equipment the Air Force (AF) uses as means to perform tank entry for cleaning and inspecting those tanks.

1–1. Fuel Tank Construction, Inspection, and Maintenance

An air base receives fuel products by cross-country pipeline, rail car, ship, or truck. The fuel is initially received into the bulk fuel storage tanks and transferred to an immediate operating storage tank (IOST), which are closer to the aircraft.

Over the course of your AF career, you will come across many different kinds of fuel tanks. Even though the basic designs of fuel tanks are similar, they also have some unique characteristics. In this section, you will learn the construction features, inspection criteria, and maintenance procedures of the most common types of fuel tanks currently in use.

201. General fuel storage tank construction features

There are many types of fuel storage tanks around the world. The AF uses specifically designed tanks for uniformity. We will discuss those in the following lessons.

Tank criteria

The AF has developed standard design criteria and minimum components for new tank construction. The design, inspection, and maintenance criteria for tanks come from both military and civilian standards set forth in the following publications:

- Unified Facilities Criteria (UFC) 3–460–01, *Design: Petroleum Fuel Facilities.*
- DOD Standard Design AW 78–24–27, *Standard Fueling Systems; Aboveground Vertical Steel Tanks with Floating Pan and Fixed Roofs.*
- American Petroleum Institute (API) 650, *Welded Steel Tanks for Oil Storage.*
- API 653, *Tank Inspection, Repair, Alteration, and Reconstruction.*
- UFC 3–460–03, *Operation and Maintenance: Maintenance of Petroleum Systems.*

Fuel types and quantities

The mission of an installation determines the different types and quantities of fuel products required on location. Fuel requirements usually change with the mission. Every installation will have diesel and automotive gasoline (MOGAS) requirements, but when the installation has a flying mission, the number and type of aircraft assigned to a base determine the *aviation* fuel requirements. The normal criterion used to figure a base's fuel requirement is a 10-day supply based on a combination of the base's wartime and peacetime fuel commitment. At bases used as primary ports, the requirement is a 15-day supply of fuel needed to meet this commitment.

Number and size of tanks

The storage capabilities of each installation change from time to time and vary from one base to another. The Defense Logistics Agency (DLA), based on the mission requirements of a base, determines type, size, and quantity of fuel tanks needed. For instance, an installation hosting an aerial refueling or a heavy bomber wing would require a larger storage capability for jet fuel than a fighter wing.

Normally, the capacity of the largest tank will not exceed 100,000 barrels (bbl.) (1 bbl. = 42 gallons [gal.]) without Headquarters, United States Air Force (HQ USAF) approval. However, the AF does have a few cone-roof tanks with floating pan, and each has a capacity of 235,000 bbl. for jet fuel. Examples of these tanks are located at Lajes Field, Azores *(Atlantic Ocean)* and Anderson Air Force Base (AFB), Guam *(Pacific Ocean)*. These locations and their large aircraft refueling capabilities provide the valuable "air-bridges" to achieve our global reach goals. These large tanks were built under special authorization in response to the extremely high fuel requirements for jet fuel and/or having limited space for construction.

Such petroleum products as aircraft lubricating oils, diesel fuel, and MOGAS are usually the low-volume fuel products. The total requirement for each product determines how the product is stored and affects the location of the storage site.

Types of tanks

Tanks in the AF inventory fall into two general classes: aboveground storage tanks (AST), and underground storage tanks (UST). The following are the four basic types of tanks:

1. Vertical ASTs.
2. Horizontal ASTs.
3. Vertical USTs, also known as (a.k.a.) "cut and cover".
4. Horizontal USTs.

All AF horizontal storage tanks and cut-and-cover tanks have similar designs, but the vertical ASTs have a few variations such as floating roof, cone roof, and cone roof with floating pan.

Larger vertical ASTs and cut-and-cover tanks are designed to store large quantities of jet fuel (10,000 bbl. or more) at a bulk storage area.

Smaller vertical ASTs, horizontal ASTs in bulk storage areas (under 10,000 bbl.) normally contain diesel and MOGAS.

Horizontal USTs of 50,000 gal. or less are designed to store lesser quantities of jet fuel in hydrant system IOSTs, and quantities of diesel, MOGAS, and aviation gasoline (AVGAS) at automotive, aerospace ground equipment (AGE), and heavy equipment refueling stations. When an installation's diesel and MOGAS requirements are small enough that bulk storage tanks are not needed, the refueling stations can receive, store, and dispense the fuel.

All horizontal USTs and cut-and-cover tanks that issue jet fuel will have the pump house located directly on top of them and have deep-well pumps.

All fuel storage tanks with a capacity of more than 10,000 gal. are of welded steel construction. The interior surfaces of all newly constructed aviation fuel storage tanks the come in constant contact with fuel must be coated with a fuel-resistant epoxy coating primarily to prevent corrosion, but it also makes the cleaning process easier. One drawback to the epoxy-coated tank floor is that the surface becomes slick and increases the possibility of slipping, so be careful. Internal surfaces that do *not* come into contact with the fuel are coated with the same material used on the tank exterior.

Common components

Tank external components, unless otherwise indicated in UFC 3–460–03, chapter 10, are visually inspected monthly for condition.

Containment

All new fuel tanks must have a means to contain spills either through a tank’s double-wall construction or diking around the tank. Double-wall tanks will have an interstitial space between the walls that must be checked manually or electronically with probes for internal and external tank wall leaks. A dike is a flat area built with vertical or sloped walls to contain any fuel spills from the tanks that lie within them. Older USTs that are not double-walled must be periodically leak checked by a contractor or replaced.

Manways and hatches

Manways enable access into a tank. There will be one or more manways near the bottom of an AST, depending on its size. Manways can also be located on an AST’s tank shell above the 6-foot level. This manway is usually accessible by the external stairs and used to bring in repair equipment and materials onto a tank’s floating roof or pan without climbing to the top of the tank. Some AST floating roof or pans will have manways for equipment access when the tank is empty. USTs can also have multiple manways, but usually only one will have an internal ladder to reach the tank bottom.

Manways on newly constructed tanks will be at least 36 inches in diameter for safe entry and egress. Manway covers will have multiple bolt holes to attach it to the manway flange. A gasket is placed between the cover and flange to prevent fuel liquid or vapor leakage. The gaskets are custom cut to match the flange. Whenever a manway cover is removed, a new gasket of the same thickness must replace the old one before replacing the manway cover. Tighten manway cover bolts in a crisscross pattern to ensure an even seal. Cover the bolts’ threads with a light coat of grease to prevent rust. Before removing a manway cover on the side of an AST, use a tape and bob to ensure the fuel level is below the lower edge of the manway flange.

Located near one of the manways will be a nameplate listing the tank's manufacturer and serial number. If the tank gauging charts or blueprints are ever lost or unreadable, this information will be helpful in obtaining copies.

Besides the gauge hatch that we will talk about later, there are two other types of hatches found on tanks—roof hatches and clean-out hatches. Roof hatches (inspection hatches) are hinged and found on the top of ASTs to allow access to internal ladders. Clean-out hatches are bolted and found on older ASTs at the very bottom of the outer shell. If the tank has multiple outer sumps, this hatch aids in tank-cleaning operations.

Stairways, ladders, and platforms

AST and cut-and-cover tanks will have stairways or external ladders to get to the top of the tank or mound and internal ladders to enter the tank. Stairways will have safety railings and some ladders will have protective cages. An AST will also have a platform to stand on before descending internal ladders and accessing the gauging hatch. Additionally, platforms will be around the tank's outer shell and rim to perform component inspections and maintenance.

Floating roof and cone roof with floating pan tanks will have either a standard vertical ladder or a rolling ladder. When a standard ladder is used, the floating roof or pan will have a rectangular hole close to the outer edge for the ladder to pass through. Rolling ladders have wheels at the bottom that ride on tracks attached to the tank's floating pan or roof. The top of a rolling ladder will be securely fastened but hinged to the top of the tank shell. The angle of the ladder will vary according to the tank's fuel level.

All USTs and cut-and-cover tanks have internal ladders to enter the tank. If an internal ladder's length is greater than 10 feet, it will have a safety cage or safety rail system to attach an entrant to when wearing a safety harness. Stairs, ladders, and platforms are inspected for loose bolts, grounding connections, welds, coatings, and rust.

Vents

All tanks must have vents to allow the tank to breathe and to protect the tank from damaging positive or negative pressures. Vents also allow tanks to release excess amounts of product (overflow vent) that could breach the tank at its weakest point. The following are some common vent types:

- Pipe vents.
- Open (roof) vents.
- Pressure/vacuum vents.
- Overflow vents.
- Slot vents.

On tanks with a vapor space (cone roof, horizontal tanks, and cut-and-cover tanks), the size and/or number of the vents and any associated piping are determined by the volume of air or vapor entering or exiting the tank that is displaced by the same volume of fuel. On the types of tanks where the vent or vent piping is too small, becomes clogged, or fails to operate properly, excessive pressure or vacuum can damage the tank. Each type of vent will be discussed with the corresponding tank.

Inlet and outlet lines

An inlet line (fill line, receipt line) allows fuel into a tank. At a minimum, this line will have a manual valve and may have an automatic valve that will close when the fuel reaches a predetermined high level. An outlet line (withdrawal line, issue line) allows fuel out of a tank and will have a manual valve. The manual valves on both lines will usually be a ball valve or a double block and bleed (DBB) plug valve. On newly installed tanks, the DBB plug valve will be used on these lines because of its feature to ensure a positive blocking of the fuel during pipeline pressure testing and tank-cleaning operations. An additional valve you will find on a vertical AST is the fuse-link butterfly valve. It is installed on both of these lines to spring closed in the event of a tank fire.

Floors

The floor of early designed cone-roof tanks sloped from the center to multiple sumps downward to the outside edge for the collection of water and sludge. The current design has the vertical AST and cut-and-cover tank floors sloped 5 percent from the outer edge towards a single center sump for positive drainage and self-cleaning action.

A horizontal AST and UST will be installed so that the floor slopes downward toward one end (where the water draw-off line is located) at a slope of 1 percent. Newer tank floors of any type are epoxy coated to prevent rust. Carefully inspect the floors after a tank cleaning or during scheduled tank inspection for rust, cracks, and bubbling in the coatings that may hide sub-surface rust. Pay special attention to all welds.

Sumps

Sumps are the lowest point of a tank's floor for the collection for water, sediment, and sludge. Older cone-roof tanks will have multiple sumps located along the outside edge of the tank floor. Newer vertical AST and cut-and-cover tanks will have a single center sump, and horizontal UST and AST sumps will be located at one end of the tank. Water draw-off lines begin in the tank sump. Sumps, as a part of a tank floor, are also epoxy coated and are inspected similarly.

Water draw-off lines

Since water is inherently part of a fuel mixture and collects in fuel tanks through condensation, every fuel tank has a water draw-off line to remove water. Usually this ¾-inch line extends through the lower edge of an AST shell (wall) *or* up and out of the top of an UST. Inside the tank, the water draw-off line terminates ½ inch from the bottom of the sump. Outside the tank, this line can terminate either with a manual valve and cam-locking style connector or connect to a product-recovery system. If the water draw-off line terminates at the tank wall, a hand pump, installed pump, or a double-diaphragm pump and hoses are used to draw water and sediment from these lines and put into buckets, barrels, or a bowser (tank on wheels). This line in the UST is often called a cleanout line.

Most vertical AST water draw-off lines are connected to a product-recovery system and have a manually operated antifreeze valve threaded into the side of the tank where the water draw-off line penetrates the tank wall. This valve has a double-block design and is normally closed to keep any water in the water draw-off line inside the tank. Since the fuel temperature inside the tank will not go below freezing, neither will the water. This will keep the line from bursting. These lines (outside the tank) are inspected for leaks and rust. In addition, any manual valve is inspected for damage and proper operation.

The only exception to the ¾-inch size of the water draw-off line will be for cut-and-cover tanks. This exception is because the suction lift required to draw water up and out of this tank's sump, will have a small deep-well pump to remove the water. The discharge of the pump can be piped to a 55 gal. or larger product-recovery tank (PRT) either on top of the tank or at the base of the mound.

Product-recovery system

Bulk fuel storage tanks and fuel pump houses need product-recovery systems. There are two basic product-recovery systems. The first is usually a horizontal tank (4,000 gal. or less) buried next to a pump house to collect fuel and water from low-point pipe sections, filter/separator (F/S) drain lines, pressure-relief lines and air-eliminator lines. These tanks will have a gravity fed inlet line, a vent line and one or more of the following components:

- A manway.
- A vertical water draw-off line.

- A small deep-well pump—to return fuel product back into the system.
- An outlet line—connected to the deep-well pump's discharge.
- A high-level shutoff valve/alarm.
- A gauge/suction line—to manually gauge the tank, dump buckets of fuel into the tank, or to provide a means to empty the tank of fuel or water with a hand or portable pump.

The second type of product-recovery system is used on a vertical AST and is located inside the dike next to the tank (fig. 1–1). This system includes a 55 or 100 gal. stainless steel PRT mounted on legs with a system of pipes and valves connected to the AST's water draw-off line. Since water is heavier than fuel, it will settle in the AST's sump. When all valves to the PRT are opened, the static pressure of the fuel in the AST will force any water and some fuel out of the AST's sump into the water draw-off line and into the PRT. The system also has a hand or electric pump connected to the PRT piping enabling the water in the PRT to be drained off leaving only fuel. The fuel is then pumped back into the AST. Since POL uses PRT systems to remove tank water on a daily basis or before issuing fuel, inspect this system monthly for leaks and condition.

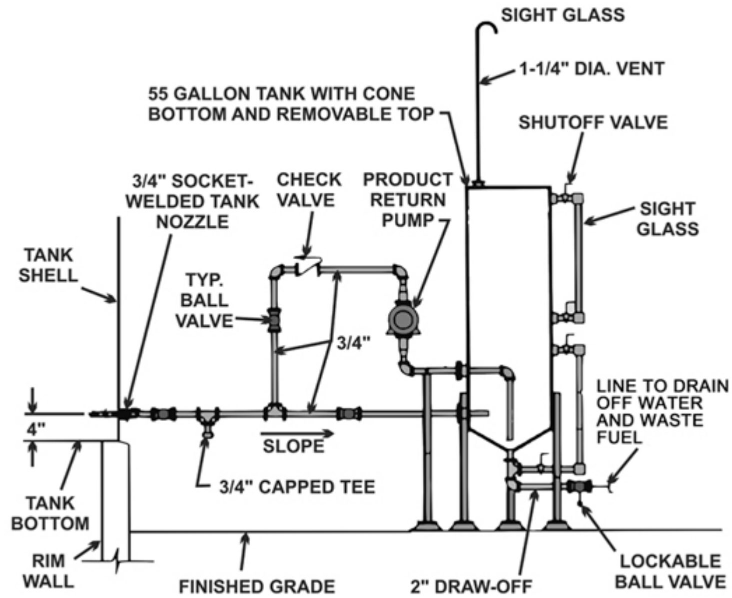


Figure 1–1. Product-recovery system.

Gauging systems

All fuel storage tanks too large to use a stick gauge must have a gauging system to determine how much product it contains. In addition to having tank features to manually gauge a tank with a tape and bob, most tanks will have either an automatic/mechanical gauging system, or an electronic automatic tank gauging (ATG) system to accomplish this task. The automatic/mechanical systems include the automatic float gauge used in an AST and cut-and-cover tanks and the liquidometer (liquid-level gauge) used in a UST. These will be discussed in those tank sections.

ATG systems

The most common ATG system employed by the AF is an electronic system that use nitrogen-filled bottles piped to liquid-level sensors (or probes) to gauge the fuel levels in any type or size tank. The sensors send their readings to their control panels, and the readings are displayed on a digital screen. Depending on their complexity, these control panels can show fuel and water levels in a single tank or multiple tanks as well as fuel temperature. The installation, maintenance, repair, and nitrogen bottle replacement for these units are done through a contractor; POL is the point of contact.

Grounds and bonds

All fuel tanks must be grounded to relieve electrical charges. Underground tanks, by virtue of their direct contact with the soil, are already grounded. According to current requirements, copper grounding components will not be used to eliminate corrosion caused by the steel tanks reacting with copper. Galvanized steel ground rods and conductors are now the standard. If an existing aboveground tanks use copper for grounding, it should be replaced with the galvanized steel.

In tanks, any component that is not bolted or welded to the tank must be bonded to the tank. Examples of this are rolling ladders and floating roofs or floating pans. UFC 3–460–03 provides the criteria and examples for the grounding and bonding of tanks and components.

All static grounds will have a resistance of less than 10,000 ohms. All existing static grounds will have a one-time test with resistance values permanently recorded. Remove or replace any static ground with a resistance greater than 10,000 ohms. Repair and retest any static ground mechanically damaged. Static grounds do not need to be tested periodically after the initial test.

202. Cone roof and cone-roof tank with a floating pan constructional features

Cone-roof tanks with a floating pan are still used in the AF inventory. Although we are moving away from them, we will still discuss them so you will be familiar when you come across them.

Cone-roof tank components

Because of its simplistic design, the cone-roof tank is one of the first tanks to appear in the AF inventory. It is used to hold various types of petroleum products, from jet fuels to heating oils. The common components of a cone-roof storage tank include a sump(s), inlet and outlet lines, vents, a liquid-level gauge, fuel and water drain-off lines, manways, a gauge hatch, and ladders and/or stairs. It is important to note that additional components may be required for newly installed cone-roof tanks depending on the product it contains and that these components can vary from tank to tank.

Vents

The vent used for the cone-roof storage tank is a pressure/vacuum vent (fig. 1–2). Cone-roof tanks can withstand very little pressure or vacuum during filling or removal of fuel. The vent is located on the tank roof and maintains working pressure in the tank within the safety limits of pressure and vacuum. It also prevents excessive loss of fuel by evaporation. When pressure/vacuum vents are used on AF tanks within the United States (US), flame arresters are *not* permitted. Some countries require the use of flame arresters, and we adhere to their laws.

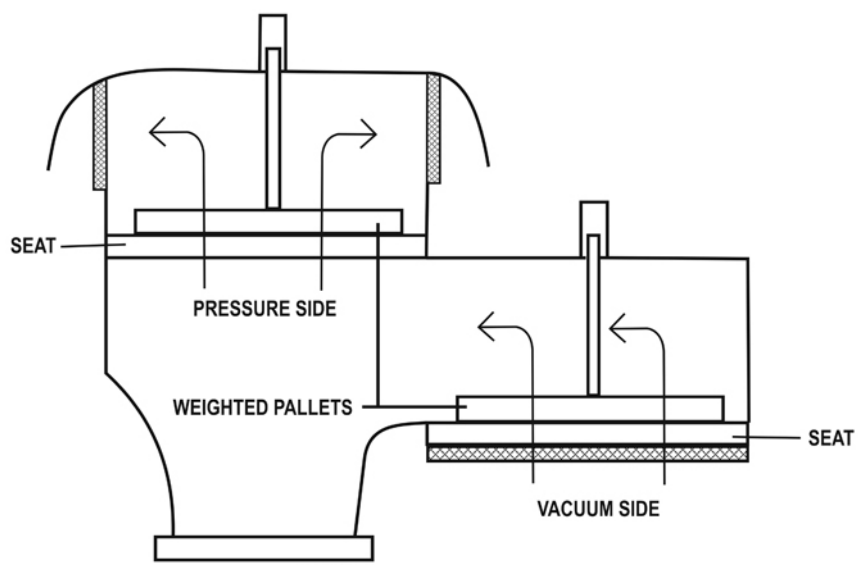


Figure 1–2. Pressure vacuum vent.

Liquid-level gauges

Also known as an automatic float gauge, the liquid-level gauge used on cone-roof tanks makes it possible to read the liquid level in the tank at ground level (fig. 1–3). The construction of all liquid-level gauges is basically the same. The components include the following:

- A gauge head and counter window are located at ground level. The gauge head contains the float cable reel and wheel-type counter to measure the liquid level in feet, inches, and fractions of inches.
- Float that rises and falls with the liquid level in the tank.
- Two guide wires are attached to the roof and to the floor of the tank. The guide wires are threaded through eye hooks on each side of the float to prevent the float from moving around in the tank.
- A thin cable attached to the float that travels up and over a pulley at the top of the tank and down to a spring-loaded reel inside the gauge head. As the cable is reeled into the gauge head, the counter measurement will decrease. On the exterior of the tank, this cable is contained within a pipe.

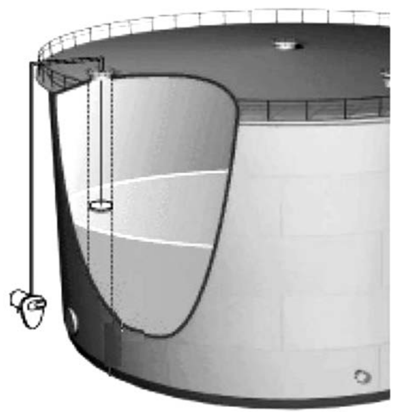


Figure 1–3. Liquid-level gauge.

Fuel drain-off lines

Some cone-roof tanks will have a fuel drain-off line if the outlet line does not extend low enough inside the tank. A fuel drain-off line extends through a vertical AST's wall to the sump. Inside the tank, this line will extend into the sump at a lower level than the outlet line but at a higher level than the water draw-off line. It is used to remove any fuel left in the tank after the installed pumps have broken suction at the outlet line. When pumping operations on the fuel drain-off line has broken suction, it will leave only a minimal amount of fuel in the tank's sump when performing cleaning or inspection operations.

Gauging hatch

Gauge hatches are openings provided on all tanks for the manual gauging of the tank's contents using a hand-held tape and bob. It is usually a pipe section welded to and extending just inside the top of the tank. It will have a hinged or a cam-locking-style lid that can be secured.

Cone-roof tank with floating pan components

The cone-roof tank with floating pan, also called the *all-weather tank*, is the newest type in the AF inventory (fig. 1–4). The all-weather tanks are primarily used for the storage jet fuels and highly volatile products (flash point under 100 degrees [°] Fahrenheit [F]). The floating pan feature of this tank rests on the surface of the fuel thereby minimizing the amount of vapors given off. The basic structure of the outside shell is similar to that of the cone roof. The major components are the gauge well, stripping line, liquid-level gauge, vents, high-level shutoff and alarms, a low-level shutoff, a vertical or rolling ladder, and a floating pan. This type of tank is the most common design for bulk storage tanks and aboveground IOSTs for jet fuels in the continental United States (CONUS).

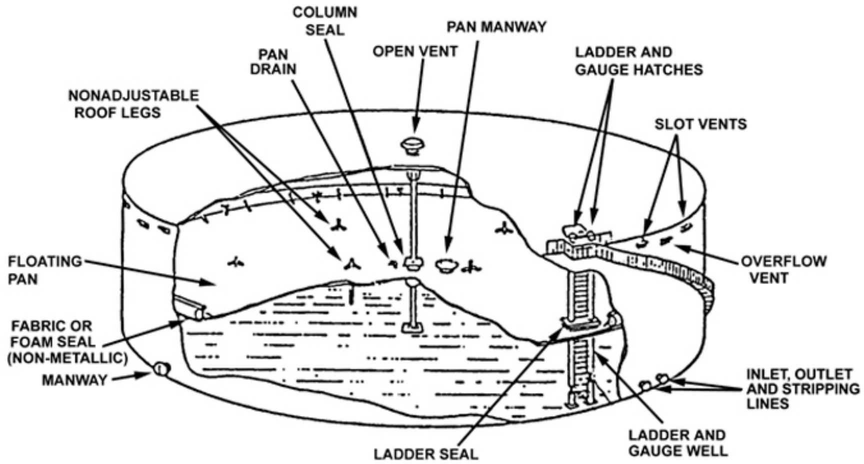


Figure 1–4. Cone-roof tank with floating pan.

Gauge well

A gauge well is a section of pipe that is located alongside the access ladder and extends the entire length from the gauge hatch on top of the tank down to the tank floor's outer edge. The gauge well has holes or slots along its length to allow fuel inside. The gauge well (fig. 1–5) is located alongside the access ladder inside the tank. It consists of an 8-inch aluminum or stainless steel pipe connected to the tank bottom with a datum plate. The datum (or striker) plate will be welded to the tank bottom and represents the official zero level in the tank.

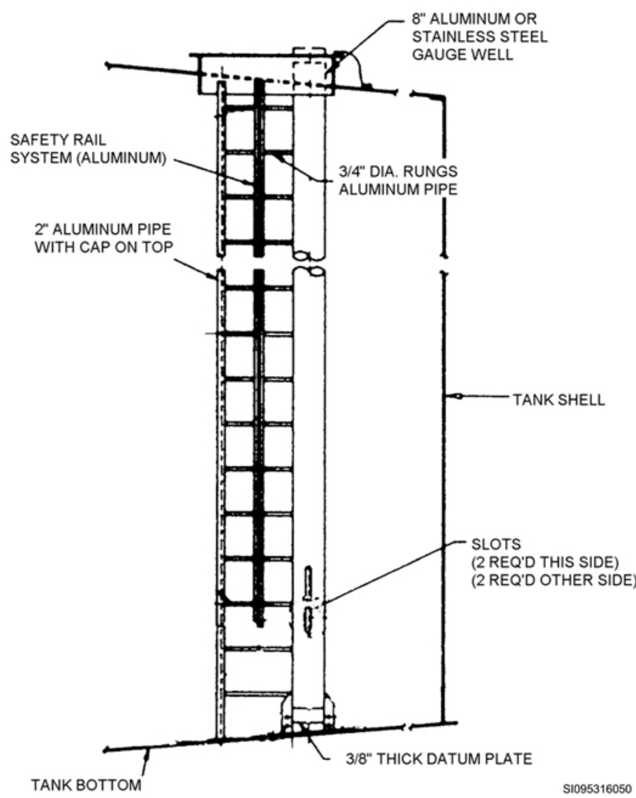


Figure 1–5. Gauging well and access ladder.

Product-withdrawal line (outlet line)

The product-withdrawal line (fig. 1–6) is sized according to the size of refueling pumps used. The line extends inside the tank and terminates in a vertical position, 6 inches above the top of the sump.

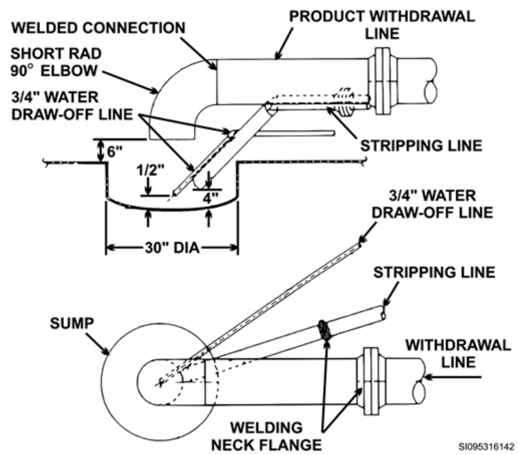


Figure 1–6. Piping inside a cone-roof tank with floating pan.

Water draw-off line

As we said before, the water draw-off line (fig. 1–6) is a ¾-inch line used to remove water from the tank. It extends inside the tank and terminates ½ inch from the bottom of the sump. The water draw-off line also slopes 6 inches per 10 feet from the tank shell to the center sump. The water draw-off line is connected to the product-recovery system in the dike next to the tank.

Stripping line

The stripping line (fig. 1–6) is a 3-inch line used to pump the tank down below the product-withdrawal line termination level. This line extends inside the tank at a slope of 6 inches per 10 feet, and one end terminates 4 inches from the bottom of the sump. The other end of the stripping line terminates on the exterior of the tank shell with a 3-inch quick-connect coupler. Figure 1–7 shows how the stripping line tees over to the product-withdrawal line. This tee allows you to use the permanently installed refueling pump to pump the tank down to the stripping line termination level.

NOTE: If your tanks have low-level shutoffs, then locally developed procedures must be developed to override the low level in order to use the installed pumps to completely empty the tank.

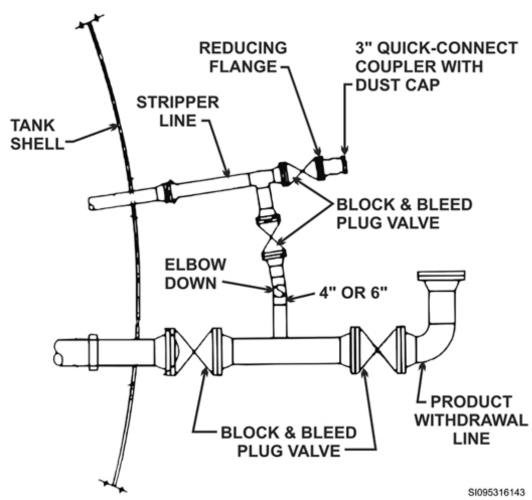
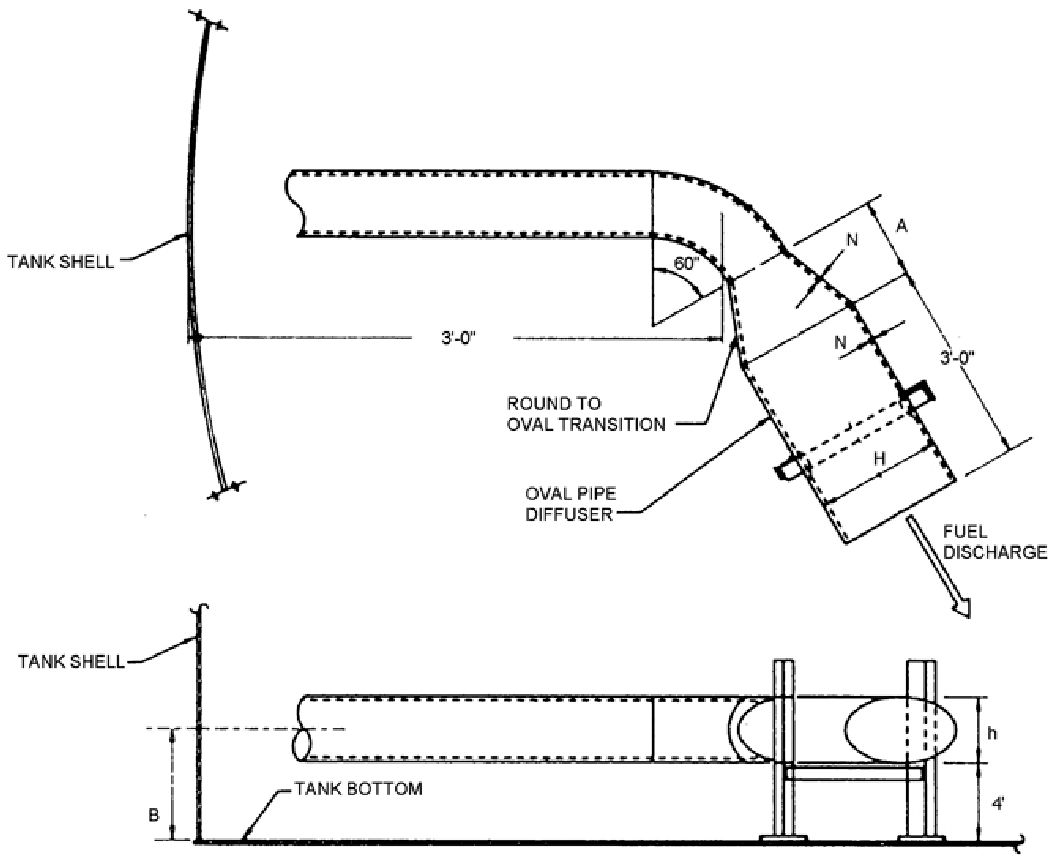


Figure 1–7. Stripping line and product-withdrawal line.

Tank fill line

The tank fill line (fig. 1–8) is the line used to fill the tank with fuel. It is sized (diameter) according to the size fuel system you have at your base. The line extends inside the tank shell 3 feet, turns 60°, flares out, and then terminates at a maximum height of 4 inches from the tank bottom. In the northern hemisphere, the fill line turns to the right so that it causes the fuel to rotate in a counterclockwise motion. In the southern hemisphere, the fill line turns to the left so that it causes the fuel to rotate in a clockwise motion. The direction of flow is important because of the Coriolis force which, as a result of the earth's rotation, deflects moving objects to the right in the northern hemisphere and to the left in the southern hemisphere. We use the Coriolis force to aid in cleaning the tank every time we put fuel in the tank. As fuel enters the tank through the fill line, the fuel swirls and moves any sediment on the floor of the tank toward the center sump. Any water and sediment collected in the center sump can be removed through the product-recovery system.



SHELL NOZZLE DIMENSIONS

SIZE OF LINE	O.D. OF PIPE	J	N	h x H	A	B
28"	28"	11"	.500	20"x36"	30"	24"
18"	18"	10"	.500	18"x34"	27"	22"
16"	16"	10"	.500	16"x30"	24"	20"
14"	14"	10"	.500	14"x25"	21"	18"
12"	12 3/4"	9"	.500	12"x22"	18"	17'
10"	10 3/4"	9"	.500	10"x18"	15"	15"
8"	8 5/8"	8"	.500	8"x14"	12"	13'
6"	6 5/8"	8"	.432	6"x10"	9"	11'
4"	4 1/2"	7"	.337	4"x8"	6"	9'
3"	3 1/2"	7"	.300	3"x6"	4 1/2"	8"
3/4"	3/4"	5"	.300			

Figure 1–8. Tank fill line.

High-level shutoff valve

The high-level shutoff valve (fig. 1–9) is a hydraulically operated automatic valve that is controlled by the float assembly located on the tank exterior. The high-level shutoff valve is installed in the tank's fill line and closes when fuel reaches a predetermined point within the high-level shutoff float assembly.

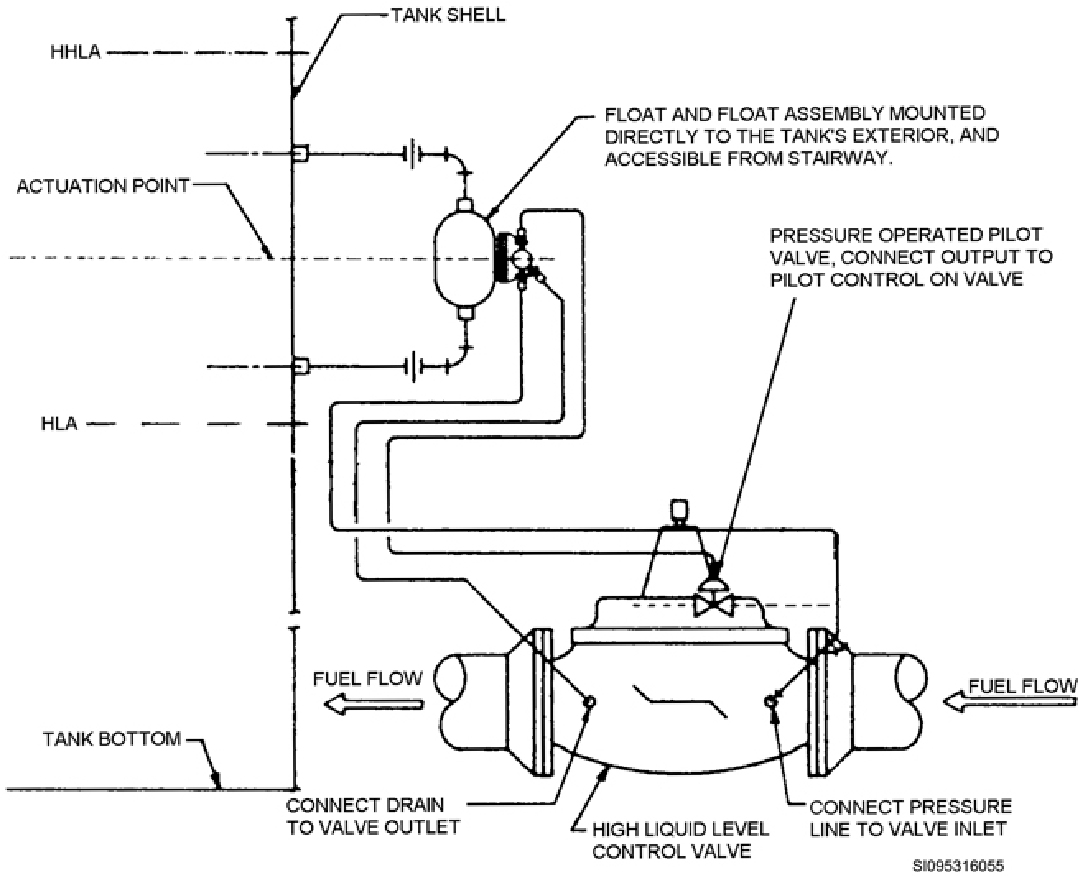


Figure 1–9. High-level shutoff valve.

High-level and high-high-level alarms

The high-level alarm (HLA) shown in figure 1–10 is an alarm actuated by a float assembly located just before the high-level shutoff level. The following table gives you the exact height of the HLA.

Level Alarms Distance from Tank Bottom

Tank size in bbl.	Low-level alarm (LLA)	HLA	High-high-level alarm (HHLA)
2,500	27"	23'3"	24'0"
5,000	27"	35'4"	36'5"
10,000	27"	35'10"	37'7"
25,000	27"	42'9"	44'1"
55,000	27"	43'1"	44'6"
80,000	27"	43'3"	44'8"
100,000	27"	43'5"	44'10"

NOTE: Tank bottom is defined as the elevation where the tank bottom intersects the tank shell.

In case of failure of the high-level shutoff valve, there is a HHLA, also shown in figure 1–10, that is set at a higher elevation on the tank than the high-level shutoff valve. This alarm is controlled electrically by means of a float assembly. The HHLA sounds an alarm and illuminates a light in the control room if the fuel reaches its level.

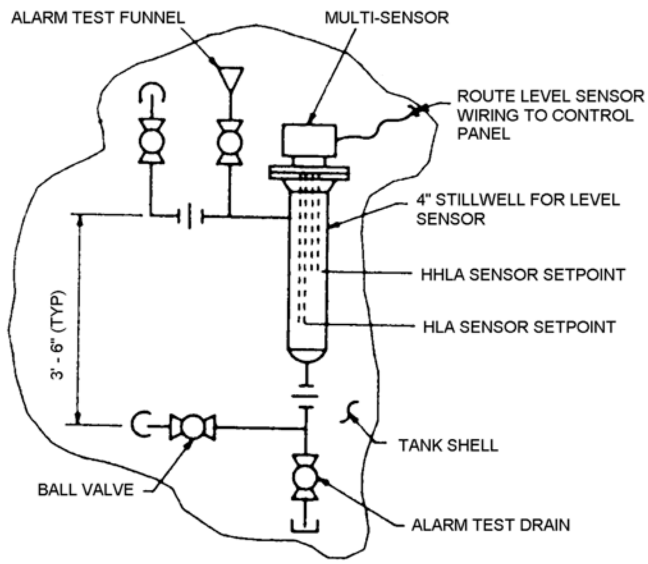


Figure 1–10. HLA and HHLA.

Low-level shutoff

The low-level shutoff (fig. 1–11) is a float-operated alarm mounted on the exterior of the tank. When the fuel in the tank reaches 27 inches from the bottom of the tank, the low-level shutoff circuitry will sound an audible alarm, illuminate a light in the control room, and open the electrical circuit to shutoff the refueling pump motors. If the fuel in the tank gets too low, the tank's outlet line to the pump will break suction and get air in the line. When this happens, the pump will be running "dry" and cause damage to the pump. Therefore, the low-level shutoff prevents damage to the pump.

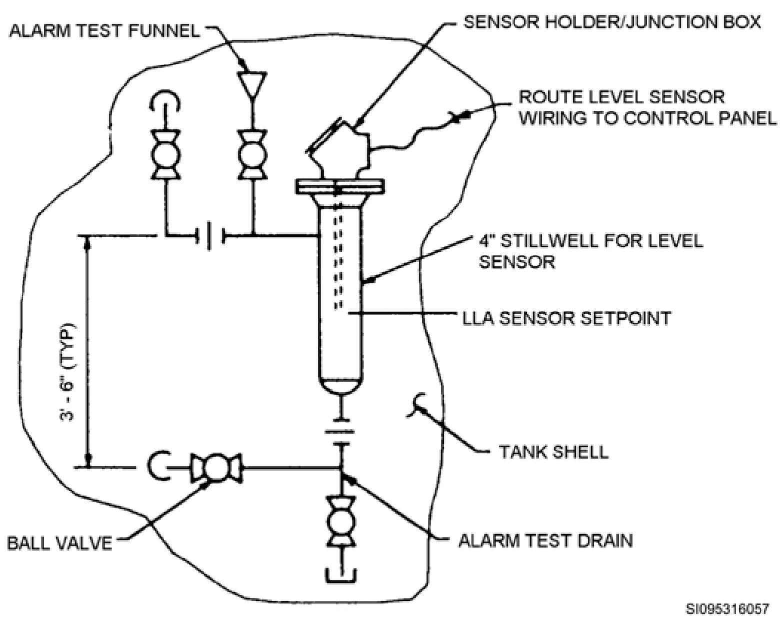


Figure 1–11. LLA.

Floating pan

The floating pan rests on the fuel (fig. 1–12) and eliminates the vapor space above the fuel. The pan has a pan seal to reduce fuel vapors and evaporation. One type uses pantograph hangers connected in a scissor pattern between the pan's outer edge and a non-metallic sealing material. The hangers keep the sealing material against the tank shell's internal wall. Another type has two flexible polyurethane foam seals in the space between the pan and the tank shell. The two seals are covered with a polyurethane-coated polyester fabric wrap. The two seals work together to expand and contract to keep a seal against the tank shell's internal wall as it changes shape due to changes in temperature and tank settling.

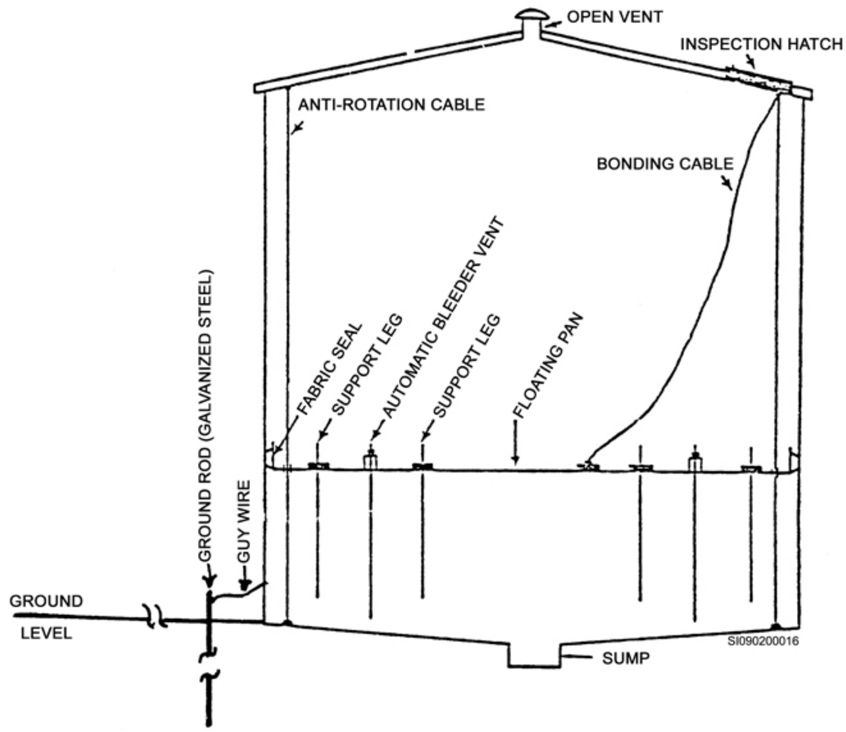


Figure 1–12. Cone-roof tank with floating pan.

The floating pan has support legs adjustable for two positions. The low position is used during day-to-day issuing and receiving of fuel and is set at 3 feet. The high position is used when entry into the tank is required and is set at 6 feet. The number and location of these legs are determined during the tank's design and construction.

Two anti-rotation cables are strung from the tank bottom to the fixed cone roof to keep the floating pan from turning, which could cause damage to internal components. The pan is bonded to the shell by means of a bonding cable from the floating pan to the roof inspection hatch or the tank floor.

Vents

This tank will have an open (roof) vent, overflow vents, slot vents, and pan automatic bleeder vents. The open vent will allow air in and out of the tank above the tank pan. Overflow vents allow fuel to flow down the outside of the tank when the tank is overfilled to prevent damage to the pan components and the cone roof. Slot vents allow air to circulate in the tank above the pan. The pan automatic bleeder vents allow air under and bleeds air from under the floating pan. The bleeder vent has a support leg that is slightly longer than the pan support legs, so that as the tank fuel level drops, the bleeder vent will open before the pan sits on its legs. When the vent opens, air is allowed under the pan to prevent a vacuum. When filling a tank while the pan is resting on its legs, the open bleeder vents will allow air to bleed from under the pan and close soon after the fuel starts to float the pan. Figure 1–12 shows the locations of the open vent and bleeder vents.

203. Floating-roof tank constructional features

For many years, the cone-roof tank was the only tank to store fuel. Then the floating-roof tank was designed and became the only tank authorized for storage of jet fuels because of the advantages it had over cone-roof tanks. Like the cone-roof tank with floating pan, the floating roof rests on the fuel surface reducing evaporation and minimizing the vapor space. Also like the floating pan, the floating roof provides a better path for dissipating static electrical charges because it is in constant contact with more of the fuel. This is a very important aspect of storing jet fuel. The regular flow of jet fuel in and out of these tanks has a greater tendency to generate static charges than do other liquid fuels. However, because the floating roof is also in contact with the fuel, and the floating roof is bonded to the tank shell, the rate of static charge dissipation is much faster than that of a cone-roof tank.

Components of the floating-roof

Many of the components of the floating-roof tank are very similar to, or the same as, the tank components already covered. The shell of the tank is similar to the cone roof, with the exceptions that it does not have a welded cone roof, but does have a wind girder installed near the top for extra support to prevent collapse of the shell.

The floating roof can be either a double-deck or a pontoon roof. Figure 1–13, A, illustrates the double-deck roof, and figure 1–13, B, illustrates the pontoon roof. Each roof is equipped with roof supports adjustable to 3 feet or 6 feet, vents, manholes, and roof water drain systems. An anti-rotation device (roof guide) is provided to prevent the roof from turning in a circular motion and damaging the roof drain piping. The problem of water accumulating on top of the roof is solved by sloping the roof to a center water sump. The sump is connected to the drain pipe, which extends through the fuel to an outside water draw-off valve (roof drain). The drain pipe has three joints that flex as the floating roof rises and falls. Fuel evaporation losses are kept to a minimum by the fabric seal located between the outer rim of the roof and the tank shell.

Today, most floating-roof tanks have been modified with a geodesic dome to cover the top to keep out rain, snow, and debris (fig. 1–13, C). With the new dome, this eliminated the need for the problem-ridden roof drain piping whose worn joints eventually leaked water into the tank.

Double-deck floating-roof tank

The double-deck floating tank (fig. 1–13, A) has two complete decks over the liquid surface. In double-deck construction, the top deck is sloped downward to drain water toward the center of the roof. The bottom deck is sloped upward toward the center so that any vapor forming under the roof will be deflected toward the center and trapped. These vapors then condense as the temperature decreases. Because of the insulating air space between the two decks, the double-deck roof is the most efficient type of floating roof. This air space greatly reduces vaporization of the fuel under the roof when the roof is subject to high ambient temperatures.

A heavy rainfall could exceed the volumetric capacity of the roof upper deck and overflow into the air space between decks; therefore, emergency open drains are provided in the roof as a protective measure.

Pontoon floating roof

The pontoon floating roof, shown in figure 1–13, B, has an annular pontoon (ring-shaped, double thickness) around the outer edge of the roof deck. However, the deck is only of single thickness at its center so it will remain afloat if damaged. The pontoon is sectioned into compartments with bulkheads. This construction allows the roof to remain afloat even if the center deck and any two of the pontoon compartments are punctured. Slack and flexibility are provided in the center deck to permit the roof to balloon upward and hold the vapors formed during the heat of the day. These provisions, however, do not always allow efficient drainage of water from the center deck. Consequently, the rolling ladder is positioned so that its weight will depress the roof deck slightly at its center to assure efficient water drainage.

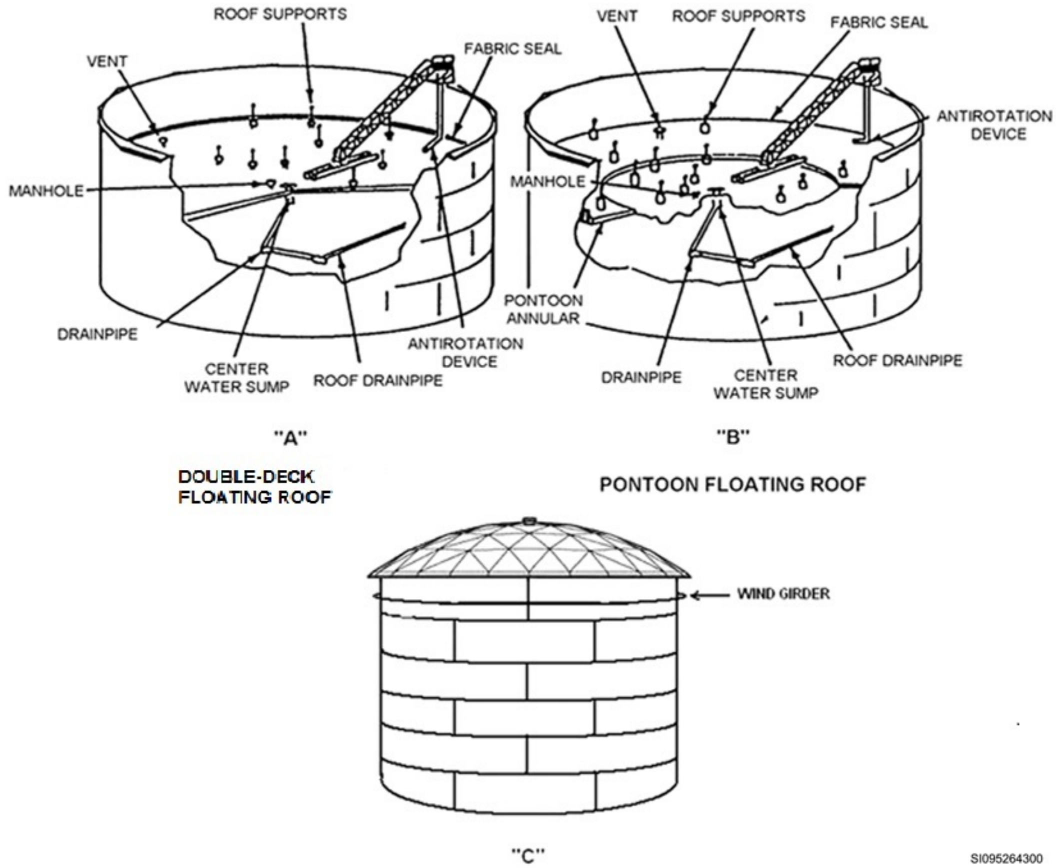


Figure 1–13. Floating-roof tanks, geodesic dome.

204. Underground and cut-and-cover tank constructional features

Horizontal USTs used to issue jet fuel are usually 25K or 50K gal. and are located under the Type I and II hydrant system pump houses near the flight line.

Horizontal USTs used for ground products such as diesel and MOGAS usually will not exceed 25K gal. and are installed at the government-owned vehicle (GOV) gas stations and bulk storage areas. When located at bulk storage areas, the ground product tanks can be installed above ground. The components of the automotive service station tanks will be discussed in unit 5 of this volume. Cut-and-cover tanks are also known as half-buried or mounded-over tanks, and were first built at overseas locations to hide their presence. These tanks were built to hold large fuel quantities, and its pump house is located on top of the tank.

Jet fuel UST components

Jet fuel USTs are provided with deep-well turbine pumps, combination liquidometer and low-level controls, clean-out lines, ladders, and high-level shutoff valves. The high-level shutoff valves are an automatic, diaphragm type that prevents overfilling the tank. See figure 1–14 for the layout of a horizontal UST.

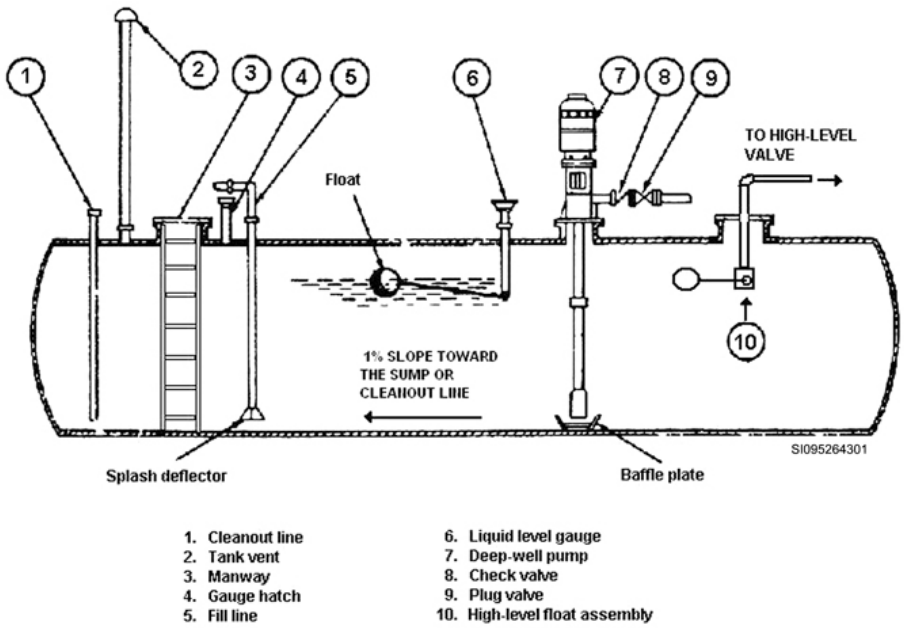


Figure 1–14. Horizontal UST.

Deep-well turbine pumps

Deep-well turbine pumps are vertically mounted, multistage centrifugal pumps. These pumps contain a pump column consisting of a series of stages, with an impeller in each stage. The number of stages varies with fuel system requirements. The *first* stage of the deep-well pump column is about 6 inches from the floor of the tank. It should always be submerged in fuel. In *most* tanks, a baffle plate is welded to the tank floor immediately below the *first* stage of the pump to prevent sludge from entering the pump column. A wire-mesh screen placed across the inlet to the *first* stage prevents solid particles of sludge from entering the pump and thus damaging the moving parts inside the pump column.

Deep-well turbine pumps are driven by explosion-proof electric motors. Normally, each motor has a built-in ratchet assembly to keep the motor and pump from running in the reverse direction. On top of the motor shaft is a hexagon nut used to adjust the pump shaft. A low-level control switch is connected electrically to the control circuit of the pump motor. When the fuel reaches a predetermined low level, the low-level control switch opens the electrical control circuit and stops the motor.

A mechanical seal assembly around the pump shaft stops fuel leakage from the pump head. During operation, the seal and the moving parts in the pump column are lubricated and cooled by the fuel being pumped. Most deep-well turbine pumps have a small bypass fuel line to bypass nearly 2 percent of the fuel when the pump is running against a “deadhead” (a closed discharge line). The bypassed fuel serves to cool and protect the mechanical seal assembly from overheating when fuel is being trapped in the discharge port of the pump head.

The operation of deep-well turbine pumps is similar to that of horizontal centrifugal pumps. Instead of having a single stage, however, the deep-well turbine pump has a series of pumping stages mounted on a vertical shaft. As the pump rotates, the *first* stage impeller draws fuel into the pump bowl and pushes the fuel up to the second stage. The fuel continues through the remaining stages into the discharge piping. As fuel goes from one stage to the next, the pressure is increased.

To maintain the high-efficiency capability of a deep-well turbine pump, the fuel passing through the various pumping stages must be distributed evenly. The slightest vibration along the pump column causes a strain on the pump shaft and increased wear on the seal and shaft bearings. To ensure even distribution of fuel through the pump column, the internal pump bowls are of the diffuser type. When fuel is thrown outward from the impeller into the pump bowl, the fuel is forced through a series of fixed guide vanes mounted in each stage. The diffuser action forces fuel through guide vanes before it enters the next stage. The design of the diffuser guides the fuel through the guide vanes and makes sure of uniform fuel flow from one stage to the next. As a result, the fuel is distributed evenly through the vanes. This maintains a balanced load on the impellers.

Liquidometer

The liquidometer (liquid-level indicator) used in an underground IOST is a float-operated, direct-reading gauge. In our discussion of the indicators, we will refer to the liquid-level indicators as *liquidometers*, since this is the terminology most commonly used among fuel systems maintenance personnel. The liquidometer indicates the amount of liquid in the tank in either gal. or one-quarter-tank increments, ranging from EMPTY to FULL.

The typical liquidometer used on underground tanks is operated by a float that rests on the surface of the fuel (fig. 1–15). The float may be of cylindrical design, as shown, or it can be ball-shaped. As the fuel rises in the tank, the float and float arm also rise. They transmit this upward movement to a push rod connection. At this connection, a float arm lever pivots on a pin attached to a stationary brace. A push rod is attached to the float arm lever by another pin. This push rod, enclosed in the liquidometer vertical support column, transmits the movement of the float arm lever to the gauge head. Through another mechanical linkage, the movement is transmitted to a shaft connected to the liquidometer dial.

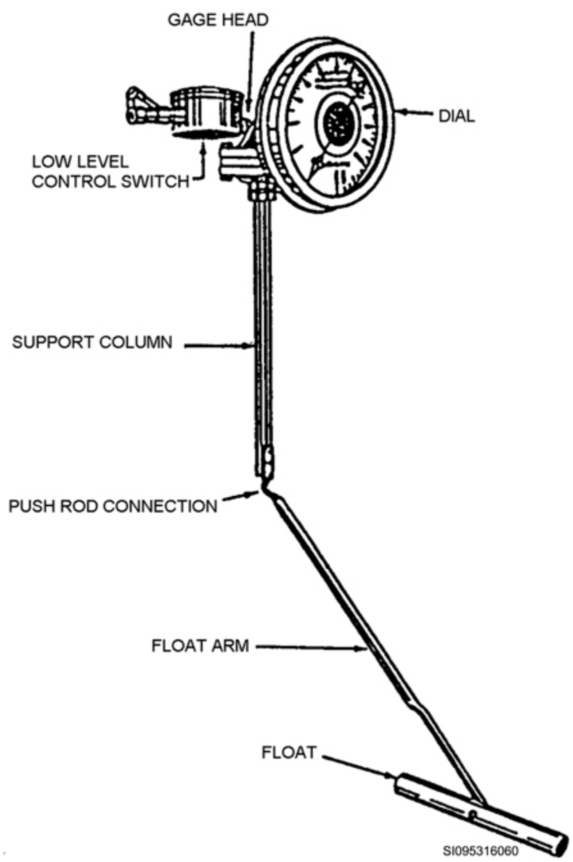


Figure 1–15. Liquidometer.

In another type of liquidometer, a narrow steel cable transmits movement of the float to the gauge head. One end of the cable is attached to the float arm lever, and the other end is wound around a cylindrical block in the gauge head. A second cable extends down from the cylindrical block, and this cable is kept taut by a steel weight. The weight on the second cable also keeps the primary cable from getting slack. Thus, positive direct movement is ensured between the float arm lever and gauge head. Any rotating movement of the cylindrical block is transmitted to the dial shaft. On some types of liquidometers, you may find the gear assembly at the float arm lever. This assembly, rather than two pivot pins, transmits the movement to the push rod. Many variations exist in the mechanical linkage used in liquidometers. They all have the same purpose of transmitting positive and direct movement from one part to another.

Low-level controls

The low-level control protects the pump when the tank is nearly empty (13 inches from the bottom of the tank) by shutting off the fueling pump motor before the pump runs dry of fuel. A low-level control switch (fig. 1–16) is mounted alongside and connected to the gauge head of the liquidometer. A shaft extends from the gauge head to the control assembly. The two types of low-level control switches used are the (1) mercury tube switch and (2) cam-actuated microswitch.

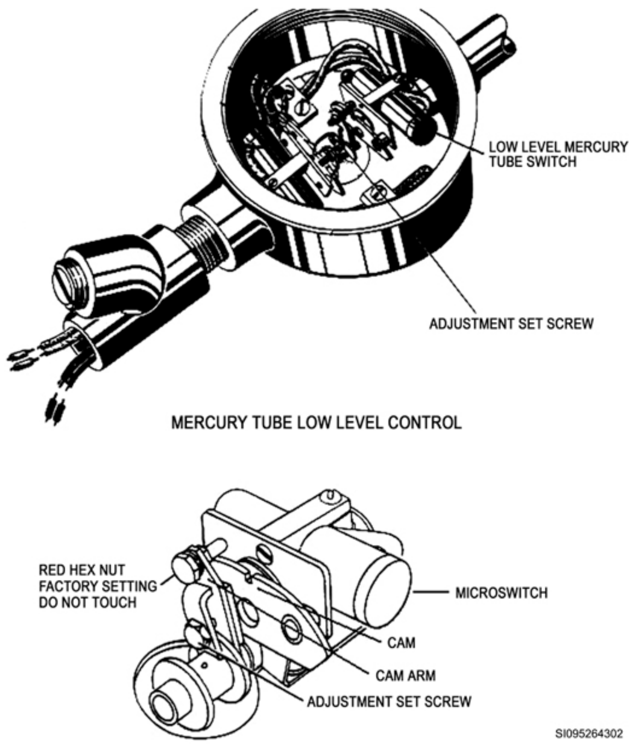


Figure 1–16. Low-level mercury switch and cam-actuated microswitch.

Mercury tube switch

The mercury tube switch (fig. 1–16, top) is attached to a shaft controlled by the linkage in the gauge head. As the shaft is rotated, the mercury tube also rotates. There are two filaments in the tube that are submerged in mercury to complete (close) the electrical control circuit. The mercury tube is positioned (pre-adjusted) on the shaft at an angle that makes it correspond to the reading on the liquidometer dial. When fuel is being withdrawn from the tank, the mercury tube rotates with the shaft. When the fuel level in the tank lowers to about 13 inches from the bottom of the tank, the mercury tube is at an angle that causes the mercury to flow away from the two filaments inside the tube. When the ends of the filaments are no longer submerged in mercury, the electrical control circuit is opened. This stops the deep-well pump motor. The pump motor will not start again until enough fuel is put back into the tank to change the position of the mercury tube. When the fuel level does rise, the tube rotates in the opposite direction. This action allows the mercury to flow back and submerge the tips of the two filaments. As long as mercury is touching both ends of the filaments, the electrical control circuit is completed.

Cam-actuated microswitch

In the cam-actuated microswitch low-level control (fig. 1–16, bottom), you will find a cam positioned (pre-adjusted) on a portion cut out around its outer edge. This serves as the low side of the cam. The microswitch (normally CLOSED) is wired into the pump motor control circuit and is positioned next to the cam. A control lever (roller) rides against the outer edge of the cam on the low side and allows the set of contacts in the microswitch to remain closed. As long as the contacts are closed, the pump motor operates. When the liquid level in the tank lowers to 13 inches, the cam rotates, and the control lever rests against the high side of the cam. This movement of the control lever towards the microswitch opens the electrical contacts. Now the pump motor stops. It will *not* start again until the cam rotates back a few degrees in the opposite direction. This rotation repositions the control lever on the low side of the cam, and the electrical contacts in the microswitch close again.

Cleanout line and ladders

A horizontal UST will have a ¾-inch cleanout line installed at the lowest end of the tank usually next to one of the manways. This pipe will extend from the sump to approximately 12 inches above ground level. A hand-operated, portable vacuum pump, with an integral glass or a plastic container, is provided for removing water and sediment from these tanks.

While this type of fuel tank has multiple manways, there usually is only one vertical ladder bolted or welded at the top of the manway just below the cover and at the tank bottom.

High-level shutoff valves

Each operating fuel storage tank will have a high-level shutoff valve. The valve is completely automatic and operates on hydraulic principles. The most widely used valves of this type are the 124AF and 129AF (Clayton-Valve [Cla-Val]). Both of these valves use the same main valve body. One difference between them lies in the type of float assembly used. The 124AF high-level shutoff valve has a pan-type float assembly, whereas the 129AF high-level shutoff valve uses a ball-type float assembly.

The 124AF valve assembly

The 124AF valve assembly is illustrated in figure 1–17. The main valve is installed in the inlet line to the tank. This valve is controlled automatically by the pilot valve and float assembly, which are installed below the tank flange. The main valve body is installed so that the incoming fuel in the tank inlet line is directed under the valve diaphragm to open the valve. During operation of the 124AF valve, the main valve is either open or closed. It does *not* modulate between closed and open to regulate the flow of fuel to the tank.

The float assembly consists of the float, a float rod with bottom and top stops, a counterweight, and a pilot valve (rotary disc). In figure 1–17, the following condition exists: When the tank is full of fuel (about 11 inches from the top), the float is pressed against the top stop, the float rod has moved upward, the counterweight has moved down, and the control valve has positioned to connect the supply tubing to the control tubing. With these two lines thus connected, fuel pressure is directed to the top of the main valve diaphragm. This pressure (plus spring tension) holds the main valve closed.

As the fuel is used from the tank, the float moves downward. Eventually the float will contact the bottom stop. The combined weight of the float and rod is great enough to overcome the counterweight. The float and rod drop down and the counterweight goes back to the upper position. This movement changes the ports in the pilot valve, so that the supply tubing is closed and the control tubing is vented to the tank. This condition allows fuel pressure in the fuel inlet line to open the main valve, which allows fuel to flow into the tank.

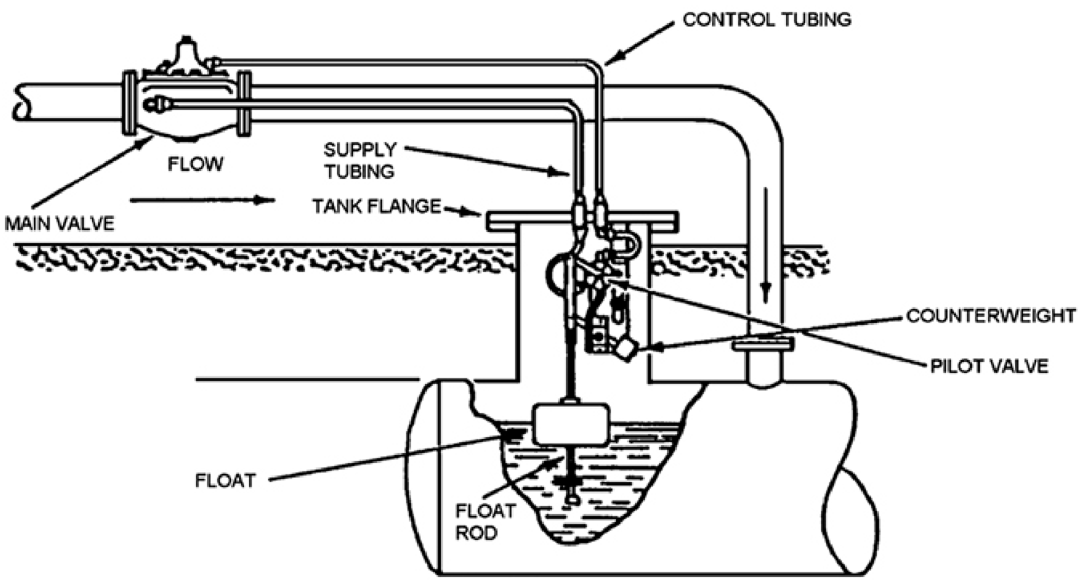


Figure 1–17. 124AF, high-level shutoff valve.

The 129AF valve assembly

The 129AF high-level shutoff valve (fig. 1–18) operates similarly to the 124AF. You can tell one valve from the other easily because the 124AF has two small lines going from the main valve to the tank flange, and the 129AF has only one. The main valve body of the 129AF is the same as that of the 124AF, and it is installed in the same manner. The incoming fuel flows under the diaphragm. The 129AF uses an *ejector* to assist in venting the cover chamber when the valve opens. Fuel under pressure passes through the ejector and is routed through the control tubing into the float assembly (pilot valve), from which it drains into the tank.

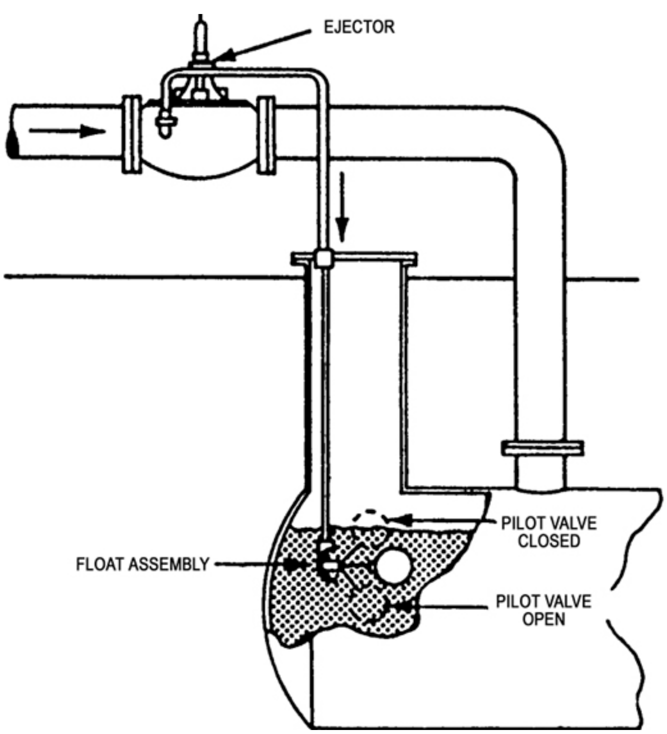


Figure 1–18. 129AF, high-level shutoff valve.

The float assembly used with the 129AF consists of a pilot valve (rotary disc) and a ball float. With the pilot valve open, the main valve opens fully to allow fuel to enter the storage tank. The fuel passes through the control tubing and drains from the pilot valve into the tank. As the tank fuel level rises, the fuel lifts the ball float to the center of its range. There the ports of the rotary disc are closed partially, thus restricting the flow of fuel through the control tubing. Now, fuel backs up in the tubing and applies some pressure in the cover chamber of the main valve. This causes the main valve to modulate (close partially) and decrease the flow of fuel into the tank. The ball float continues to rise until the fuel level rises to approximately 11 inches from the top of the tank, and the pilot valve is closed. This prevents any further flow of fuel drainage from the control tubing and the cover chamber to the top of the main valve, and spring force closes the main valve.

Cleanout line

In newly constructed underground horizontal aviation fuel operating tanks, a ¾-inch water draw-off pipe is installed, extending from the sump to approximately 12 inches above ground level. A hand-operated, portable vacuum pump, with an integral glass or a plastic container, is provided for removing water and sediment from these tanks. The product-recovery system for underground tanks is mounted on top of the tank. It is similar to the system for aboveground tanks, except that the pump is used to extract the fuel/water from the tank.

Cut-and-cover tank components

This type of tank will have components most similar to underground horizontal tanks even though its tank structure is much like a cone-roof tank with a center sump. This tank is half-buried with earth mounded up the sides and top as well as at the pump house on top.

Inside the tank, with the added weight on top, the interior has several roof support columns to prevent its collapse. There is usually only one vertical ladder to enter the tank. It is attached and supported at the top and bottom and at multiple locations in between. The ladder may also have a fall arrest channel to attach the personnel harness/lanyard assembly worn by entrants.

Components outside the pump house will include multiple pressure/vacuum vents and multiple roof manways to aid in vapor-freeing the tank and to allow light in during tank cleaning and inspection. The gauge well is also normally located outside the pump house.

Components inside the pump house will include at least two deep-well pumps, high-level valves, liquid-level gauges/low-level shutoffs, and a clean-out line to the sump with its own motor and pump going to a 55 or 100 gal. product-recovery tank.

205. General fuel storage tank inspections and maintenance

All AF equipment needs to be inspected. Any good maintainer will notice problems right away and will be able to head off the potential problem. Let’s look at the inspection and maintenance for the storage tanks.

Tank inspection

To maintain operational and contamination-free storage tanks, it is necessary to inspect and maintain them. There are many reasons for contamination. For one, water causes a growth in fuel called sulfides. Also, if fuel is not filtered properly before its being received, small solid particles will settle out of the fuel. In addition, pipelines contain mill scale and sometimes rust, all of which will settle out. Because of all these and other possibilities of contamination, it is necessary to periodically enter the tank physically to inspect them.

Storage tank inspection schedules

Aviation fuel bulk storage and operating tanks are inspected internally (by physical entry) for accumulation of contaminants and tank interior condition on the following schedule:

1. Tanks without an inlet F/S, micronic filter, or internal coating—4 years.

2. Tanks with an F/S or micronic filter on the inlet *or* internal coating—6 years.
3. Tanks with an F/S or micronic filter on the inlet *and* internal coating—8 years.
4. API 653 “out-of-service” inspection on aboveground tanks—10 years.

After its first inspection at 8 years, future inspections of an AST with an inlet F/S or micronic filter *and* internal coating may be delayed to coincide with its API 653 out-of-service inspection.

Tanks used for storage of ground products such as MOGAS and diesel fuel should be inspected and/or cleaned, if deemed necessary by the fuels management office (FMO). This requirement is determined by fuel sampling or testing methods and solid limits as prescribed in TO 42B–1–1, *Quality Control of Fuels and Lubricants.* Determination will be based on solid content in an “all level” sample. Tank sampling must be done at least once a year.

The exterior of aboveground tanks requires monthly inspection for leaks, signs of corrosion, and condition of markings and grounds.

AST settling and out-of-round inspection

All storage tanks are subject to some settling during their first few years of service. Because of the design of floating-roof tanks, it is important that this type of tank be nearly level at all times. An uneven settlement of 3 to 5 inches is usually enough to cause the tank shell to go out-of-round and is considered dangerous. When this happens, the roof may hang up and then suddenly drop as the fuel level lowers. There is a danger of fire because of the increased vapor space and the possibility of sparks from metal sliding on metal. Should a roof “hang up” when you are emptying a tank, immediately start pumping fuel back into the tank. If the roof drops a considerable distance, the force of impact may be enough to rupture any weak tank seams. The roof can also hang up as the tank is being filled and flood the top of the roof. Fuel has to be taken out to a level equal to the bottom of the roof. When a roof hangs up because the tank shell is out-of-round, all you can do is report it.

When a floating-roof tank goes out-of-round because of uneven settling, the tank shell at the top becomes elliptical (oval) in shape. A wind girder on all floating-roof tanks on the outside top edge of the tank shell helps to prevent an out-of-round condition. Once a tank has settled unevenly to about 3 inches, the tank shell loses much of its support from the wind girder and is likely to go out-of-round. An out-of-round condition presents a serious fire and safety hazard to personnel on the floating roof because vapors are released. For best results, make your inspection with the tank between three-fourths full and full. At opposite points on the roof of a tank that has gone out-of-round, the space between the roof edge and tank shell will be narrow. At two other opposite points, the space will be wide. At the wide points, the sealing ring may not even contact the tank shell, and this will permit excessive vapor loss.

With fixed-roof tanks, you do not have the same problems. They can absorb considerable uneven settlement without serious damage to the tank structure. Whenever you find that a storage tank, fixed roof, or floating roof has settled unevenly, report it, even if it is only an inch or two. Tanks have been known to settle several inches a week because of earth tremors. Therefore, aboveground tanks, especially those with floating roofs or pans, must be checked on schedule.

Checking for uneven settling

Checking a fuel storage tank for uneven settling is not as complicated a task as you might think. We will first discuss settling and then discuss how to check a floating-roof tank for being out-of-round. Settling is difficult to detect by merely looking at the tank at a distance. Therefore, accurate measurement is suggested. You will want to keep these measurements for future reference and to track movement of the tank over time. A mechanical engineer, along with an engineering assistant, can help you tailor the following method to your specific tank.

WARNING: Be sure to use fall protection when working on the top of the tank. Consult base safety for recommended equipment and attachment points.

The basic method is to attach a plumb bob to a cord long enough to reach from the top of the tank to ground level. Extend the cord out from the roof of the tank and lower the plumb bob. Holding the cord steady at a set distance from the edge of the roof (about 8 inches is sufficient), measure the exact distance between the cord and the top edge of the tank shell. Let a second person at ground level measure the distance between the cord and tank shell at the base. Do *not* let the plumb bob lie on the ground or sway, as this will affect the reading. The difference between the two measurements is the amount the tank has settled unevenly.

This measurement should be taken at four points around the roof. If the tank has settled 5 inches, for example, the reading at the roof would be 8 inches, and at ground level, it would be 13 inches or 3 inches, depending on the side of the tank where you made the measurement. The side that had the highest reading at ground level is the direction in which the tank is actually settling.

Checking for tank out-of-round

To determine how much the tank shell has gone out-of-round, measure the diameter of the shell at the points where there is a narrow gap between the shell and roof on each side of tank. Now measure the diameter of the tank shell across the roof from the points where there is a wide gap between roof and shell. The difference between the two readings tells you how much the tank has gone out-of-round. With the tank full (or almost full) of fuel, check the distance between the tank shell and the edge of the roof. The narrower the gap is between the roof and shell, the more chance there is of the roof hanging up. All fuel operations with the tank should stop before the tank decreases 10 inches in diameter from any two opposing points or when one side of the tank has settled 5 inches lower than the opposite side. Normally, if maintenance personnel are observant, they will notice these troubles before a larger problem develops.

Maintenance

Maintenance of outer surfaces of storage tanks, piping, and components includes periodic inspections for corrosion and repainting as required. You may be required to do some touch-up painting from time to time. Periodic technical inspections should be conducted by a certified authority according to API 653.

Corrosion control

In corrosion control, it is important to remove as much rust as possible with a wire brush. Clean the area to bare metal and apply a primer coat to the bare surface before applying additional paint. Inspect all areas carefully because paint could be hiding metal that is badly corroded. The danger may exist but not be readily noticeable. Remember, corrosion is a serious problem in all parts of the fuel system and must be treated before serious damage results.

Leak-detection systems

Leak-detection systems are used to determine if and in some cases where a leak as occurred. Let’s take a look at interstitial spaces of tanks and tell-tale pipes.

Interstitial spaces of tanks

All new USTs and ASTs without dikes will be double-walled and have an interstitial space between the inner and outer walls of the tank. Interstitial monitoring is simply checking the space between the tanks for evidence of a leak. Some tanks have automatic leak-detection systems with sensors in the interstitial space. Automatic leak-detection systems must be checked monthly to ensure proper operation.

If there are no leak-detection sensors, the interstitial space must be checked monthly for fuel (indicating a leak in the inner wall of the tank) or water (indicating a leak in the outer wall of the tank). The interstitial space will have a well at one end of the tank that can be manually gauged. If a small amount of water is discovered, it may be due to condensation instead of a hole in the outer tank wall. Remove the water, dry the interstitial space, and re-gauge the interstitial well the next day.

If the underground tank is an older single-wall tank, it will have to periodically undergo tightness testing by a contractor. Your civil engineer environmental (CEV) flight should have the tank on a testing schedule. In between tests, the tank's fuel level should be checked regularly (locally developed schedule) for evidence of fuel loss or an excess amount of water gain. Also, dead grass or a strong fuel odor around the tank could indicate a fuel leak.

Tell-tale pipes

Vertical aboveground tank floors usually have ¼-inch welded metal plates on top of sand or other granulated medium on top of a fuel-resistant liner. Older tanks may not have a liner, so check the tank's "as-built" drawings. In the sand between the metal and the liner, there may be interstitial pipes with holes drilled along its length to allow liquids to enter. The pipes are also known as "tell-tale" pipes because they will let you know (or "tell" you) if fuel is leaking through the tank floor or water is coming up to the surface. These pipes are laid like the spokes of a wagon wheel starting at the sump and ending just outside the tank's outer edge. The number of pipes will vary with the size of the tank, but usually a minimum of four pipes is needed to cover enough tank bottom area. The interstitial pipe ends are usually capped, have ball valves, and are located in a valve box outside the tank's concrete ring wall. The ring wall supports the weight of the tank shell along the tank's circumference.

Open these pipes and check monthly for evidence of fuel, fuel vapors, or water. Fuel or fuel vapors would indicate a tank bottom leak. If no fuel is coming out of the pipe, use a vapor indicator to test for fuel vapors. If evidence of fuel or vapors is present, report it immediately. If water comes out of the tell-tales, you may have a breach in the liner that is allowing water to enter during periods of high ground water or retained dike water breaching the seal where the ring wall and the bottom of the tank shell meet. Water under the tank floor can cause corrosion and make holes in the metal that could lead to a loss of fuel. In any case, if water or fuel is found, notify your supervisor, increase the frequency of tell-tale checks, and schedule an out-of-service floor inspection to include floor thickness testing. This can be performed as part of an upcoming API 653 inspection.

If a fuel tank has an ATG system, it is permissible to use a tank monitoring function of the ATG as a leak detector *if* the ATG system is capable of detecting a 0.2 gal. per hour loss of fuel. The ATG should be configured to perform this test monthly during periods of tank inactivity.

Identification markings

Exact identification of petroleum products in each storage tank and piping system is mandatory. Military Standard (MIL-STD) 161G, *Identification Methods for Bulk Petroleum Products Systems Including Hydrocarbon Missile,* provides us the proper methods to accomplish this. The title of the product must be displayed clearly across the yellow group bands with white letters on a black background. The markings are painted on the side of the tank in a location where they can be seen easily. Tank markings are not subject to defacing, as are those on pipelines. However, all markings must be kept painted so that you will have no trouble determining which product they indicate.

You should already know the identification markings, but we will refresh your memory. The number of yellow bands represents the type of petroleum product. The title represents the type of petroleum product. One band is used for AVGAS, two bands for MOGAS, three bands for jet fuel, and four bands for diesel fuel. The title painted across the band(s) should look like this: "AVGAS 100/130" or "JET FUEL JP–8" (fig. 1–19).

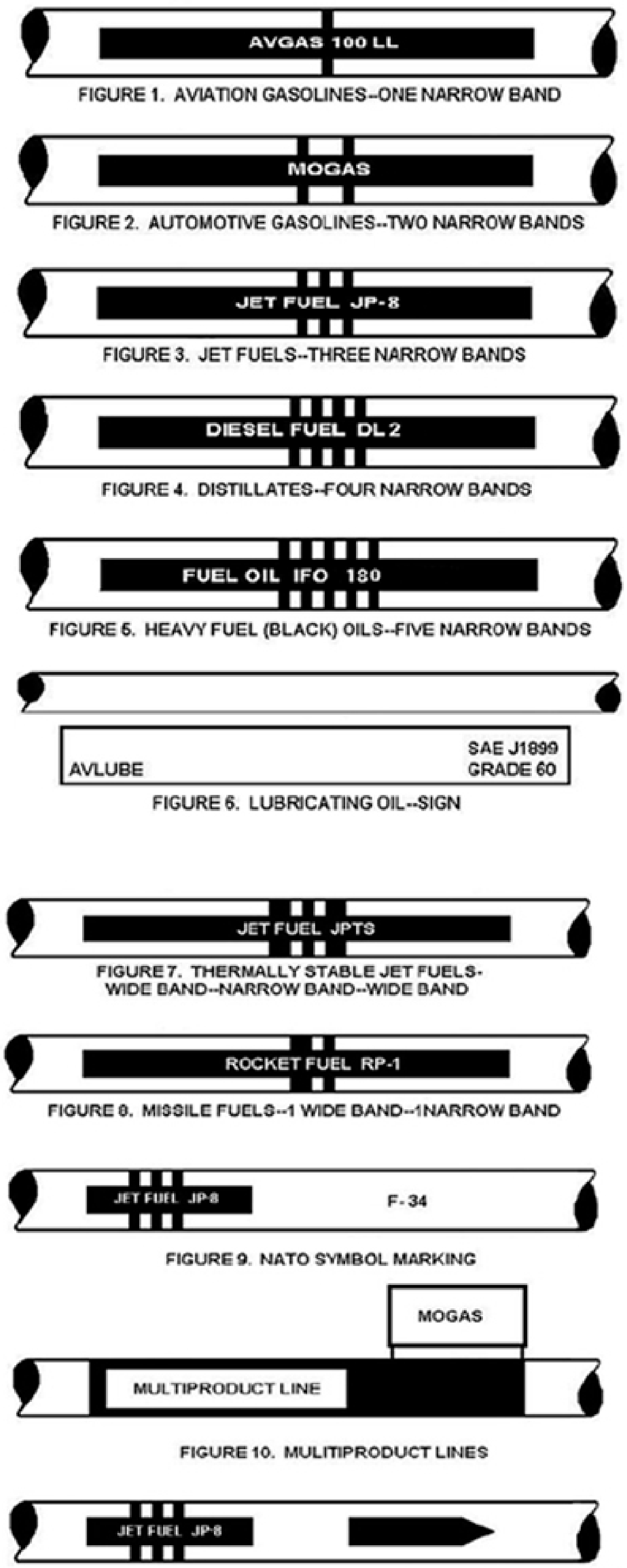


Figure 1–19. MIL-STD 161G, Petroleum product identification markings.

Diesel fuel tanks include the grade along with the title. The use of stencils is recommended for painting the title. The black background has a minimum border ¾-inch wider than the lettered area. The first table shows the storage tank band and letter size required by MIL-STD 161G. The next table shows the fuel piping identification marking requirements, also required by MIL-STD 161G.

Storage Tank Identification Markings				
Tank size	**Width of bands**	**Space between bands**	**Length of bands**	**Title letter size**
10,000 bbl. and under	3"	3"	33"	6"
Over 10,000 bbl.	4"	4"	54"	12"

Fuel Piping Identification Marking				
Piping size	**Width of bands**	**Space between bands**	**Length of bands**	**Title letter size**
Under 3"	3"	3"	encircle	½"
3" to 6"	3"	3"	encircle	1"
6" to 9"	3"	3"	encircle	2"
Over 9"	4"	4"	encircle	3"

In addition to the second table above, piping systems that handle products for which a North Atlantic Treaty Organization (NATO) symbol has been established and are located in an area subject to servicing ground, sea, or air equipment of NATO countries will include the appropriate NATO markings. Some of the NATO markings are F–46 for MOGAS, F–54 for diesel, F–40 for JP–4, E–85 for Ethanol, and F–34 for JP–8. All of the cross references for NATO markings are found in Standard Agreement (STANAG) 1135, *Interchangeability of Fuels, Lubricants, and Associated Products Used by the Armed Forces of the North Atlantic Treaty Nations*. The NATO marking is yellow in color and is enclosed by a yellow broken rectangular line.

Dikes

Dikes are used to contain fuel spills in case of tank or piping rupture. The dike is built to provide the volumetric capacity and height to hold 110 percent of tank(s) maximum fuel capacity plus a 12-inch free-board according to the National Fire Prevention Association (NFPA) code 30. The additional 12 inches of dike height allows foam and water to be used to extinguish a tank fire without overfilling the dike. A dike will surround an AST or multiple ASTs within the same containment area having the capacity of 661 gal. or more. Several small tanks may be enclosed in one dike up to a total combined capacity of 15,000 bbl. Tanks with a capacity of 10,000 bbl. or more are enclosed by an individual dike. The dike’s interior will be graded to flow liquids toward a drain or drainage area. A swing line (a pipe lowered into the drainage area) or open drain will be used according to geographical requirements.

An open drain uses a lock-type gate valve on the exterior of the dike. This valve must be in the CLOSED and LOCKED position and opened only as required. The valve is constantly manned during drainage operation to prevent possible discharge of fuel pollutants into sanitary systems or bodies of water. The drainpipe must be large enough to drain rainfall within the tank enclosure and not less than 6 inches in size to prevent normal stoppage. Provision is made for drawing water from diked areas to prevent fuel products from entering natural water courses, storm drains, or sanitary sewers. Water should never be allowed to stand in the dike area or in the drainpipe from the dike enclosure.

Earthen dikes

Today, earthen dikes are not common for fixed facilities. If they exist at your base, they need to be maintained until a concrete dike project is completed. Check earthen dikes for signs of vegetation and erosion on an annual basis. Vegetation can quickly compromise the integrity of the soil on earthen dikes and should be sprayed by the BCE entomology section. If you suspect erosion has reduced the height of the earthen dike, you should have BCE survey the dike and recalculate the volumetric capacity.

Concrete or cement brick dikes

Concrete or brick dikes should be checked for signs of deterioration or settling on an annual basis. Also, check expansion joints for deterioration of the backer rod and fuel-resistant joint sealant. Concrete or brick dikes should have a flexible, ultraviolet (UV)-resistant, fuel-resistant coating applied to the interior walls.

206. Cone-roof tank inspections and maintenance

Components of the cone-roof tank to be inspected are the fuse-link valve, the pressure-relief valve, the pressure/vacuum vent, and the liquid-level gauge. Let’s start this lesson by covering the fuse-link valve.

Fuse-link valve

This type of valve can be installed in the inlet and outlet piping on ASTs. Figure 1–20 shows one type of fuse-link valve that is used. The purpose of a fuse-link valve is in the event of a tank fire, this spring-loaded valve will close, isolating the fuel in the pipeline. The valve handle is held in the OPEN position by a fuse link (made of lead) and a chain tightly secured to prevent the valve from closing. Should a fire occur, the heat from the fire would melt the fuse link and release the valve handle. A disc inside the valve body is spring loaded to close and stop the flow of fuel into the tank. Periodic inspections of the valve, which are usually monthly visual inspections, include checking for fuel leakage and corrosion around the connections for the fuse link. Disconnect the link and chain to allow the valve to close. Then open and close the valve a few times to see whether it operates smoothly. Anytime the fuse link has been damaged, it must be replaced. Normally, the fuse link melts at 160° F.

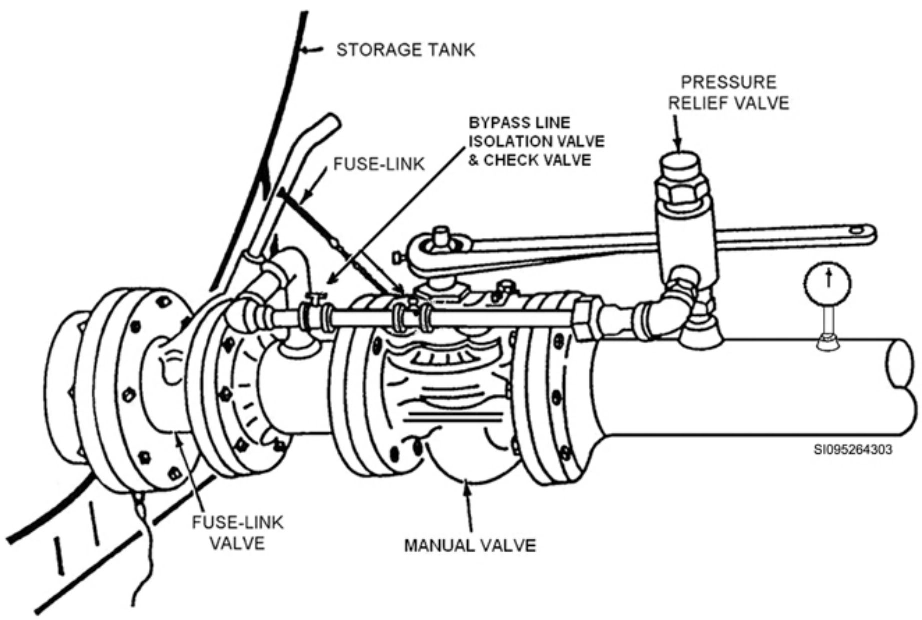


Figure 1–20. Fuse-link and pressure-relief valves.

Pressure-relief valve

Both the inlet and outlet manual valves have pressure-relief valves and bypass lines installed, as shown in figure 1–20. The pressure-relief valve is adjusted to open when pressure in the pipeline, caused by thermal expansion, increases to 10 percent above system deadhead pressure. Pressure is relieved and discharged into the storage tank. The pressure settings for two pressure-relief valves, one on the inlet and one on the outlet piping, are not the same. The inlet piping pressure-relief valve is set higher than the outlet is set. To adjust the pressure-relief valves, you must first determine what the system deadhead pressure is for that line. You find this by closing the manual valve associated with the pressure relief that is running the pump(s), and checking the pressure gauges. Turn the adjusting screw on the pressure-relief valve clockwise to increase the pressure setting and counterclockwise to decrease it. After making the adjustment and replacing the cap, be sure to safety-wire and seal the cap.

Notice that there is a check valve in the pressure-relief bypass line. Should you have to remove the pressure-relief valve to repair or replace it, the check valve stops any reverse flow of fuel from the storage tank. When removing the pressure-relief valve, you must close the tank block valve and isolate the pipeline between the pressure-relief valve and the pump house. When installing a new relief valve, make sure that the pressure range of the valve (stamped on the data plate) covers the operating range of the pipeline.

For maintenance purposes, manual valves should be installed in the pressure-relief bypass line, but the manual valves must be wired open or their handles removed. This is done to prevent a manual valve from being left closed and causing damage to the system piping. Some of the older storage tanks used grooved (victaulic) couplings on the inlet and outlet piping in the diked area. Should pressure increase in the piping beyond a safe limit, this type of coupling can separate, causing a fuel spill. A pressure-relief valve not adjusted (bottomed out) properly would cause the same reaction as a closed manual valve in the bypass line. Pressure-relief valves must be checked annually for proper operation.

Pressure/vacuum vents

Pressure/vacuum vents can be found on cone-roof tanks, cut-and-cover tanks, and horizontal USTs or ASTs where the tank is essentially sealed and has no other vent types (refer back to fig. 1–2). It operates to allow just enough air into or out of the tank to reduce product evaporation and emissions and prevent dangerous internal tank vacuums. Pressure/vacuum vents are attached to the tank vent lines either by a flange or threaded connections. The two moving parts in the vent are the (1) pressure pallet and (2) vacuum pallet that normally rest on their seats. Each pallet is weighted so that a fixed amount of pressure or vacuum is needed to unseat the pallet. The pallets are protected by a wire screen to prevent birds from jamming nesting materials into the pallet chambers.

When a tank is filled, pressure builds up in the tank. When enough pressure builds up, the pressure pallet is forced up off its seat and “burps” the pressure before re-seating itself. When fuel leaves a tank, a vacuum is created within. When enough vacuum is created, the vacuum pallet is lifted up off its seat to allow just enough air in to equalize the vacuum before it re-seats itself.

The amount of pressure or vacuum it takes to lift the pallets is determined by the weight of each pallet The pallets use either brass discs or small pellets (similar to steel ball bearings enclosed in a small cover) attached to the top of the pallets to give it weight. The settings (pressure and vacuum) are stamped on the data plate attached to the side of the vent. The weights of the pallets are fixed at the factory and are *not* adjustable. Normally, pressure/vacuum vents are set to open at one-half ounce of pressure per square inch.

Pressure/vacuum vents must be maintained in perfect working order to keep them from sticking and preventing the tank from collapsing or bursting. During freezing weather, you must check the vents daily to make sure that the pallets do not freeze to their seats. Moisture collected around the pallets can freeze, keeping them from opening and the tank from breathing properly. You must remove both pallets semiannually for inspection and clean them thoroughly. Clean the seating surfaces with the manufacturer's recommended cleaning solvent and inspect them for damage and excessive wear. Also, clean the wire screens at the pressure and vacuum ports.

Eventually, excessive corrosion appears on pressure/vacuum vents with metal-to-metal seating surfaces. If replacement parts are not available, it may be necessary to lap the seating surfaces to maintain proper seating of the pallets. Lap each pallet onto its respective seat using extra-fine lapping compound and a light, even, oscillating motion. After lapping, make sure that all parts are thoroughly clean and dry them before reinstalling them. When you replace the pallets, make sure that you install the brass discs exactly the way they were before. Some vents may have two or three discs for each pallet. On vents that use pellets instead of discs for weight, be careful that you do not lose any of the pellets. Also, do not change the weight of either pallet in any way. On pressure/vacuum vents with nonmetallic seat inserts, it may be necessary, if leaking is detected, to replace the inserts. Clean the insert groove carefully. Install the new insert in the groove, making sure that it fits evenly and smoothly.

Manually gauging a tank

Electronic and automatic/mechanical gauges can indicate a level of fuel within a tank, but may not distinguish between fuel and water. As part of their maintenance, their accuracy has to be periodically checked by manually gauging the tank. The tape and bob is used to manually gauge a tank through the gauging hatch or well. The bob is made of brass, looks like a torpedo, and is attached to the end of the tape. The metal measuring tape is made of ½-inch-wide flexible stainless steel, is graduated in $^{1}/_{8}$-inch increments, and is wound on a spool. The length of the tape and bob spool in your shop will depend on the depth of the base's tallest fuel tank. The tape and bob tool operates like a fishing reel to lower and raise the bob to and from the tank bottom's datum plate.

Besides the tape and bob, to manually gauge a tank you will also need fuel- and water-finding paste (if also measuring for water) and a few wiping rags. First, ground yourself with a bare hand to the gauge piping or before ascending external ladders. Next, open the gauging hatch lid and make a note of the measurement on the metal tag attached near the gauging hatch or stenciled on the tank next to the gauging hatch. This measurement is the length from the top edge of the gauging hatch down to the tank bottom. This measurement is important as you reel the bob into the tank, so that you know when you are getting close to reaching the bottom.

DANGER: Always wait at least 30 minutes after a tank receives fuel before using a tape and bob or ascending any AST stairs or ladders to allow the static charges within the tank to dissipate. From the moment you place the bob into the gauge pipe and throughout the gauging process, the tape **must** remain in contact with the top edge of the gauge pipe to prevent the discharge of a spark.

Before lowering the bob into the tank, you can coat the bob or tape with water-finding paste to determine the water level in the tank. To find the actual fuel level, first take the reading from the electronic or automatic/mechanical gauging system, and as you lower the tape and bob into the tank, coat the tape with fuel-finding paste at least 6 inches above and below the automatic gauge reading. Continue to lower the bob until its tip touches the tank floor. Lowering the bob past the point when its tip touches the tank bottom will give you an inaccurate reading on your fuel and water paste. Reel the tape in until you reach the fuel-finding paste and note the highest measurement where the fuel paste changed color from the wet fuel. Wipe the fuel paste off and re-apply to double-check the measurement.

When consistent fuel measurements are achieved, wipe the paste and fuel off the tape as you reel it in making sure to keep the tape in constant contact with the gauge pipe. Check the water-finding paste on the bob for discoloration and report any indication of tank water to POL. Use the tank-gauging chart to convert your measurement to gal. These charts are broken down into $^{1}/_{8}$ inches. Finally, check your manual readings with the liquid-level gauge to determine it accuracy.

Liquid-level gauge

The first inspection item for liquid-level gauges is for accuracy. If the liquid-level gauge's reading is different from your tape and bob reading, an adjustment is required. This adjustment is done at the float. The cable is normally looped through the float's center eyelet and secured to itself with a cable clamp. If there is more fuel in the tank than what is read at the gauge head, then the gauge is under-reading. To correct this, three people are needed to perform this task efficiently—one at the float, another at the gauge head, and a third at the top of the stairs to relay information between the other two. First, take a vapor reading at the floating pan or floating-roof level to ensure it is safe to descend the ladder and perform the work. Next, loosen the cable clamp, and slide the clamp slowly toward the float's eyelet. This allows more of the cable to be reeled into the gauge head like it would if the float were rising with the fuel. Once an accurate reading registers at the gauge head, secure the cable clamp. If the gauge is under-reading, slide the clamp away from the eyelet pulling more cable from the gauge head.

Other inspection items require you to check the gauge head window for clear readable numbers, moisture, and signs of corrosion. Check the float for holes or damage. Ensure the guide wires are secure, and check the cable or tape for wear or kinks. Replace any damaged components as needed. Be careful when opening the side compartment because it contains the spring-loaded reel for the cable or tape. The reel's spring tension should be relieved before opening this compartment. Follow the manufacturer's instructions to take the necessary steps when performing the internal check for water and corrosion. Inspections for all tank gauges are done annually.

207. Floating-roof tank inspections and maintenance

Components of the floating-roof tank to be inspected are the roof supports, tank vents, manways, roof drain system, and fabric roof seal. Let's start this lesson by discussing the roof supports.

Roof supports

Supports are installed at various locations around the roof to support the roof when the tank is empty. The supports are constructed of pipe and are adjustable, having two positions: DOWN and UP. The DOWN position is used for internal inspections and cleaning of the tank. The roof supports at this position are lowered and secured, thus placing the low point of the roof approximately 6 feet above the floor of the tank. The UP position is used for normal fuel operations; the supports are raised and secured in place, allowing the roof to stop at approximately 3 feet from the floor of the tank when it is empty.

Inspect the supports for corrosion and to make sure they are positioned properly. Two people are needed to raise and lower the roof supports. Do not try to do the job by yourself. It takes one person to position the support and the other person to insert the guide pin. A light coating of grease may be used on the support legs and pins to reduce friction and make it easier to position the support legs and remove and insert the pins.

All of the roof supports must be kept at the same height at all times. If not, the roof will be damaged. The number of supports necessary depends on the diameter of the roof. The larger the roof, the more supports you have to position.

Tank vents

Floating-roof storage tanks use two types of vents, both of which are located on the roof: (1) an automatic bleeder vent and (2) a rim vent. The bleeder vent is sometimes hard to distinguish from a roof support. They look alike, except that the bleeder vent has a shroud around the bottom of its support to act as a seat for the vent. In addition, the bleeder vent support is about 2 inches longer than the roof supports. The bleeder vent, like the roof supports, has UP and DOWN positions. The position of the bleeder vent must match the position of the roof supports. When the roof is resting on its supports, the bleeder vent is held open. This allows the tank to breathe as long as it is empty. The floating-roof automatic bleeder vent must be set at 6 feet when preparing for an internal inspection. Inspection of the bleeder vent is the same as that for the roof supports.

A rim vent, found at the outer edge of the roof, relieves slugs of air or vapor entering the tank through the fill line. The rim vent, like the pressure/vacuum vent, is set to open at a pressure of ½ ounce (oz.) per square inch. The rim vent is often mistaken for a gauging hatch. This vent is always located 180° opposite the side of the tank where the inlet line enters. Normally, the vent cover is made of aluminum. Inspect the vent periodically for freedom of movement. Pay close attention to the cover hinges. Corrosion around the hinge affects the opening of the cover. The cover must move freely and show no signs of binding. During freezing temperatures, keep a close watch on the vent to see that it is not frozen closed.

Roof drain system

As you know, the roof drain line consists of a multi-jointed pipe connecting the underside of the roof to the bottom of the tank shell. This allows water to be drained from the roof conveniently just by opening the roof drain valve and removing a plug from the roof drain sump. Check the roof daily for an accumulation of water and drain it when necessary. Keep the drain valve closed with a plug in the roof sump.

During freezing temperatures, do not allow water to remain in the drain line. Should the water freeze, it will crack the drain valve and line making it possible for fuel to spill if the drain-line joints leak. If this happens, the tank will have to be emptied and the spill cleaned up before repairs can be made.

When repairing the roof drain-line joints, you must first empty and vapor-free the tank. Normally, there are three swing joints flanged in the line. Flange gaskets and asbestos ring packing on each side of the swing joint keep fuel from entering the drain line. When replacing the packing, you must stagger the split ends to stop leakage. The packing gland needs only to be tight enough to stop leakage. A packing gland, if tightened too much, puts a strain on the swing joint, causing it to bind and restrict its movement.

After you have made repairs to any part of a roof drain line, you must check the line for leaks. To do this, fill the drain line with water and install the plug in the roof drain sump after bleeding the air out. Enter the tank and check the line carefully for leaks. If a swing joint is leaking, adjust the packing.

When inspecting the roof drain valve on the outside of the tank shell for corrosion, check the short section of pipe between the valve and the tank shell carefully. Most drain valves are threaded to the pipe. Because of the presence of air and moisture in the line, corrosion occurs here. It is a good practice to remove the roof drain valve and the tank water drain valve while making interior tank repairs or cleaning and to inspect the connections carefully for corrosion. If they are corroded badly and the condition is left undetected, you will have a serious problem on your hands later if leakage develops and the fuel storage tank is full.

CAUTION: Never leave the roof drain valve open when fuel is in the tank. Should a leak develop in the roof drain line, the fuel will drain into the dike.

In extremely cold climates, you should fill the roof drain line with an approved antifreeze. Place a 55-gal. drum at the drain-line outlet to collect the antifreeze when water (melted ice or snow) has to be drained from the roof. Then return the antifreeze back into the drain line. The solution should be half antifreeze and half water for best protection. Never use pure antifreeze.

Fabric roof seal

The efficiency of a floating roof in preventing evaporation losses, entrance of water, and rim fires depends largely on the effectiveness of the seal closing the space between the rim of the roof and the tank shell. Figure 1–21 shows a fabric roof seal with pantograph hangers. This structure consists of a metallic sealing ring with vertical flexures spaced about 22 inches apart. These flexures serve as stiffeners to distribute pantograph hanger pressure over the height of the sealing ring. They also serve as hinges that allow the sealing ring to conform to the curvature of the tank shell. The sealing ring is supported and held firmly, but gently, against the tank shell by pantograph hangers, which apply a uniform outward radial pressure against the flexures. The light pressure minimizes abrasion of the sealing ring and of tank shell coatings. The roof seal is a weatherproof, synthetic-rubber-coated, asbestos fabric. The lower edge of the fabric is bolted to the edge of the roof. The upper edge of the fabric is attached to the top of the metallic sealing ring. Also, notice in figure 1–21 the stainless steel shunt that bonds the roof to the sealing ring.

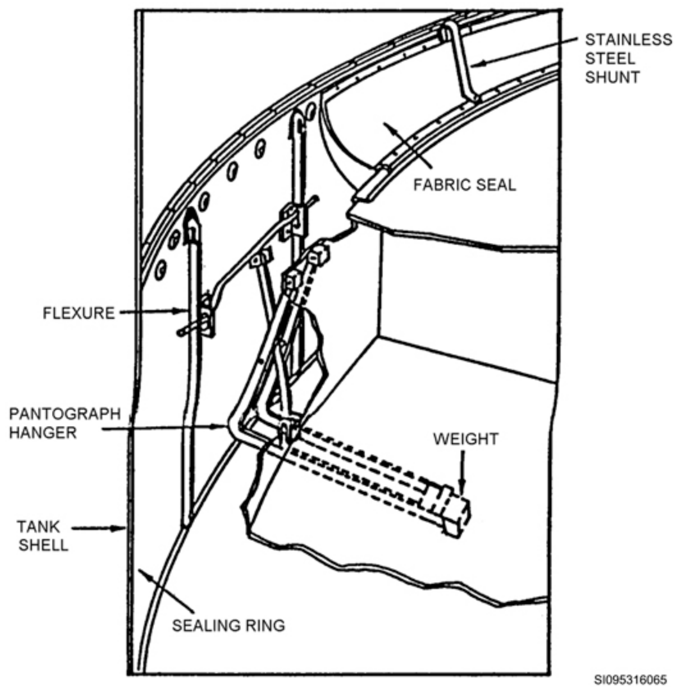


Figure 1–21. Floating roof seal structure.

The pantograph hangers also keep the roof centered. When the roof moves off center, the force exerted by the hangers increases on the side where the rim space is the narrowest. This action corrects the roof location. The pantograph hangers can accommodate a rim space width variation of plus or minus 5 inches (10 inches in tank diameter) from near the bottom of the tank, where the shell is round, to the top of the tank, where maximum distortion occurs.

Inspect and clean the fabric seal each month. Inspect the seal closely for deterioration of the fabric and for tears that would let water enter through the seal. There are patch-repair kits for repairing small holes and tears in the seal. During freezing weather, the seal must be kept free of ice so that the fabric is not damaged when it freezes to the tank wall. Do not try to chip or break the ice away from the seal. You can very easily crack or puncture the fabric. Instead, you should use a small amount of calcium chloride crystals, or an equivalent, to melt the ice. When spreading these crystals over the seal, you must wear protective gloves and eyewear to avoid any contact with your skin or eyes.

When inspecting the fabric seal on floating-roof tanks, check carefully for any gap between the metallic sealing ring and tank shell. A gap covering a length of 10 to 15 feet indicates that the sealing ring is warped or the pantograph hangers are somehow faulty. In figure 1–21, notice the weight on the pantograph hanger. If the weight falls off, the hanger will not apply force against the sealing ring flexure. You must inspect the hangers the next time the tank is entered. These hangers can be inspected only from inside the tank. Also note the width between the roof and the tank shell. If the tank settles unevenly an inch or two, the pantograph hangers will compensate for this and center the roof. But if the width is greater on one side than it is on the other, you have a serious problem of tank settling and, possibly, an out-of-round tank shell.

In the last few years, most of the floating-roof tank seals with pantograph hangers have been replaced with the type seal we covered on the cone-roof tank with a floating pan.

Adjustments of the high-level valve

As you know, the high-level valve is connected to a float chamber with a rotary disc assembly. To check its proper closing function, the tank needs to be filled to the prescribed shutoff height. Once the height is reached, the high-level valve should close. If it does not, you will need to troubleshoot the valve and the float chamber/rotary disc assembly. Clogged lines and rotary disc assembly are common problems that are easily solved by disconnecting the lines and rotary disc and cleaning them out. The float can also become defective, and the float arm can get stuck in the down position. Replace a defective float and use emery cloth to smooth any rough spots making the float arm stick. When repairs are complete, re-test the high-level valve. If the float chamber has test piping installed, then the tank does not need to be filled.

Adjustments of the HLA and HHLA

Adjustments to these units are relatively simple and are the same for each alarm. The tank must be filled to the prescribed high-level settings or use any alarm test piping and funnel (as seen in fig. 1–10) installed just for this purpose. If no test piping is installed, this is normally done in conjunction with testing the high-level valve. However, to test the HHLA, the high-level valve's shutoff function will have to be disabled. Once the sensor tube starts to fill and the level reaches the two sensors, first, the HLAs and then the HHLAs should sound and light up the alarm panel in the control room.

First, you need to know at what level each alarm should sound. These levels should be recorded somewhere in your shop or in the pump house control room. As the tank fills to the prescribed alarm levels and the HLA sounds, shut off the pump and record the fuel level given at the liquid-level gauge. Repeat this procedure for the HHLA. Check your test fuel levels against the recorded fuel levels. If your test levels are significantly off the mark, the sensor's set point will have to be adjusted.

If the alarms do not sound, electrical troubleshooting will be your next step. Check to see if there is power and proper voltage to the unit (see manufacturer's manual for proper voltage). If no electrical problems are found, then the sensors may need replacing.

Adjustments of the low-level control switch

The low-level control must be checked to assure that it is cutting off the pump at a predetermined level (usually 13 inches from the underground tank bottom and 2 feet, 3 inches on cone roof with floating pan tanks). You do this by pumping the fuel out of the tank until the low-level control cuts off the pump. Then gauge the tank manually to determine the liquid level. If the reading is incorrect, make the adjustments and recheck for accuracy. If the pump does not shut off, then electrically troubleshoot the circuit and replace the sensor if necessary.

208. Underground tank component inspections and maintenance

Inspections are limited to the liquidometer and low-level controls. They sometimes need adjusting due to wear and tear of components.

Liquidometer

Inspect the liquidometer for condition, accuracy, and function annually. The housing should be free of damage and corrosion. The gauge needle on the gauge face should have a smooth movement when filling or emptying the tank, and the face increments should be clear and not faded. Use a tape and bob and the tank gauge chart to determine the liquidometer's accuracy. If the gauge is reading inaccurate, remove the gauge face cover, use a gauge needle puller to remove the needle, and replace it on the correct volume measurement. Repair to the liquidometer is limited to the replacement of the gauge needle, float, and float arm.

If the liquidometer needs replacing, the tank will be emptied, and the float and linkage sections inside the tank are removed in order to unthread the gauge head from the pipe riser located inside the pump house. But, before the gauge head is unthreaded, you must first electrically isolate the low-level control, and then the linkage from the liquidometer to the low-level control must be disconnected.

Low-level controls

Since they work together, a low-level control is inspected along with the liquidometer. Inspect it for condition, internal corrosion, and proper operation. The external housing should not be damaged and the cover gasket should be in good condition to remain explosion-proof. Internal parts should be free of corrosion. If corrosion is present, the cover gasket is probably faulty. Use a small wire brush to remove any corrosion and replace the cover gasket. Check the insulation on all wires for nicks and cuts, which could short or ground the unit, and check the contact points for heat damage.

As stated before, the low-level control should shut off the UST’s pump motor approximately 13 inches from the tank bottom. The float arm linkage to the low-level control simply rotates the mercury tube or cam-actuator to make or break the electrical contacts to turn off the pump or allow it to turn on. Occasionally, an adjustment to either the mercury tube switch or the cam-actuated microswitch is needed if the fuel level in the tank is above or below the 13 inch mark. First, you must lower the level of the fuel in the tank to 13 inches by measuring it with a tape and bob. After turning off the power to the control, open the control cover, and loosen the set screw on either type switch will allow you to rotate the tube or cam to the set point that will shut off the pump motor. The manufacturer’s instructions will determine which way to rotate the mercury tube or cam-actuator to achieve the desired results. Then tighten the set screw, replace the cover, turn on the power, fill the tank just enough so the pump will come on, and empty the tank with the deep-well pump until the low level shuts off the pump motor. Repeat this procedure until the 13-inch-level shut off is achieved. As for repairing this type of control, replacement parts may not be available because the device is usually sold as a unit.

Since cut-and-cover tank’s constructional features and components are composed of a combination of ASTs and USTs, their inspection and maintenance will coincide with the appropriate schedule and tasks.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. General fuel storage tank construction features

1. What determines the quantity and the different types of fuels that are stored at a particular base?

2. Who determines the size of fuel tanks and how many will be located at each base?

3. Normally, what type storage tank is used for storing 25,000 gal. of MOGAS?

4. Manways on newly constructed tanks will be what size?

5. Why are DBB valves used on the inlet and outlet lines of newly installed tanks?

6. What size is the water draw-off line, and where does it terminate inside the tank?

7. What are the components of the product-recovery system on a vertical AST?

8. The electronic system of the ATG system uses what components to gauge the fuel in a tank?

202. Cone roof and cone-roof tanks with a floating pan constructional features

1. Name the components of a cone-roof tank.

2. What are the components of a liquid-level gauge on a cone-roof tank?

3. What type aboveground tank is primarily used to store jet fuel and fuels with a flash point less than 100° F?

4. Where does the product-withdrawal line terminate inside a cone roof with floating pan tank?

5. What is the purpose of the 3-inch stripping line tee?

6. Why does the tank fill line enter the tank and cause the fuel to rotate counterclockwise in the northern hemisphere?

7. What is the purpose of the HHLA?

8. What happens when the low-level shutoff is activated?

9. What is the main purpose of the pan on a cone roof with floating pan tank?

203. Floating-roof tank constructional features

1. Name the two types of floating-roof tanks.

2. What has been added to some floating-roof tanks to keep out water and debris?

3. What are the design features of the pontoon floating roof?

204. Underground and cut-and-cover tanks constructional features

1. What is the purpose of the wire screen placed across the inlet to the first stage of a deep-well turbine pump?

2. What is the purpose of the motor’s built-in ratchet assembly?

3. What is the purpose of the liquidometer installed on an underground fuel tank?

4. What are the two types of low-level controls on a horizontal underground tank?

5. What is the size of the cleanout line on an underground tank and where does it terminate outside the tank?

6. What two valves are used as high-level shutoffs on an underground tank and how do they differ?

205. General fuel storage tank inspections and maintenance

1. How often is a bulk storage tank inspected if it has a receiving F/S *or* is internally coated?

2. How often is an operating storage tank inspected if it has a receiving F/S *and* is internally coated?

3. Explain what could happen if an aboveground tank goes out-of-round.

4. Explain how to use a plumb bob to inspect an aboveground tank for settling.

5. How often and why do you check the interstitial space of an underground tank?

6. How often do you check the bottom of an aboveground vertical tank for leaks?

7. What publication tells you how to mark a JP–8 fuel tank for identification?

8. What type valve is used as a dike drain valve?

206. Cone-roof tank inspections and maintenance

1. What is the purpose of a fuse-link valve, and at what temperature will the fuse link melt?

2. How do you adjust a pipeline pressure relief and what is its pressure setting?

3. How is the amount of pressure or vacuum it takes to lift the pressure/vacuum vent pallets determined?

4. When using a tape and bob to gauge a fuel tank, what must you do to prevent the discharge of sparks inside the tank?

5. What are the inspection items for liquid-level gauges?

207. Floating-roof tank inspection and maintenance

1. List the components requiring inspection on the floating-roof tank.

2. Name the two positions of the roof supports and how they are used.

3. Why are two people needed to raise and lower the roof support?

4. To assure ease of operation, what should you do for the roof support legs and guide pins?

5. During freezing weather, you should watch the rim vent closely to prevent *what* from happening?

6. Before you can repair joints of the roof drain line, what must you do first?

7. What steps are performed after repairing a roof drain line?

8. During freezing weather, what must you do to protect the fabric seal?

208. Underground tank inspection and maintenance

1. When replacing the liquidometer on an underground tank, what steps do you take?

2. What steps do you take to adjust a low-level control?

1–2. Tank Entry

In June 1952, a contractor started work to clean and repair 44 storage tanks. Five weeks later, one of the contractor's workers failed to show up for work. The following week, several more workers failed to report to work. Before the job was suspended, 17 workers, including the contractor, were hospitalized for lead poisoning. An investigation of this incident showed that even though the contractor had cleaned fuel storage tanks before, that company had never cleaned an active tank. All of this company's experience had been on tanks that were out of service. This contractor's lack of knowledge of the dangers of lead poisoning almost cost the lives of 17 people.

When a tank-cleaning project starts at your base, you must make sure that safety practices are followed in every action taken to clean and inspect fuel storage tanks. If you permit any disregard for safety, your tank-cleaning project can end in the same way the following project ended at an AF installation December 18, 1974. It was a major ground accident. Below are the disastrous results:

- Tank #1 destroyed—cost $1,500,000.
- Tank #2 holds fuel, but cannot be used.
- Other damage—cost $50,388.
- Five men killed.
- Several men injured.
- Cost? – Too high!

The report of the investigating board showed a complete disregard for safety.

To avoid repeating the accidents of the past, all involved personnel must learn and constantly review all hazards and safety precautions for cleaning and inspecting fuel storage tanks, and then without fail, apply and practice them. In other words, never take chances!

209. Pre-entry requirements

Confined-space entry requirements are particularly important because of the high probability of encountering fuel vapors and confined-space (CS) hazards. CS requirements are founded in federal law and subject to federal inspections. Do not take these or any other safety requirements lightly;

most of them are based on lessons learned from previous accidents. Do not learn the same lessons the hard way.

The following steps are part of an entire tank-cleaning process that can be found in UFC 3–460–03, chapter 11.

Preparing for entry

When a fuel storage tank requires cleaning, many things have to be done before the actual cleaning begins. Some of the requirements are the same whether a project is completed by contract or in-house.

Notification to major command

Before you or a contractor can enter any tank for inspection, cleaning, or maintenance, the major command (MAJCOM) must be asked for permission to enter the tank. This notification to the MAJCOM fuels engineer must be given a minimum of 15 workdays before the proposed entry date. The MAJCOM fuels engineer will assign a qualified tank-entry supervisor to supervise the procedures and operation.

Base fuels management office

The base fuels management office (POL) is responsible for the removal of fuel from the tank to the lowest point possible by using the installed pumps. This usually involves transferring the fuel from the tank to be cleaned or inspected to another tank. Early notification is necessary to give POL time to make room in another tank(s) for the transfer.

The confined-space program team

The three agencies that comprise the confined-space program team (CSPT) are base ground safety (SEG), the base fire department (CEF), and base bio-environmental engineer (BEE). They must be notified well within the 15 workdays prior to commencing work so that they may be present during an operation.

SEG and CEF

When on-site, these agencies will examine the entire set-up and procedures to ensure overall safety, fire prevention, and rescue operations. If present, they will sign the entry permit.

BEE

The BEE from your base medical squadron must approve all personal protective equipment (PPE) and their uses during a CS or tank-cleaning operation. They also provide medical surveillance to document hazardous exposures and to ensure the PPE is performing adequately to protect everyone involved in the operation. If present, they will also sign the entry permit.

In-house cleaning

When a tank-cleaning project is to be completed in-house, the requirements given here must be met.

Tank entry supervisor

During tank inspections and cleaning, you are directly responsible to the tank-entry supervisor (TES). This person may be your noncommissioned officer in charge (NCOIC), a shop supervisor, or a supervisor borrowed from another base if there are no qualified people at your own base. Not just anyone is chosen to shoulder this responsibility. The TES must have experience in cleaning tanks to understand how the entire operation works and attend formal training in the *Liquid Fuels Storage Tank Entry Supervisor* course. Following the formal training, the individual must submit their training and documented experience to their MAJCOM fuels engineer to receive certification. Assuming the responsibility of the TES is no small undertaking since the lives of his crew will be in his hands. As a 5-level, you may become qualified as a TES if you meet the requirements cited.

The TES is responsible for the following:

- Will provide the overall supervision and coordination of the cleaning project.
- Must notify the MAJCOM of the proposed starting date and obtain permission to do the work.
- Must be thoroughly familiar with and comply with AFI 91–203, *Air Force Consolidated Occupational Safety Instruction*, chapter 23; AFI 48–137, *Respiratory Protection Program;* the SEG's CS program; the BEE's respiratory protection program (RPP); UFC 3–460–03; the shop's master entry plan (MEP); and any other associated operating instructions (OI).
- Inspect all equipment to be used.
- Must notify in advance and may request assistance from POL, SEG, CEF, and BEE prior to starting work.

Contract cleaning

When a tank-cleaning project is to be completed by contract, the requirements given next must be met.

Contractor

The invitation for bids for contracts such as tank cleaning, coating, or welding must require the contractor to submit evidence the company is qualified to perform such work. The company must provide the following documentation to show their qualification:

1. A narrative explaining why they are qualified, along with specific references.
2. Examples of three similar projects completed by the firm over the past 5 years. The examples should include the scope of work; applicable size of tanks, pipes, and system capacity; customer's name (company and owner); and a point of contact.
3. Certification that the contract supervisor is thoroughly familiar with the fuel characteristics, worker safety requirements, and related OSHA requirements.
4. The names and qualifications of each contractor's representative who will be in charge of the work and be present at the job site when tank work is being accomplished.

Command fuels engineer's representative

Normally, the MAJCOM fuels engineer's representative is the WFSM supervisor with the most fuel systems experience or a MAJCOM certified tank-entry supervisor. The MAJCOM representative provides the overall coordination of the cleaning project. The MAJCOM representative's responsibilities are to advise the contractor of known potential hazards within the tank and surrounding area, to inspect the contractor's equipment, and to act as quality assurance evaluator (QAE) in all technical matters pertaining to tank work. The MAJCOM representative should immediately notify the contracting officer of any safety-related violations or noncompliance on the part of the contractor regarding the contract's statement of work.

210. Safety hazards and precautions

In 1982, a POL Airman entered a 6-foot-deep fuel pit to mop up 2 feet of water and 1 inch of fuel. Once at the bottom of the pit, he was overcome with fuel vapors, fell face down in the water/fuel mixture, and drowned. The standby person went in the pit to help but he was also overcome with fuel vapors. A third person went into the pit to try to help, but he was also overcome with fuel vapors. The last two Airmen survived the ordeal, but they spent time in the hospital. The AF investigated the situation and found that Airmen were entering such fuel pits every day. Something had to be done. Even though a fuel pit is not a tank, it shows that areas that are not normally dangerous can turn deadly if the proper precautions and forethought are not accomplished.

Safety hazards

Anyone engaged in the cleaning of petroleum storage tanks may suffer accidental injury as a result of explosion; fire; the presence of toxic liquids, vapors, or dusts; an excess of petroleum vapor; or oxygen (O_2) deficiency. They may also be injured from any of these physical hazards:

- Discharging of petroleum products into a tank while people are at work.
- Failing to use PPE.
- The dropping of swing lines.
- Objects falling from the upper part of a tank.
- Falling from scaffolding, stairways, or ladders.
- Falling from or through the roof of a tank.
- Tripping over hose lines or over other objects.
- Slipping on tank floors.
- Colliding with structural tank supports or piping.
- A tank or its appurtenances failing structurally.
- Insufficient lighting.
- Defective electrical cords.
- Failing to use good judgment.

Sources and causes of explosions and fires

Mixtures of petroleum vapor and air in certain limits can be ignited. For gasoline vapors in air, these limits are approximately 1.4 percent and 7.6 percent by volume. For JP–8 fuel, these mixtures are 0.6 percent to 4.7 percent by volume. Combustible gas or vapor indicators are used to measure the percentage of petroleum vapors present in air. Always consult the manufacturer’s instructions on the proper use of such equipment.

Ignition does *not* occur in fuel vapor and air mixtures that are richer than the upper explosive limit (UEL) or leaner than the lower explosive limit (LEL). Rich mixtures may be ignited and burn at tank opening such as hatches, vents, and manways if caution is not taken. At these points, air combines with and dilutes the rich vapors to produce a mixture well within the flammable range.

Even after a tank has been well-ventilated to bring the LEL down to zero, flammable mixtures may be formed as the work progresses. Fuel and fuel vapors can enter a tank through a poorly secured pipeline, a pressure-relief line that was not disconnected, holes in the tank floor or components, or generated from sludge during cleaning operations. If this occurs, additional or continual ventilation may be required.

When ventilating a tank, be aware of possible sources of ignition downwind where the fuel vapors can migrate and settle in low-lying areas. There is a chance that vapor ignition away from the tank can flash back to the tank.

Toxic hazards

Some of the toxic hazards to which cleaning personnel are exposed are leaded compounds, benzene, and O_2 deficiency.

Leaded compounds

Tetraethyl lead (TEL) and other organic lead compounds contained in gasoline constitute health hazards to personnel cleaning storage tanks. Lead compounds may be present in residual fuel, and deposits may accumulate in the tanks. These compounds may exist as vapors from the liquid fuel or solid deposits may be dispensed into the air in the form of dust particles during scraping or abrasive cleaning procedures. If welding is done, the lead may be present in fumes. The use of proper respiratory protection protects against inhalation hazards. Organic lead compounds are also absorbed readily through the skin. Thus, this route of exposure must also be prevented.

NOTE: All tanks that have been used for the blending or storage of gasoline to which TEL has been added should be considered as a potential lead hazard throughout the cleaning process, regardless of whether they have been freed of hydrocarbon vapors. A gasoline-vapor-free tank is *not* a lead-vapor-free tank.

Benzene

All fuels contain benzene to some degree (1.0 percent to 5 percent by volume). Gasoline usually contains higher concentrations of benzene than do JP–8 or heavier distillate fuels. However, benzene is so toxic that even when it is present in fuels in very low concentrations, it must be considered the dominant vapor and contact hazard during fuel operations. This is particularly true in CSs, such as petroleum storage tanks. Because the exact concentration of benzene in fuels varies from batch to batch, it is impossible to specify a single permissible exposure level for fuel vapors below which work may be done in a tank without using a supplied air respirator (SAR). This would have to be determined by specific measurements of air contamination on a case-by-case basis. Since this is rarely done before our work begins, SARs are required throughout the tank-cleaning process.

Excess fuel vapors and deficiency of O_2

When a person inhales enough fuel vapors, they can exhibit a stage of excitement followed by unconsciousness. If the person is removed from the toxic environment before an extended exposure occurs, with rest and fresh air the person can recover in a few hours. You should immediately report all fuel vapor exposures that cause physical reactions or unusual behavior to a physician. If a person stops breathing, call your emergency medical service (EMS) for assistance, and a competent person should apply artificial respiration until help arrives.

O_2 deficiency

Tanks, when first opened, are usually O_2 deficient because of displacement of air by fuel vapors. No one will initially enter a fuel tank until it has been properly ventilated as close to zero percent but no higher than 10 percent of the LEL. The entrant MUST wear the mechanical, electrical, and plumbing (MEP)-approved respiratory protection.

Vapor testing

Initial testing of the tank atmosphere with a combustible gas indicator will be made at the man-way opening, where vapors are being exhausted, or at the exhaust of the ventilating equipment. The tester must be trained and thoroughly familiar with the reading and handling of the instrument. Before taking a reading, the tester should determine that the instrument is in proper working condition and is calibrated correctly. It is important to follow the manufacturer's recommendations for checking and calibrating the instrument.

If the vapor indicator registers 10 percent or less of the LEL, initial entry is authorized for further testing provided the individual is equipped with the proper PPE.

Since vapors will be present as long as any fuel, scale, or sludge remains inside the tank, forced ventilation must be continued until all such material has been removed, unless the noise of the eductor interferes with communication with the workers. Vapor readings must be taken continuously and recorded every 15 minutes while workers are in the tank. Stirring sludge releases vapors and increases vapor concentrations. Remove puddles of fuel and sludge to keep vapor readings below 20 percent LEL.

All tanks being cleaned or repaired must be considered leaded unless positive proof exists that the tank has never contained leaded fuel, or the tank has been coated using the AF standard epoxy tank-coating system and has not held leaded fuel since. Before tank entry is authorized without PPE, the LEL reading must be zero; O_2 levels must be between 19.5 percent and 23.5 percent; and the BEE must determine that the lead, benzene, and other toxic material levels are within permissible exposure limits.

Safety precautions

The TES must be at the job site and make sure that personnel have been briefed on what is to be done, what each worker is to do in the event of an emergency, and how long each person or cleaning crew can remain in the tank under normal conditions. Additionally, the TES must make sure the following tasks are completed:

- All required equipment is approved and located properly, all personnel are equipped with properly fitted protective equipment, and the entire area adjacent to the tank is secured.
- Eductor-type air movers have been operating continuously for at least 1 hour or until LEL and O_2 are within safe limits immediately prior to entrants entering the tank and throughout the operation to maintain a safe working atmosphere of less than 20 percent LEL.
- All personnel know the location of the nearest emergency shower and emergency communication equipment (i.e., land-line, radio, cell phone) with contact numbers.
- The organizational rescue team has been trained, tasked, positioned, and properly instructed to perform their duties in case of an emergency.
- Enough approved containers are on hand and available to hold the sludge and water removed from the tank.

All equipment used for tank cleaning must be upwind of the tank opening. When the wind direction changes, you must move the equipment to maintain an upwind location.

There must be no smoking or eating by any personnel on the tank-cleaning crew until they are completely out of the area, have showered, and have changed clothes. Matches or cigarette lighters are forbidden and must not be carried by any tank-cleaning crew member or other persons entering the tank-cleaning area.

At least one person on the tank-cleaning crew must be qualified and certified to administer artificial respiration and simple first aid.

Emergency and rescue procedures

The MEP must include emergency and rescue procedures consistent with the nature of each known operation that requires entry into a permit-required CS. AFI 91–203 and 29 Code of Federal Regulations (CFR), 1910.146, *Permit-Required Confined Spaces*, direct the development of emergency and rescue procedures. The CSPT must approve these procedures and the training of personnel.

Responsibilities

The TES must ensure that the tank-cleaning personnel have the training and demonstrate the knowledge and capability to know what to do in an emergency during a tank-cleaning operation.

The supervisor must coordinate with the installation SEG, CEF, and BEE staffs when it is necessary to enter non-routine, permit-required CSs not included in the MEP and establish emergency rescue procedures before entry. Members of the rescue team must be provided with, and trained to use properly, the PPE and rescue equipment necessary for making rescue from CSs.

Visual, voice, or single-line communications must be maintained among the entrants in the CS and the attendant located outside the CS area. Inspection, testing, maintenance, and documentation of safety and rescue equipment must be made according to AFI 91–203 and TO 00–25–245, *Testing and Inspection Procedures for Personnel Safety and Rescue Equipment*.

Rescue teams must be granted access to all permit spaces from which rescue may be necessary so that the rescue team can develop appropriate rescue plans and practice rescue operations.

Emergency rescue procedures

For tank-cleaning operations, the three primary means of rescue are self-rescue, centrally located rescue team (fire department), and organizational rescue team.

Self-rescue

All entrants (CS workers) must be trained and briefed before entering CS on what to do in an emergency.

They must safely exit from the CS as rapidly as they can during the following situations:

- When an order or signal to evacuate is given by the attendant.
- When an automatic evacuation alarm is activated.
- When they or their fellow workers recognize the warning signs of toxic exposure.
- When directed by the TES.

They must know the toxic effect or symptoms of exposure to the hazardous materials they are exposed to. They must relay an alarm to other entrants and must attempt self-rescue immediately on becoming aware of effects discussed above.

Centrally located rescue team (base fire department)

The CEF normally provides rescue service for operations requiring entry into permit-required CSs. When deemed appropriate by the fire chief, the rescue team should stand by at the scene.

When a centrally located rescue team is used, the on-site entry supervisor must contact the rescue team before entry, coordinate emergency rescue assistance as deemed necessary, and make sure it is available within a reasonable period of time. He or she must inform the rescue teams of the hazards they may confront when called on to rescue someone.

Organizational rescue team

An organization rescue team must be on-site and in position in accordance with UFC 3–460–3 and AFI 91–203. Organizational rescue team members must consist of trained personnel equipped with appropriate PPE, including respiratory protection equipment necessary for entry into CSs and retrieval equipment suitable for the type of CSs involved.

All team members must have documented training in basic first aid and cardiopulmonary resuscitation (CPR). They must be qualified and trained for removing victims from CSs (tanks). They must remain in the immediate area, but outside the CS. They must have the same training requirements as entrants. In immediately dangerous to life and health (IDLH) atmospheres, they must use respirators that are a combination full-facepiece pressure-demand SAR with auxiliary self-contained air supply for egress, certified by the National Institute for Occupational Safety and Health (NIOSH).

The team members must be equipped with a full-body harness and have one end of the retrieval line attached to the harness D-ring and the other end of the retrieval line attached to a mechanical device or fixed point outside the permit space. They must notify the on-site supervisor before entering the CS to provide emergency rescue. They must remove the victim immediately and place him or her upwind of the CS.

The team members must not remove any victim who has been seriously injured (broken bones, trauma to the back, or internal injures) unless the victim is in a life-threatening situation. For those victims seriously injured but not in a life-threatening situation, the rescue team must administer first aid. They must perform the five basic lifesaving steps to injured personnel: (1) establish an open airway, (2) make sure of breathing, (3) stop the bleeding, (4) prevent or treat for shock, and (5) dress and bandage wounds and splint fractures.

The team members must receive hands-on rescue training to include equipment knowledge and use and removing simulated victims (such as dummies, mannequins, or actual persons) from the actual CS or representative CSs that have openings like the types from which rescue is to be made. This training must be conducted initially for each team member and at least annually thereafter for as long as the individual remains on the organizational rescue team.

Incident notification

After any emergency or mishap connected with any CS incident, notify the SEG, CEF and BEE. These offices must evaluate the specific situation and recommend corrections or improvements to existing procedures.

211. Specialized clothing, equipment, and tools

Safety is especially important when you are entering an area that is hazardous to your health. Supervisors and their employees have some distinct responsibilities with regard to hazards and the use of the proper clothing, tools, and equipment.

Supervisor responsibilities

Supervisors conduct and document hazard assessments in each workplace where their employees are working. If PPE is required, the supervisor consults the SEG and BEE concerning the selection and use of PPE and makes sure that PPE is provided, used, and maintained in a sanitary and serviceable condition.

NOTE: All personnel must have job safety training; however, commanders, functional managers, supervisors, and staff members whose work environment is primarily a low-risk administrative area do not require documentation. Supervisors document job safety training for all other personnel.

The entry supervisor must make sure inspection, testing, maintenance, and documentation of safety and rescue equipment are done according to AFI 91–203 and TO 00–25–245.

Staff responsibilities

All AF personnel must promptly report safety, fire, and health hazards to supervisors or managers and must comply with PPE requirements. They must use the PPE that is provided (when required), adjust it to the proper fit, and maintain it in sanitary and serviceable condition. They must notify their supervisors if they wear contact lenses (this information is vital to emergency medical personnel who may need to remove a lens from the individual's eye). They must notify supervisors about any known medical condition or illness before exposure to hazardous tasks or operations.

Training requirements

Supervisors must make sure their troops are trained and well-informed before entering a CS. They must develop a structured and effective training program to establish safe work practices and techniques. They must obtain installation SEG, CEF, and BEE officials' approval on all training lesson plans before their use and any time changes are made to the plans. They must make sure all CS personnel are trained in accordance with AFI 91–203.

Personnel clothing

The tank-cleaning supervisor must make sure that all necessary clothing is on hand, inspected, and approved before actual tank work begins. Supervisors must base the selection of appropriate hand protection on the characteristics required relative to the task to be done, dexterity required, conditions present, duration of use, frequency, physical stresses, limitations of protective clothing, and degree of exposure to identified hazards.

Head protection

People working in areas where there is a potential for injury from falling or flying objects, bumping the head against a fixed object, or electrical shock or burn shall be provided with, and must use, protective helmets. Protective helmets must comply with American National Standards Institute (ANSI) Standard Z-89.1-2014, *Industrial Head Protection*. Safety helmets must not be painted since the paint may hide cracks or defects in the outer shell and destroy or degrade the insulating characteristics. Helmets are manufactured in several colors, and units wishing to specify a particular color must first contact the local ground safety office for approval. Helmets are normally worn when working in aboveground tanks with floating roofs or pans, but may be worn at any time.

Eye and face protection

Employees are provided with, and must use, the appropriate eye or face protection when exposed to flying particles, liquid chemicals, or other hazards. Proper selection will be based on the kind and degree of hazard present. Protective eye and face devices must comply with the ANSI Z87.1-2010, *Eye Protection Standard*. For tank-cleaning operations, the sludge handler will wear a face shield.

Hand and arm protection

When an employee’s hands or arms are exposed to hazards, such as those from skin absorption of harmful substances, severe cuts, lacerations, abrasions, punctures, chemical burns, or harmful temperature extremes, appropriate hand or arm protection shall be provided and must be used. Before purchasing any protective equipment, make sure that the manufacturer's recommended use for the glove matches the particular application and anticipated hazards involved.

People working with hydrocarbons and other harmful chemicals must wear acid-resistant rubber gloves (gauntlet type) gloves. Consult the safety data sheet (SDS) for each chemical used, and the local BEE for assistance in selecting the proper glove material. Each person, when entering the tank or handling sludge materials on the exterior of the tank, must be provided one pair of gloves for use and one extra pair for emergency use. When heavy lifting or handling objects with rough surfaces and contact with hazardous liquids is not a concern, use shop-issued leather gloves to prevent damage to your acid-resistant gloves.

Before using gloves, inspect them to make sure they are made of a material impermeable to tetraethyl lead (acid-proof rubber) and that they are in serviceable condition. Gloves should be pliable enough that they will not crack while in use.

NOTE: Before purchasing gloves or any protective clothing, the supervisor must obtain documentation from the manufacturer that indicates that the item meets the appropriate test standards for the hazards anticipated.

Foot protection

Protective footwear shall be provided and must be worn when there is a reasonable possibility of sustaining foot injuries due to heavy or sharp objects and electrical and/or static electricity considerations. For protection of feet from falling or rolling objects, sharp objects, and wet slippery surfaces, workers must use appropriate safety shoes or boots. All individually issued safety footwear used in AF daily operations must meet the requirements of applicable American Standard of Testing Material (ASTM) F2413–11, *Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear*. For tank-cleaning operations, one-quarter length boots to knee-length boots can be used.

Before using, inspect the boots to make sure they are made of a material impermeable to tetraethyl lead (acid-proof rubber) and that they are in serviceable condition. Inspect boot soles for excessive wear to prevent slipping while inside the tanks.

Coveralls

Maintenance personnel working on or around fueling equipment and operations should wear coveralls made of a combination blend of 50 percent cotton and 50 percent polyester as outer garments (light colored to show dirt). The 50/50 blend has been tested to produce the least amount of static electricity, even less than the 100 percent cotton; therefore, it is the preferred clothing. Civilian or military clothing of all wool, silk, or nylon materials, or blends of silk or nylon, generates far greater electrostatic charges and constitutes an unacceptable hazard potential. However, wool stockings, glove inserts, stocking caps, and underwear of nylon, silk, or polyester may be worn as long as they are not removed around open fuel systems.

Anyone in a tank is to wear clean clothing from the skin outward. Before using any coveralls, inspect them carefully to make sure they are *not* equipped with metal fasteners and are in serviceable condition. Each tank-cleaning crew must have available at least two changes per person of underclothes and coveralls. A painter's cap may be worn to keep long hair contained and sludge out. If, at any time, your clothing becomes soaked with fuel or sludge, remove it promptly after you are outside the work area and away from explosive vapors and ignition sources. Remove the clothing slowly to avoid any buildup of static electricity.

Do *not* remove heavily contaminated clothing until it is drenched completely in water. Remove jet fuel and gasoline from your skin by washing or showering with soap as soon as possible after contact. Take a bath promptly, and then put on clean clothing. Before handling food or tobacco, remove your outer clothing (coveralls) and wash your face and hands thoroughly.

Hearing protection

Exposure to high-noise levels can cause hearing loss or impairment, in addition to physical and psychological stress. Specifically designed protection is required, depending on the type of noise encountered and the auditory condition of the employee. Contact the local BEE office for information on the Air Force Hearing Protection Program (29 CFR, 1910.95, *Occupational Noise Exposure*). Ear plugs or ear muffs are the only acceptable and proven forms of hearing protection. Hearing protection will always be worn around coppus blowers, diesel-driven compressors, and other high-noise producing machinery or tools.

Specialized protective equipment

There is a lot of safety equipment used to ensure nobody gets injured. We will discuss this to get you familiar with the equipment.

Air respirators

Only type "C" respirators can be used for AF petroleum tank-cleaning operations. The type "C" air respirators you are supplied for tank-cleaning operations must be approved by Mine Safety Appliances (MSA). The type "C" respirator is approved for entry into IDLH areas. IDLH conditions exist above 40 percent LEL. In addition to the respirators provided for those people inside the tank, one extra respirator must be available for emergency use.

CAUTION: Personnel cleaning AF petroleum storage tanks must NEVER use portable O_2 tanks and masks, portable gas masks, or "walk-around" O_2 bottles and masks.

Inspect the face piece (mask) visually for any holes, tears, or breaks; stretched or torn straps; damaged buckles; aged rubber; cracked lens; and loose clamps. Tighten all loose clamps and replace damaged parts. However, discard the mask if it is unrepairable. Of course, you should check the hose for wear.

Prescription lenses or spectacle kits are available from the respirator manufacturer. Do not mix manufacturers' spectacle kits or attempt to use gas mask inserts with supplied air respirators. Only the manufacturer's spectacle kit designed for the specific model is to be used. Do not wear contact lenses with supplied air respirators on AF tank-cleaning projects.

Inspect and maintain all respirators and associated equipment per AFI 48–137 and the manufacturer's instructions.

Communications equipment

An approved communication system must be provided and used when cleaning underground tanks larger than 50,000 gal. capacity, or when manhole accesses are deeper than 10 feet from ground (working) level. Communication equipment must be used in any situation where the attendant does not have direct communication with the entrant.

The communications equipment must be compatible with approved respiratory protective equipment. Communication equipment must be labeled by Factory Mutual or Underwriters Laboratory (UL) as intrinsically safe for Class I, Division 1, Groups C and D of the *National Electrical Code*.

Hoses and air lines

The air line for supplied air respirators has a limited life and must be made of a material impermeable to fuel (acid-proof rubber). Test all sections of this hose or air line by flexing it manually.

If such a hose or air line is stiff or shows signs of cracking, discard it. Note that the respirators are approved as a complete unit, such as the hose or air line, mask regulator, and so forth. When a hose or air line component must be replaced, replace it with an identical item (i.e., same manufacturing and part number); otherwise, the approval is voided. Replace deteriorated O-rings in air hose connections.

The length of hose or air line for each mask must not exceed the NIOSH approved length of 300 feet unless approved by the BEE. Inspect the air line or hose to make sure there are no restrictions or leaks and to make sure that air is freely discharged from the hose outlet.

NOTE: When you prepare hose and masks for storage, clean them and put them carefully in their carrying cases; properly identify each by a tag or markings on the case; and place the cases in a safe, accessible, and fairly cool (40–70° F) place.

Air movers

All air movers used must be of the eductor-type and be capable of educting vapors from the tank. They must be explosion-proof and air-driven. Air movers are usually attached to the tank's access way and operated pneumatically by a portable diesel-driven air compressor. Inspect for loose parts and excessive noise, as this may be an indication of worn bearings.

Electrical equipment

All electrical equipment to be used within 50 feet of any fuel system, or where a hazardous accumulation of flammable vapors may exist, must be Class I, Division I, Group D, with maximum temperature ratings of "T2D"–419° F, as defined in the *NEC* for use in hazardous areas.

Explosion-proof, portable, battery-powered lights approved by Bureau of Mines or NIOSH are the only lights authorized for use inside the tank.

Inspect all electrical equipment for damaged housing, gaskets, and protective wire coatings.

Gasoline-engine-driven equipment

If necessary, gasoline-engine-driven equipment can be used for a tank-cleaning operation but must be equipped with a flame arrester, have a protected ignition system, and must be located at least 50 feet upwind of the tank. Inspect per the manufacturer's instructions.

Fall-protection and rescue equipment

Personal fall-protection equipment should be selected to match the particular work situation. Any time a worker is at a height of 6 feet or more, the worker is at risk and needs to be protected. Any possible free-fall distance should be kept to a minimum. The supervisor must fully evaluate the work conditions and work environment before selecting the appropriate personal fall-protection system.

Fall-protection systems can consist of devices that arrest a free-fall or devices that restrain a worker in position to prevent a fall from occurring. Use a fall arrest when at risk of falling from an elevated position. A positioning system restrains the elevated worker, preventing him or her from getting into a hazardous position where a fall could occur, and it also allows hands-free work. Both systems have three components—harnesses or belts, connection devices, and tie-off points.

The availability of rescue personnel, ladders, or other rescue equipment must be considered before working in areas that require a fall arrest system.

Use and apply Technical Order (TO) 00–25–245, *Testing and Inspection Procedures for Personnel Safety and Rescue Equipment*, and AFI 91–203.

Safety harness

A full-body harness wraps around the waist, shoulders, and legs. A "D-ring" located in the center of the back provides a connecting point for lanyards or other fall arrest connection devices. In the event of a fall, a full-body harness distributes the force of the impact throughout the trunk of the body—not just in the abdominal area. This allows the pelvis and shoulders to help absorb the shock, reducing the impact to the abdominal area.

Maximum force arrest on a full-body harness, which is used for the most severe free-fall hazards, is 1,800 pounds. Full-body harnesses come with optional side, front, and shoulder D-rings. The side and front D-rings are connection points used for work positioning, and the shoulder D-rings are for retrieval from CSs. Equipment purchased must have the manufacturer's name, identification code, and date of manufacture stamped on the equipment or on a permanently attached tag.

The service life of fall-protection equipment manufactured of synthetic fiber shall be 5 years (unless otherwise specified by the manufacturer) or sooner if determined unserviceable per AFI 91–203, paragraph 13.4.6.2.1. The 5-year service life begins once the equipment is put in service, assuming the new, unused equipment is stored in a climate-controlled location (i.e., in a plastic bag not exposed to vapors, and in a cool location out of direct sunlight). Supervisors shall ensure all personal fall arrest safety (PFAS) components receive a thorough inspection at least quarterly. This inspection shall be documented and maintained for at least one year.

Inspect each harness constructed of leather for deep cuts or deep open scratches and cracks; damaged grain; loose or missing rivets or stitching; open holes or tears; burnt leather; broken, cracked, or deformed D-rings, snap hooks, plates, and buckles; or a bent, broken, or missing snap hook keeper latch. Any of these defects is cause for rejection of the piece of equipment.

Lifelines

Synthetic or cotton-blend lifelines of required length are provided for use when inspecting or cleaning both underground and aboveground tanks. The lifeline should be long enough to extend to the furthest point in the tank plus a few extra feet. The lifeline need not be attached to the personnel harness, but one end should be attached to the manhole or adjacent to it.

Tank-cleaning personnel must wear a full-body harness assembly. When an emergency arises requiring removal of these personnel from the tank, hand-carry the end of the lifeline to the "prone" individual and attach it to that person's harness. This will enable the rescuers to pull the individual to the access way of an aboveground tank or to the bottom of the ladder of an underground tank to be hooked up to the tripod/winch for tank removal.

Lifelines (ropes) must be inspected and identified or marked before being used and checked for any cuts, chafe, or nicks; bulged strands; knots in individual strands; improperly attached end fittings (i.e., severed, spliced, wrapped, etc.); abnormal weaknesses detected visually; or discoloration or rotting. Anyone of these defects is sufficient basis for rejection. An approved lifeline must be capable of supporting a minimum deadweight of 5,400 pounds (per person) applied at the center of the lifeline. Clean lifelines with warm soapy water and let air dry before storing them.

Lanyards

Lanyards are used both to restrain workers in position and to arrest falls. When using a lanyard as a restraining device, keep the length as short as possible—a restraining lanyard should not allow a worker to fall more than 6 feet. Restraining lanyards are available in a variety of materials, including steel cables, rebar chain assemblies, and nylon rope or straps. Fall-protection lanyards can be made of steel, nylon rope, or nylon or Dacron webbing. Fall-protection lanyards may also have a shock-absorbing feature built in, thus reducing the potential fall arrest force. Keep lanyards as short as reasonably possible to reduce the length of a free-fall. Never permit a vertical fall of more than 6 feet (1.8 meters [m]) or contact with the lower level.

NOTE: Lanyards that have been subject to *impact loading* from a falling person or weight test must be removed from service and destroyed.

Tie-off points

A tie-off point is a fixed anchor location where the lanyard or lifeline is attached to a structural support. This support must have a 5,000-pound capacity for each worker tying off. Workers must always tie off at or above the D-ring point of the belt or harness. This ensures that the free-fall is minimized and that the lanyard does not interfere with personal movement. Workers must also tie off in a manner that ensures no lower level will be struck during a fall.

Connection devices

Connection devices attach the harness to the final tie-off point. This can be one device, such as a lanyard, or a combination of devices, such as lanyards, lifelines, work lines, rope grabs, tie-off straps, and carabineers.

Other devices

For CS applications, a tripod and winch system is used as both the tie-off point and the connection device. It is used in conjunction with a full-body harness to lower and raise workers into tanks or manholes. Make sure the tripod system you choose is designed for your application. Never use a material-handling device (i.e., tool bucket rope) for personnel unless it is specifically designed to do so. The tripod and winch system is commonly set up over underground and cut-and-cover tank access ways, as well as storm and sewer line manholes.

Inspection and maintenance

If you are to conduct operations and maintenance properly within CSs, you should know some details about the safety equipment and special training it requires. To develop confidence in the equipment, you must periodically use, inspect, clean, maintain, and train with the equipment. Follow the manufacturer's instructions for cleaning and maintenance. Once a system is in use, monitor its effectiveness to determine its continued use.

Fall-protection and rescue equipment may be locally or centrally procured. All equipment purchased must meet or exceed the requirements outlined in ANSI Z359.1, *Safety Requirements for Personal Fall Arrest Systems, Subsystems and Components.* Only commercially manufactured fall and rescue equipment must be used. The use of "homemade" or modified equipment is strictly prohibited. Equipment purchased must have the manufacturer's name and identification code and the date of manufacture stamped on the equipment or on a permanently attached tag. The free end of lanyards of synthetic materials must be lightly seared and, in the case of natural fiber rope, must be seized (whipped).

Supervisors must maintain manufacturer's performance testing information for the personal fall arrest system being used. The fall arrest system must meet test requirements of 29 CFR 1926, *Safety and Health Regulations for Construction*, Sub-Part M, *Fall Protection*. Users of fall arrest systems must comply with TO 00–25–245 and all manufacturer instructions regarding the inspection, maintenance, cleaning, and storage of the equipment. The using organization must maintain copies of the manufacturer's instructions.

At a minimum, all fall arrest system equipment must be thoroughly inspected before each use and at least once annually using the criteria found in TO 00–25–245 and the manufacturer's manuals. More inspections will be conducted if directed by the manufacturer or at the discretion of the using organization. When inspection reveals defects, damage, or inadequate maintenance of equipment, the equipment must be immediately tagged as "unserviceable" and removed from service. The equipment must be repaired before it is returned to service. Here are some examples of components that must be removed from service:

- Components with an absence of or illegible markings.
- Equipment missing any items affecting the equipment form, fit, or functions.
- Equipment showing evidence of defective or damaged hardware elements. This evidence includes distorted hooks or faulty hook springs; tongues unfitted to shoulder buckles; loose or damaged mountings; non-functioning parts; cracks, sharp edges, deformation, corrosion, chemical attack, excessive heating, alteration, deterioration, contact with acids or other corrosives; and excessive wear.
- Equipment showing evidence of defective or damaged straps or ropes. This evidence includes fraying, unsplicing, unlaying, kinking, knotting, roping, broken or pulled stitches, excessive elongation, chemical attack, excessive soiling, cuts, tears, abrasion, mold, undue stretching, alteration, needed or excessive lubrication, excessive aging, contact with fire or other corrosives, internal or external deterioration, and excessive wear.
- Equipment showing alteration, additions that may affect efficiency, absence of parts, or evidence of defects in, damage to, or improper function of mechanical devices and connectors.
- Equipment with an overdue recertification date.
- Body harnesses, lifelines, lanyards, and safety ropes with a maximum usable date in excess of 5 years from the date of manufacture.

Inspect harnesses, lifelines, and lanyards at least every 6 months. Your MAJCOM or base may direct the recording of inspections either on the piece of equipment, on a tag attached to the equipment, or on a paper- or computer-based equipment log. Air Force Technical Order (AFTO) Information Management Tool (IMT) 244, Industrial/Support Equipment Record, is commonly used.

Read TO 00–25–245 to ensure all inspection criteria is accomplished. Follow the manufacturer's instructions for inspections and maintenance on all other safety equipment, such as tripods and winches.

The user organization must maintain and store equipment according to the manufacturer's instructions and retain the manufacturer's instructions for reference. Unique issues, which may arise due to conditions of use, shall be addressed with the manufacturer.

Equipment that is in need of or is overdue scheduled maintenance must be tagged as "unserviceable" and immediately removed from service. Equipment must be stored in a manner to preclude damage from environmental factors such as heat, light, excessive moisture, oil, chemicals and their vapors, or other degrading elements.

It is common practice to interchange lanyards, connectors, lifelines, deceleration devices, and body harnesses since some components wear out sooner than others do. However, *not* all components are designed to be interchangeable. Follow manufacturers' guidance when replacing out-of-service equipment.

Training

As with all training, the shop must develop clear measurable objectives to make sure each worker is properly trained. Personnel using fall arrest systems must be trained in the safe use of all fall arrest system components before initial use and at least every 12 months. This training must include application limits; proper anchoring and tie-off techniques; estimation of free-fall distance, including determination of deceleration distance and total fall distance to prevent striking a lower level; methods of use; inspection; and storage. When personal fall arrest systems are used, the supervisor must make sure that workers can be properly rescued or can perform self-rescue should a fall occur.

Tools

Ordinary and non-sparking hand tools are used on a tank-cleaning job. You can use the tool box, issued by the AF; however, be cautious. If volatile vapors are present, use tools in such a way as to avoid sharp blows that could cause sparks. Non-sparking tools are usually made of tempered brass or bronze alloys and hard molded plastic. Care must still be taken with non-sparking metal tools because the components you use these tools on may not have non-sparking surfaces. Shovels, scrapers, or scoops are normally made of plastics that do not pose a friction spark hazard.

Where necessary, cleaning equipment (e.g., buckets, scrapers, squeegees, rags, mops, brooms, brushes, and scoops) will be provided. Do *not* use brooms or brushes that have plastic or synthetic bristles, because synthetic material is *not* authorized. Buckets are used to lower/raise small tools inside underground tanks as well as hand carrying solids and sludge out of a tank for disposal.

Inspect all tools for serviceability. If a tool becomes damaged, attempt to repair it to the original serviceable condition. If the tool is not repairable, notify supervision and have the tool replaced.

212. Preparing tanks for entry, cleaning, and return to service

This is the most important part of the process, so pay special attention to safety. Take your time and look at everything to ensure no object is missed.

Preparing tanks for entry

Planning and vigilance in the cleaning of petroleum storage tanks will help to avoid injury or property damage that may result from fire, explosion, or fuel vapor exposure.

The TES should review any records pertaining to the history of the tank to include any modifications and repairs and any mechanical drawings to aid in formulating an inspection list and identifying safety hazards.

Possible ignition sources will be removed from the surrounding area. Consider, too, the existing wind and weather conditions. Do not start working if the direction of the wind might carry vapor into any area where it could produce hazardous conditions or when an electrical storm is threatening or in progress. An advanced call to the base’s weather flight is recommended to obtain local weather conditions for the duration of the tank-cleaning operation.

WARNING: If lightning is sighted within 5 miles, stop all operations immediately.

Remove as much of the petroleum product as possible. This is usually done by POL personnel using the installed pumps. Any remaining fuel must be removed by portable pumps. Fuel must be pumped or drained off to the lowest possible level. Equipment used for pumping sludge and excess water and fuel from tanks should be the air-operated, double-diaphragm type, with an exhaust outside the tank. Do not use electric- or internal-combustion, engine-driven equipment unless it can be placed a minimum of 50 feet upwind of the tank for tanks without dikes, or just outside the dike on diked tanks.

Disconnect all pipelines connected to the tank and remove the valves, when feasible. Be sure to install a bonding cable between the pipe flanges before attempting such removal. Blind flange or plug the ends of the pipe to prevent the return of any vapors or fuel to the tank. (Do *not* rely on closed valves alone to serve this purpose.) The blind flanges must be thick enough to withstand any system pressure to which they may be subjected. If used, spectacle blinds must be inserted between the tank valve and the flange nearest the tank. Insert gaskets on both sides of the spectacle blind.

CAUTION: Do *not* remove valves or disconnect piping from any tank until you are positive that the line has been emptied of fuel, any impressed-current cathodic protection has been turned off, and the bonding cable has been installed between pipe flanges.

Before a floating roof or pan tank is taken down for internal inspection or cleaning, the tank-cleaning supervisor inspects the pin location on the tank's adjustable legs to ensure proper settling of the roof or pan.

On underground tanks where connecting lines are buried, blind off the lines at the nearest exposed valve box.

By physically surveying the entire area around the tank to be cleaned, the tank-cleaning supervisor makes sure that no vapors are present in pits or low areas, that unauthorized personnel are cleared from the area, and that there is no possibility of anyone smoking in the immediate vicinity. Therefore, all personnel entering the area must leave all cigarettes and flame-producing devices at a previously determined location.

The tank-cleaning supervisor also makes sure that all equipment is placed upwind of the tank openings. Such equipment should be put at the highest elevation possible—never in an area lower than the surrounding terrain. Do not use artificial lights other than explosion-proof portable battery-powered safety lanterns inside the tank until the tank is vapor-free.

Make sure any portable lights used outside the tank, in the potential vapor travel from the tank openings, are of the explosion-proof type. These lights must be connected to a 3-wire extension cord that is equipped with connectors or switches approved for hazardous locations. A qualified electrician should inspect such equipment thoroughly for shorts, proper grounding (3-wire system), and defects before using it. Specifically identify all lighting equipment for tank-cleaning purposes *only*.

Inspect motors before they are used to make sure that they are explosion-proof and designed for use in hazardous areas. Check motor and bearings for local heating. Lubricate them, if necessary, with lubrication recommended by the manufacturer.

Before using the grounding and bonding cable connection points, wires, and clips, inspect them for good condition, and check electrical continuity with a multimeter. Replace the cables immediately if insulation or wires are damaged or broken, and repair any damaged cable-clip connections.

Before using gasoline engine-driven equipment, inspect it to make sure that the engine is equipped with a flame arrester and a protected ignition system. Also, inspect the engine for gasoline and oil leaks, and repair all leaks before starting the engine. Test equipment to make sure it is in proper operating condition.

Tank ventilating and vapor-freeing

Always use natural ventilation to help in the removal of tank vapors. Remove the roof and shell manhole covers, and allow air to circulate freely through the tank. To augment tank ventilation, use eductor-type air movers like the coppus blower or the Lamb air mover to suck the air out of the tank. Blowing air into the tank tends to stir the vapors in the tank rather than remove them.

The location of tank ventilating equipment is determined by local conditions. Although eductors may be used through bottom manholes on an aboveground tank, it is preferable that top manholes or vent piping be used on both aboveground and underground tanks. Using eductors on top of the tank allows for dispersing the vapors, thus preventing them from settling in low places at ground level.

Continue ventilation until the tank is essentially vapor-free, or until the fuel vapors in the tank have been replaced with fresh air. The principal consideration in vapor-freeing a tank is the removal of fuel-sludge and the disposal of displaced vapor in a way that will minimize the possibility of any hazardous condition (toxicity, asphyxiation, fire, and explosion) inside the tank and in the surrounding area.

Initial cleaning

After ventilation, initial cleaning from outside the tank is an option to consider. This is done by using pressurized water directed into the manways to force as much sludge and fuel as possible to the sump where it can be pumped out into waste containment. It is important to continue ventilation during this process to maintain air circulation within the tank, because the stirring of the sludge will increase the LEL. If the vapor LEL reaches 20 percent or higher, suspend washing and resume ventilation until a safe LEL is obtained.

Pumping equipment used for the removal of sludge and excess water from tanks should be of the air-driven, double-diaphragm type, with the air exhaust to be located outside the tank.

If an electric- or fuel-driven pump is used to remove residuals from the tank, it must be constantly manned to start and stop pumping operations. Each time the equipment is to be started, first test the area for explosive vapors. Also, *always* stop a gasoline engine to refuel it.

Tank inspection and cleaning

After the initial cleaning of the tank from the outside (when performed), continue ventilation and take vapor readings at the manhole or equipment exhaust to determine when entry can be made to complete the cleaning. If vapor levels are below 10 percent of LEL, workers may enter the tank with the approved supplied air respirators.

No work will begin in the tank until the initial vapor readings are below 10 percent LEL. However, if efforts to bring the LEL below 10 percent are unsuccessful, the TES will notify the MAJCOM fuels engineer, who considers all relevant information to determine if tank-cleaning work will proceed.

Before the first worker enters the tank, the TES will perform an initial inspection of the interior of the tank. When inspecting the tank, the TES will look for and notify all entrants of any physical hazards. Collision hazards to watch for might be low hanging pipes, floating-roof drain lines, mechanical-tank gauge floats or automatic-tank gauge probes, or pantographic hangers for floating-roof seals. Examples of tripping hazards are water stripping or product drain lines, sumps, and warped floor plates.

CAUTION: Floors coated with epoxy will be slick. Use extreme caution when walking on epoxy-coated floors.

After the TES's initial inspection, the workers enter the tank while vapor monitoring continues, and readings are recorded every 15 minutes. This is important because as the workers perform their cleaning operations, the movement of fuel sludge can generate increased vapor concentration. If these concentrations reach 20 percent LEL, the work must stop, the workers must leave the tank, and ventilation must resume to reduce the LEL below 10 percent. The tank-cleaning operations will then proceed with the expeditious removal of any remaining sludge and puddles of fuel to keep the LEL as low as possible. Constant ventilation is an option to keep the LEL down, as long as it does not interfere with the workers' ability to exit the tank in an emergency.

Workers will use squeegees to push as much sludge and liquid to the tank's lowest point, usually the sump, where hoses connected to an air-driven, double-diaphragm pump will remove it from the tank. Workers will remove all solids and liquids and scrape the bottom of the tank and 3 feet up on the sides until all loosely adhering rust and scale has been removed. They will then wash or wipe down the remainder of the tank and components that show signs of dirt or sludge residue. Workers will use buckets, shovels, scoops, and rags to remove any remaining sludge from the sump, and then they will wipe it clean.

Even after the tank is clean, fuel and fuel vapor can still leak from, or be produced by, the internal components such as pan compartments, pan seals, and support legs. For this reason, vapor readings will continue during any repairs, modifications, and the TES's final inspection. Entry into a fuel tank without any protective equipment is not authorized until the tank has been cleaned, dried, zero percent LEL is sustained, verifiably never contained leaded products, and the BEE has approved the entry by verifying the tank does not contain any other toxic substance above permissible levels. Vapor and O_2 readings must be entered on AF IMT 172, Tank Inspection Summary (fig. 1–22).

TANK INSPECTION SUMMARY	1. DATE 20071012	2. PROJECT/WORK ORDER/JOB NO. 25374	*FORM APPROVED* *OMB NO. 0704-0188*

Public reporting burden for this collection of information is estimaed to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Sending comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to the Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project 0704-0188 Washington DC 20503. Please **DO NOT RETURN** your form to either of these addresses. Send your completed form to: **HQ AFESC/DEMM, TYNDAL AFB FL 32403-6001.**

3. INSTALLATION	4. LOCATION	5. COST OF WORK *(Include labor)* 6. IN-HOUSE	7. CONTRACT
MALSTROM AFB	GREAT FALLS, MONTANA	$ 4452.00	

8. FACILITY NO.: 41101

9. TANK NO.: S-1

10. TYPE OF TANK

[ ] INVERTED BOTTOM	[ ] UNDERGROUND	[ ] ABOVE GROUND
[ ] BOTTOM COATING	[ ] ENTIRE COATING	[ ] FLOATING ROOF
[ ] FLOATING ROOF W/COVER	[ ] CONE ROOF	[X] CONE ROOF W/FLOATING PAN
[ ] OTHER *(Specify)*		[ ] HORIZONTAL

11. NAME OF CONTRACTOR *(If applicable)*

12. ADDRESS OF CONTRACTOR *(Include Street, City, State and Zip Code)*

13. DEGREE OF RUSTING

[ ] HEAVY [ ] MEDIUM [ ] LIGHT

14. LOCATION OF RUSTING *(Specify wall, bottom, roof)*
NONE

15. BOTTOM OR SIDES OF TANK WERE PITTED *(If yes, state action taken to repair pits and prevent further corrosion.)*

[ ] YES [X] NO [ ] LOCALIZED [ ] RANDOM

16. GENERAL CONDITION OF TANK AND APPURTENANCES INCLUDING ADEQUACY OF BOTTOM SLOPE AND WATER SUMPS
EXCELLENT

17. TANK COATING WAS IN GOOD CONDITION *(If no, explain.)*

[X] YES [ ] NO [ ] NONE [X] EPOXY [ ] POLYURETHANE

18. MAJCOM AUTHORITY TO ENTER TANK *(Approval date)*
20071003

19. DATE WORK STARTED
10 Oct 2007

20. REASON FOR ENTRY

[ ] INSPECTION [ ] FUEL CONTAMINATION [X] CLEANING

21. REMARKS *(Use Reverse for Additional Space)*
VAPOR READINGS

DATE	TIME	LEL	DATE	TIME	LEL
----------	-------	-----	--------	-------	-----
10 OCT 07	1000	12%	10 OCT 07	1430	2%
10 OCT 07	1015	10%	10 OCT 07	1445	0%
10 OCT 07	1030	8%	10 OCT 07	1500	0%
10 OCT 07	1045	11%	10 OCT 07	1515	0%
10 OCT 07	1100	9%	10 OCT 07	1530	0%
10 OCT 07	1115	7%			
10 OCT 07	1130	4%	11 OCT 07	0900	0%
10 OCT 07	1145	2%	11 OCT 07	0915	0%
10 OCT 07	1200	0%	11 OCT 07	0930	0%
10 OCT 07	1215	0%	11 OCT 07	0945	0%
10 OCT 07	1230	0%	11 OCT 07	1000	0%
10 OCT 07	1245	0%	11 OCT 07	1015	0%
10 OCT 07	1300	0%			

22. NAME OF MAJOR AIR COMMAND AUTHORIZED REPRESENTATIVE	23. POSITION TITLE
JAMES C. LEIGLAND	LFM FOREMAN
24. SIGNATURE OF AUTHORIZED REPRESENTATIVE	25. CERTIFICATION NO. AMC 201

AF IMT 172, 19910201, V1 PREVIOUS EDITION IS OBSOLETE. LFM SHOP COPY

Figure 1–22. Sample, AF IMT 172.

The fuel-water-sludge mixture must be contained in drums or a portable tank and disposed of as directed by the BCE environmental coordinator.

Return to service

Once the tank is clean and you have made any repairs, you are ready to put the tank back into service. Use new gaskets when re-attaching pipeline components and manway covers. When you put the system back into service, you and POL must refill the tank(s) very slowly to avoid static generation. Flow through the receipt or fill line during the initial fill should not exceed 3 feet per second until the entire fill pipe inside the tank is covered or the floating pan or roof is floating. After the tanks are full and the system has been checked to make sure that all components are working and nothing leaks, the tank is now operational.

213. Deactivating a fuel system

If the fuel system is to be out of service for a short period of time, you must do maintenance to a degree in keeping with the expected period of time that the system will *not* be used. You have to protect against rust, dirt, and water getting into the fuel system. Remember, if you don't take care of your system while it is down, when you go back to use it again, it may not only take more man-hours to get the system operating well but also will cost more in materials.

Tank discontinuance

When you stop using a fuel system, you must take care of many problems. You have to protect the equipment from rust, dirt, water, heat, and freezing. The big problem is in eliminating the hazards of fire in the area. This means cleaning up all fuel spillage in the area. Some of the more important things to consider are to physically disconnect from all active fuel systems, remove all fuel, clean the tanks, and comply with state and local environmental requirements.

Cone-roof-type tank

The tanks must be emptied and cleaned, if necessary. The pipelines should be disconnected from the tank nozzles and the openings blind flanged. All small bypass lines should be removed from the tank. Water draw-off valves must be secured in the OPEN position and a wire screen must be fastened over each of the valve openings to stop rodents from entering the tank. Also, the roof pressure-vacuum vent pallets must be blocked in the OPEN position. Take the side plate from the automatic float gauge, oil the gauge mechanism, and put the plate back in place. Remove the pipe plug or valve from the counterweight housing drain opening. Place the dike drain line valve in the OPEN position and put a heavy coat of grease on the valve stem and threads. Replace all manholes that were removed during tank work. Fill tanks located in areas where high winds occur partially full with fresh water containing an inhibitor to prevent the tank from blowing over. At sites where water may freeze solid, you may use light oil or kerosene instead of water.

Floating-roof-type tanks—pontoon and double-deck

Place the roof support legs at their highest level before all of the fuel is out of the tank, and clean the tank. After cleaning the tank and treating the area under the roof, disconnect the roof drain line at the roof junction and tank shell. Store the line in the tank. Remove the drain line roof plug and valve from the water draw-off end and place a wire screen over the opening where the valve was removed. Place the valve and plug in the tank. On the tank, stencil that items are therein and make sure the drain line has been disconnected. In areas where freezing weather seldom occurs, drain line removal is not required; only the removal of the roof plug and valve is necessary. Tank roofs that will be subject to snow and ice loads greater than 25 pounds per square foot must be shored with 4-inch by 4-inch timber to prevent damage to the roof.

Underground tanks

For the abandonment of tanks in place to occur, a final determination as to whether to abandon or to remove these must be left up to the government or the leasing real estate agency. The decision will be based on labor, materials, available equipment, cost, and environmental concerns. The age of the tank and the possible reuse or salvage value is also a factor to consider. If there is any doubt, the removal of a tank is the preferred way, and for tanks of 2,000 gal. or larger capacity, removal usually is more economical. If the tank or tanks are left in place, you have additional work to do, which is outlined in the following paragraphs.

Do a soil and groundwater analysis to determine if a fuel release occurred. Review and comply with 40 CFR 280, *Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)*, and any applicable state and local environmental regulations. If allowed by federal, state, and local regulations, do closure in place, as outlined in API Recommended Practice (RP) 1604, *Closure of Underground Petroleum Storage Tanks*. However, this alternative may be more expensive than removal for small volume tanks. Abandoning in place also impedes soil clean-up and future land use.

If removal is required, excavate and dispose of the tank in accordance with API RP 1604. Remove all products from it or them. Disconnect, drain, and cap or plug all product lines. Remove all equipment and pipe stubs that are on the tank or tanks, and plug or cap openings. Fill the tank or tanks with sand and earth through the manhole until the material is near the top. The remaining required material can be washed into the tank or tanks with a small amount of water to cause it to flow to the tank ends. Backfill all excavations and equipment pits with earth, allowing for settling of the material.

Procedures for removing tanks for reuse or salvage are the same as those for abandoning tanks, except that you do not fill them with sand and dirt and remove vent lines and plug openings. You will excavate the earth from over and around such tanks and cut the hold-down straps. These tanks can then be rolled or lifted from foundations to an area where flushing can be done, if necessary. Tanks that have had jet fuel or leaded gasoline must be flushed thoroughly to free them of product and leave them free of product vapors. You can use pressurized water to do the flushing. You remove vapor fumes by using an air eductor. After completing the work, close all tank openings and position the tank or tanks so that the manhole is on top. Now that the tank preparation is complete, it is important to properly make and stencil the tank in order to identify the tank's current state.

Tank stenciling

Stencil the following on the ends of a tank or tanks that contained jet fuel:

WARNING: Tank may contain hazardous vapors. Vapor test before entering.

You must drain a tank or tanks that had fuel oil, diesel oil, or lubricating oil after removing it or them from the foundations. Then close all openings. Stencil the kind of product that was contained within on both ends of the tank or tanks.

Where tanks are so treated, the tank that has contained leaded gasoline must have the following warning stenciled on it:

WARNING: This tank previously contained leaded gasoline and is not safe for storage of any material destined for human or animal consumption.

DO NOT ENTER THIS TANK WITHOUT THE PRIOR APPROVAL OF THE MAJOR COMMAND.

Pipeline discontinuance

When discontinuing a pipeline, drain and flush all piping and then cap or close it off with flanges. Before any hot work is authorized on gasoline pipelines or before they are removed for any purpose, the pipeline must be vapor-freed using water or steam. Excavate the line only if required by federal, state, or local regulations or if deemed necessary for land reuse.

Electrical discontinuance

When discontinuing pumps and motors, clean and lubricate them thoroughly. Do not leave pumps and motors in pits or other locations where they are subject to damage by water and dampness. Instead, remove them and store them in a dry place. When permanently disconnecting and removing any piece of electrical equipment, disconnect the wires for that item from the source of power and cover both ends of the wire with wire nuts. Then label the wires as abandoned either on the service junction or on the wires themselves using a piece of tape. This prevents confusion over a dead circuit and accidental electrocution from an unnecessarily energized circuit.

Mechanical equipment and fittings discontinuance

When discontinuing the use of F/Ss, drain all fuel, remove the filter elements, and thoroughly clean and lightly coat their interiors with oil. Remove all float-control valves, tank-capacity gauges, mechanical and electrical low-level pump shutoff switches, and other equipment subject to damage in UST equipment pits. Cap, plug, or blind-flange the tank openings. Meters in pits that are subject to being flooded must be drained, removed, lubricated, and placed in storage. In contrast, drain meters that will not be subject to flooding, flush them with light oil, place tape over the counter unit, and leave them in place. Also, lubricate internally gate valves, plugs valves, solenoid valves, and so forth, and leave them in the open position, if possible. In addition, clean the hydrant system, apron fueling, and outlet pits, and seal the covers to stop water and foreign material from getting into the pit. Finally, before sealing the covers, place waterproof tape over the valves.

Inventory

Prepare an inventory of valuable fueling equipment that could be easily salvaged and reused at another base. Equipment such as pantographs, control valves, pumps, and filtration equipment are always in demand. Submit the list to your command fuels engineer.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

209. Pre-entry requirements

1. The MAJCOM fuels engineer must be notified a *minimum* of how many workdays before the proposed entry date?

2. Who is responsible for removing fuel from the tank to the *lowest* point possible through the installed pumps?

3. What are the responsibilities of the tank-cleaning supervisor for tank-cleaning projects to be done in-house?

4. What are the responsibilities of the MAJCOM fuels engineer’s representative when a tank-cleaning project is performed by contract?

210. Safety hazards and precautions

1. What is used to determine the vapor concentration in a given area?

2. Which fuels contain benzene?

3. To avoid the hazards of excess fuel vapors, under what conditions can an initial entry into a fuel tank be made?

4. What is the vapor testing protocols when workers are in a fuel tank?

5. Where is all equipment used in a tank-cleaning operation located?

6. What items are forbidden and must not be carried by tank-cleaning personnel?

7. What are the primary means of rescue during tank-cleaning operations?

8. Who is normally the “centrally located rescue team” that provides rescue service?

9. How many members of the rescue team must have CPR training?

211. Specialized clothing, equipment, and tools

1. Who is responsible for ensuring that PPE is provided, used, and maintained?

2. Who is responsible for complying with PPE requirements?

3. Why can’t safety helmets be painted?

4. What clothing material produces the *least* amount of static electricity?

5. What type respirator is used for tank entry and what condition is it approved for?

6. Air lines for respirators must not exceed what length? Who can approve longer air hoses?

7. Specify the type of electrical equipment and conductors that can be used within 50 feet of fuel pipes of storage tanks, according to the *National Electrical Code*.

8. Whose approval is required on lights used during a tank-cleaning operation, and what type must they be?

9. All gasoline-driven equipment used in a tank-cleaning operation must be equipped with *what* and positioned *where*?

10. At what heights should fall protection be used?

11. What information must be on stamped on a safety harnesses or contained on its permanently attached tag?

12. What is the maximum distance that a lanyard should allow a worker to fall?

13. What must the capacity be for each worker tying off to the tie-off support point?

14. At a minimum, how often must all fall arrest systems be inspected?

15. What is the service life of lifelines?

212. Preparing tanks for entry, cleaning, and return to service

1. What weather condition would cause the immediate halt of tank-cleaning operations?

2. What must be done before disconnecting piping on a tank?

3. During initial cleaning, at what vapor reading must you temporarily suspend washing down the tank?

4. After sludge has been removed, what part of the tank should be scraped to remove rust and scale?

5. How is the remaining portion of the tank cleaned?

6. Who will direct the disposal of fuel-water-sludge mixture from a tank cleaning?

7. When returning a tank to service, how do you refill and empty tank?

213. Deactivating a fuel system

1. List the problems that discontinuance of a fuel system can present.

2. In a floating-roof tank, where would you store the drain line?

3. What size lumber would you use to support a floating roof to prevent damage?

4. What must be stenciled on a deactivated leaded MOGAS tank?

5. What steps do you take when you are going to discontinue use of an F/S?

1–3. Fuels Support Equipment

The two pieces of specialized equipment that are vital to fuels maintenance are the vapor indicator and the air compressor. As you found out in the previous section, both pieces of equipment are very important to tank cleaning. We cannot perform tank-cleaning operations without them.

214. Vapor indicators

The manufacturers of combustible gas or vapor indicators have used various descriptive trade names. These have led to the acceptance in the industry of the following terms: “vapor indicator,” “explosion meter,” “combustible-gas indicator,” “gas indicator,” and “gasoline-vapor indicator.” The instruments used to detect a vapor-air mixture should use photo-ionization detection technology.

The importance of the vapor/O_2 indicator

Before the invention of the vapor/O_2 indicator, miners, oil field workers, and other people who worked in hazardous, explosive atmospheres depended on their noses. Later, other types of crude vapor indicators were available besides the nose, but today they would probably horrify the Humane Society personnel. Some of these antiquated methods were mice and birds placed in suspected hazardous areas. If they lived, those areas were assumed safe; if they died, you waited a little while longer or ventilated the area.

NOTE: You and your coworkers' lives depend on this instrument! Therefore, *never* trust your nose or think you will *not* be in the hazardous atmosphere long enough for the vapors to affect you. The AF provides you with this instrument and a fresh-air respirator for your protection. Use them!

Types of indicators

The standard indicator the AF had adopted for measuring jet fuel vapors is the RAE System's MultiRAE PGM–50 photoionization detector (PID), national stock number (NSN) 6665–01–457–0472, part number (P/N) 009–3001–01N. PIDs shine ultraviolet light on a vapor sample and measure the electrochemical activity to determine the amount of vapor in the air. Regardless of the type of indicator you have, before using it, you must be trained thoroughly and use the manufacturer's instructions and calibration curves charts.

When to use indicators

Any time you suspect vapors in an enclosed area, take the indicator with you and check the atmosphere. Inhalation of petroleum vapor concentrations greater than 500 parts per million (ppm) will produce a stage of excitement, eventually leading to unconsciousness. Furthermore, if you breathe petroleum vapors in a CS, you may asphyxiate rapidly and die because of O_2 deficiency. Locations where you will need to use a vapor indicator to take vapor/O_2 readings are in and around F/Ss, inside pits, and inside tanks. Keep in mind, it can be used anywhere you feel the need to protect yourself and others. Also, keep in mind that these areas must also need to be checked for O_2 levels. Only an atmosphere between 19.5 and 23.5 percent O_2 is safe for you to enter.

F/S

If you change elements on an F/S, you can be exposed to large concentrations of fuel vapors. Unless the F/S is located outdoors with good ventilation all around you, you will probably need to wear respiratory equipment. Take vapor readings inside the vessel and periodically around the work area.

Pits

A positive mechanical means of ventilation should be provided for all below-grade pits with installed pumps or pits of more than 6 feet in depth that personnel must enter. Note, however, that positive mechanical ventilation is not, in itself, a sure sign of safety. Vapors are heavier than air, so whenever you work in a CS where fuel might be leaking, or when you have drained a section of the system for repairs, take a vapor/O_2 reading.

Tanks

There are maintenance requirements for floating-roof tanks and all-weather tanks that will necessitate you climbing up and inside them. Again, before descending down onto the floating roof or pan of these tanks, you must take readings, and you must continue to take these readings while you are working on or inspecting such tanks.

During tank entry, inspection, and cleaning, not only is it important for you to take readings, it is also mandatory. You must document the readings on the AF IMT 172 every 15 minutes you are within the CS.

Major components

The automatic toxic-gas alarm consists of an indicator with a wrist-carrying strap, rubber cover, inlet probe, dust filters, charcoal filters, battery adapter, and recharging adapter. The accessories kit includes the hard transport case, remote-sampling probe with a 6-foot polytetrafluoroethylene (PTFE) hose, and a tool kit. The calibration kit includes male and female regulators with tubing and calibration gas.

Safety

Use only specified components for parts replacement. Substitution of components may impair intrinsic safety.

The sniffer has been certified intrinsically safe for use in class I, division 1, group A, B, C, and D areas. Do not use the sniffer in O_2-enriched areas that are known to have an explosive gas/air atmosphere with an O_2 concentration greater than 20.9 percent. Charge sniffer batteries only in non-hazardous areas, preferably, in the shop the night before you use them.

Do not use or store the gas cylinder near heat or open flame. Store and use it with adequate ventilation. De-pressurize (empty) it before preparing it for disposal. Dispose of spent cylinders safely and in the manner prescribed for non-reusable pressure vessels. Consult the base environmental office for required disposal precautions.

The combustible sensor and main printed circuit board contain electrostatic discharge sensitive (ESDS) devices. ESDS is applied to low-power, solid-state parts that could be damaged or destroyed when exposed to discharges of static electricity.

Sniffer familiarization

The dimensions of the PGM–50 vapor indicator (fig. 1–23) are 4.65 inches long x 3 inches wide x 1.9 inches high. The weight of the indicator is 16 ounces.

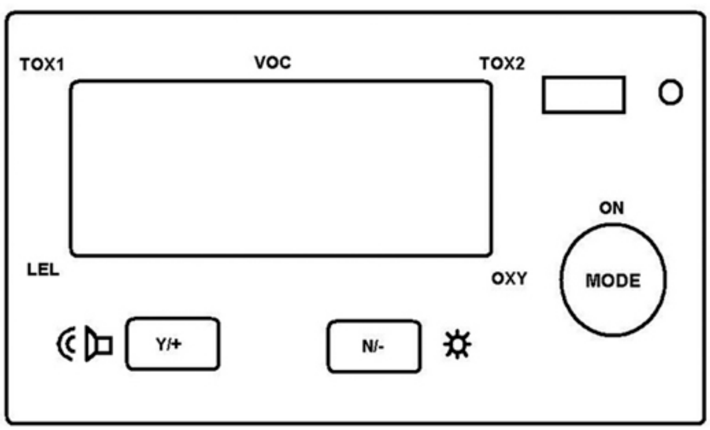


Figure 1–23. MultiRAE PGM–50 vapor indicator faceplate.

The power supply is an internal rechargeable sealed lithium-ion battery. A fully charged battery supplies 4.8 volts. Discharged voltage is 4.2 volts. Run time with a fully charged battery is around 10 hours. When the low-battery alarm sounds, you have about 15 minutes of operating time left. Recharge time is 10 hours from full discharge. The units should be stored plugged in to the charger, as the internal sensors can deplete the battery. If the indicator is going to be stored for more than two weeks off its charger, remove the battery unit.

The standard sensor package that comes with the PGM–50 is for volatile organic compounds (such as hydrocarbon fuel vapors), LEL, O_2, carbon monoxide (CO), and hydrogen sulfide (H_2S). The following gases may be detected, depending on the sensors installed in the indicator:

TYPES OF GASES	
volatile organic compounds (VOC)	hydrogen cyanide (HCN)
methane (CH_4)	nitric oxide (NO)
O_2	nitrogen dioxide (NO_2)
H_2S	phosphine (PH_3)
CO	sulfur dioxide (SO_2)
ammonia (NH_3)	chlorine (Cl_2)

Detection ranges

The different sensors in the MultiRAE can only display gases and vapors below a certain concentration. The detection ranges are given in the chart below.

Sensor	Range
VOC	0–2000 ppm
LEL	0–100 percent
O	0–30 percent
CO	0–500 ppm
H_2S	0–100 ppm

CAUTION: If the O_2 level is below 10 percent, the LEL will not read accurately!

Alarm set point

There are two alarm points for each sensor—low alarm and high alarm. The alarm set points are user adjustable. For our purposes, have precision measurement equipment laboratories (PMEL) set the low LEL to alarm at 10 percent and the high LEL alarm at 20 percent. For O_2, the low alarm is factory set to low alarm at 19.5 percent O_2 and high alarm at 23.5 percent O_2.

Gas concentrations and battery voltage are continuously compared against alarm set points. These alarms can be set to automatically reset after the hazardous condition is cleared, or to remain in alarm mode until manually reset. To manually reset the alarms, sample fresh air for 60 seconds and press the Y/+ button. Below are different indicator alarms:

- Low battery alarm—when battery voltage reaches minimum recommended charge level of 4.4 volts, the detector will beep once every minute and the word “BAT” will appear on the display. After 15 minutes, or when the battery voltage reaches 4.2 volts, the sniffer shuts down.
- Pump stall alarm—if the sampling pump is unable to draw air, the alarm will activate and the word “Pump” will appear on the display. Clear any obstructions, acknowledge the alarm by pressing the Y/+ button, and the pump should restart.
- Low O_2 level—the indicator will flash and beep twice a second and display “OXY LOW” when O_2 levels drop below the set point of 19.5 percent.
- High O_2 level—the indicator will flash and beep three times per second and display “OXY HIGH” when O_2 levels exceed the set point of 23.5 percent.
- Low gas alarm—the indicator will flash and beep twice a second and display “LEL LOW” if the sample exceeds 10 percent LEL or “VOC LOW” if the VOCs exceed 600 ppm.
- High gas alarm—the indicator will flash and beep three times per second and display LEL HIGH” if the air sample exceeds 20 percent LEL or “VOC HIGH” if the VOCs exceed 1,200

ppm. If the VOCs exceed 2,000 ppm, the display will read "VOC MAX"; however, the LEL sensor will function all the way to 100 percent LEL.

- Short-term exposure limit (STEL) alarm—if the limit for a 15 minute exposure to a toxic gas is exceeded, the indicator will flash and beep once a second and the display will give the sensor name followed by "STEL."
- Time weighted average (TWA) alarm—if the amount of toxic gas measured since the unit was started exceeds the amount that would overexpose a person in eight hours, the indicator will flash and beep once a second and the display will give the sensor name followed by "TWA." Remove the worker from the CS and turn the indicator off then back on to reset it.
- Negative reading—if a sensor reads less than zero, the alarm will beep and flash once a second and the display will read "NEG." Perform a fresh air calibration to reset the zero level on the sensor.
- Bad sensors—if a sensor fails, the unit will beep and flash 3 times a second and the display will read the sensor name followed by "MAX." If the PID lamp goes out, the display will read "LAMP." Try turning the indicator off and back on to reset it. If the LEL sensor shuts off, possibly due to excessive fuel vapor, the unit will say "LEL OFF." Sample fresh air for 60 seconds and press the Y/+ button to turn it back on.
- Data errors—when the data logging memory is full, the indicator will beep and flash once per second and "MEM" will be displayed. Have the PMEL set the indicator to wrap the data logging so that the newest readings erase the oldest ones. "EEM" will be displayed if there is an error writing to the data log. Turn the unit off and then back on to clear this error.

Response time

The internal air pump should be set to high flow for detecting jet fuel vapors. The response time is 15 seconds at standard operating temperature, but it will take longer if using the 6-foot sampling hose, since the air has to travel through the hose before reaching the indicator.

Environmental

The operating and storage temperature for the vapor indicator is –20 to 45º C (–4 to 113º F). It can operate in 0 to 95 percent relative humidity, non-condensing. The indicator is intrinsically safe for use in class I, division 1, group A, B, C, and D hazardous areas.

Theory of operation

During normal operations, the indicator draws continuous air samples through the probe and hose assemblies into the O_2, toxic, and combustible gas sensors. As air samples are drawn through the O_2 sensor (O_2 cell), it produces a millivolt signal proportional to the concentration of O_2 in the sample.

The PGM–50 uses both a catalytic sensor and a PID to detect hydrocarbon vapor. The PID contains a lamp that generates ultraviolet light of a specific energy level. When the energy of the light exceeds the ionization potential (IP) of a gas, molecules of the gas will be ionized. (i.e., broken down to negatively and positively charged components). A detector measures the charge of the ionized gas and converts it into an electric current that is then displayed by the PID in ppm, which is the number of molecules of the gas of interest that exist in each one million molecules of the atmosphere being analyzed. The LEL for JP–8 is 6,000 ppm.

Operational checkout

The following procedure provides a complete operational checkout of the toxic gas alarm with the indicator fully assembled. The purpose of the operational checkout is to determine whether the alarm functions properly. If unit gives error indications or fails to perform as described during any step of the operational checkout, the alarm must be serviced.

First, turn on the indicator by pressing the MODE button and allow it to advance through a 90 second startup sequence. Once complete, the display will read "Fresh Air Calibration." To check the battery voltage, press MODE until the battery voltage is displayed. Install the calibration adapter in the inlet of the indicator. Connect the zero organic filter, RAE part number 008–3024–000, to the calibration fitting. Then press the Y/+ button. The indicator will then cycle through each sensor, setting the readings to 0 or in the case of O_2, 20.9 percent. The display will read "Zero Cal Complete!" when it is finished. The zero organic filter may be used 20 times before discarding.

Verify that battery voltage is above 4.4 volts. You do that by pressing the MODE button until the battery voltage is displayed. If it is not, charge the indicator or change the battery before proceeding. Be aware that the low-battery set point is 4.4 volts. If battery voltage is 4.4 volts or less, the indicator will operate for only 15 minutes more before initiating automatic shutdown.

Next, you will need to verify the calibration of the indicator. This is called a bump test. Start by attaching the regulator to the calibration gas bottle and the tygon tube to the regulator.

Remove the zero organic filter. Open the regulator valve and attach the calibration gas to the calibration fitting on the indicator. Allow to run for at least 30 seconds. The values on the vapor meter should match the values marked on calibration tank within plus or minus 10 percent. If not, the indicator needs to be calibrated by the PMEL. Ensure that the audible and visual alarms are going off. Disconnect the calibration gas from the indicator, close the gas valve completely, and allow the indicator to run for at least 60 seconds to clear out any remaining calibration gas. The indicator is now ready for use.

Calibration

Calibration is performed by PMEL according to TO 1–1–3, *Inspection and Repair of Aircraft Integral Tanks and Fuel Cells*. The vapor indicator needs to be calibrated upon initial receipt, every 6 months, and when the readings on the indicator fail to match the values of the calibration gas during bump testing. It is the WFSM shop's responsibility to supply PMEL with the calibration kit, calibration gas, the user manual, computer interface cable, and software.

Normal operations

Connect the remote sampling probe to the vapor indicator. The standard hose length is 6 feet of PTFE tubing, but up to 100 feet of tubing may be used for sampling from remote areas. However, the longer the tubing, the longer the response time between the presence of hazardous vapors and detection by the sniffer. Let the sniffer sample the air at each point for at least 30 seconds when taking readings. The sniffer may be used to sample continuously for up to 10 hours on a full charge. When you are finished, sample a gas-free area for 60 seconds to purge the sniffer. Press and hold the MODE button as the indicator counts down from 5 until it turns off.

The combustible gas indicator is probably the most important piece of equipment you will use as a WFSM technician. Protect, use, and calibrate it as if your life depended on it. It actually does!

215. Air compressors

The MC–7 air compressor (fig. 1–24) is the most commonly used air compressor in WFSM shops. You may find yourself using it weekly for maintenance activities such as operating air-driven double-diaphragm pumps, air eductors, and pneumatic tools. It is important to understand the inspection procedures and operation of such an essential piece of equipment. This lesson contains highlights from TO 34Y1–244–1, *Compressor, Air, Rotary, Diesel Engine Driven, 2 Wheel Trailer Mounted*

125CFM, 100 PSI, Type MC–7, Model 11M125RPDQ, as manufactured by the Davey Compressor Co.

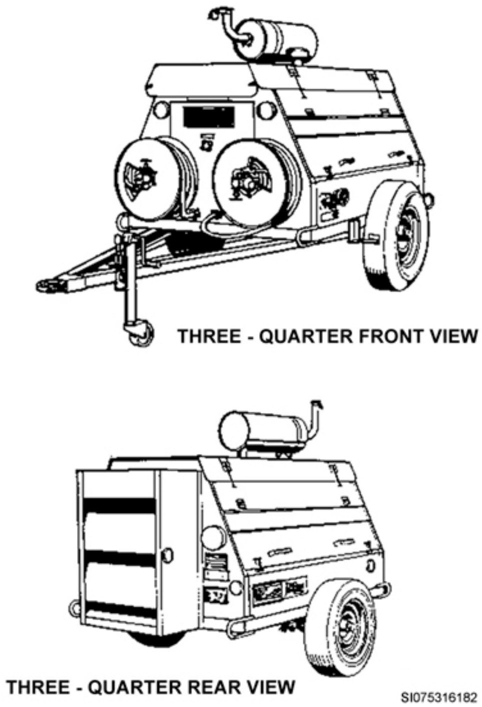


Figure 1–24. MC–7 air compressor.

As mentioned before, this air compressor has been the most common model found out in the field, but there are others in use. Consult the manufacturer’s manual for inspection, operation, and user maintenance of your units.

Inspection

Refer to the TO for B-Before Operation, D-During operation, A-After operation, W-Weekly, M-Monthly, and Q-Quarterly inspection requirements. Before moving the unit, check the exterior for damage, the tires for proper inflation, and all fluid levels. Ensure the coolant level in the radiator and oil cooler assembly is no more than 2 inches below the filling neck. Make sure the fuel tank has enough fuel for the job. You don’t want to run out of fuel before the job is finished, and running the engine dry of fuel will require lengthy maintenance work to get it re-started! Check the oil level in the engine crankcase, and fill to the full mark on the dipstick with grade oil equivalent/heavy duty oil (OE/HDO) 30 motor oil if the temperature will be over 40° F. Use grade OE/HDO 10 oil if the temperature will stay under 40°F. Check the oil separator to see that the unit is full to overflowing with grade OE/HDO 30 oil. Make sure the drive belt is not worn, frayed or cracked. Check the electrolyte levels in the battery, and make sure the cables and mounting connections are secure. Ensure the speed control linkage moves freely. Check the restriction indicator for the air cleaner and clean the air filter element if a restriction is indicated. Finally, check for any loose or damaged controls or instruments. Sign off that the inspection was performed on AF Form 1800, Operator’s Inspection Guide and Trouble Report.

Operation

Locate the unit in an area as free of dust and dirt as possible. Select a location as near level as possible—out-of-level shall not exceed 10 degrees in any direction. Set the parking brake. During normal operation, keep the housing side doors closed to meet sound level requirements. Connect hose reel hoses, or additional air hoses, to air service valves, and attach air tools (i.e., double-diaphragm pump or air eductor) or system for work to be performed. Perform all of the Before Operation maintenance checks and services in table 5–1 of the TO.

There is an unloader/idle control located on the front center of the sheet metal housing between and slightly above the two hose reels. Turn this manually operated control clockwise to close the compressor intake valve and move the engine fuel injection pump level to the idle position. This action permits starting the engine with the compressor in unloaded mode. After the engine warm-up period, turn the unloader/idle control counterclockwise to allow the compressor to begin normal load mode. Again, turn the knob clockwise to idle the engine before shutdown.

CAUTION: Do not operate the unit with side doors open, do not operate it alone, and do not play with the compressed air. Do not operate the unit in a building or enclosed area unless exhaust gases are piped outside. Before operating, make sure you are familiar with all of the controls and instruments on the unit.

Starting

To start the compressor, you must perform all operation instructions. Open the air discharge service valves. Turn the compressor unloader/idle control handle clockwise to close the intake valve to allow the engine to start up with the compressor unloaded. With the ignition switch in the OFF position, press the start button to crank the engine for approximately 3 seconds; then, release the start button. Oil pressure should reach 60–100 pounds per square inch (psi) within 5 seconds. If it does not, shut the unit off and determine the cause.

Place the ignition switch in the ON position. Press the reset button to make certain it is not tripped. Press the start button and safety override button. When the engine starts, release the start button, but continue to hold the safety override button until the engine oil pressure is approximately 10 psi, as indicated on the oil pressure gauge; then release the safety override switch. If the weather is cold, below 40° F, place an ether capsule in the starting aid holder. Operate the handle of the capsule holder when the start switch is pressed. After the engine starts, allow it to idle until engine water temperature reaches approximately 140° F as indicated on water temperature gauge. When operating temperature is reached, turn the unloader/idle control handle counterclockwise to bring the compressor to full-load condition. Close the air service valves. Check the readings on all gauges against normal parameters indicated in the TO.

The unit is now ready for use and will cycle through load and unload automatically in relation to air demand. As demand increases, the engine will accelerate and the compressor will replenish the compressed air supply in the separator tank. As demand decreases, or stops, the engine will return to idle and the compressor will run in an unloaded condition until demand for air again causes the unit to load.

Stopping

To stop the compressor, close the air discharge service valves. The engine will return to idle, and the compressor will operate unloaded. Allow the unit to run at idle for 5 minutes. Push the ignition switch to the OFF position. When the engine stops, the compressor will automatically blow down air from the compressor system. Turn the lamp switch OFF. Stow all tools and hoses as necessary.

216. Electrical equipment in hazardous locations

While we do not install electrical equipment, we do use it in the course of our operational inspection of the fuel systems. As part of our overall application of safety precautions, and before any electrical equipment is energized, inspect all equipment and components in hazardous locations.

Storage area pump house electrical equipment

Pump houses can be of the *enclosed* or the *open-shed* type. A few installations may have *unsheltered pad* construction. In each case, however, there are areas in or near the pump house that should be considered hazardous. By *hazardous locations,* we mean those where flammable atmospheres are likely to be present. The NFPA requires that all electrical equipment and wiring in hazardous locations be enclosed totally. This requirement helps maintain the safety of all fuel storage systems. Consequently, all installed electrical equipment (e.g., switches, motor starters, and relays) must be housed in explosion-proof cases. Exceptions are made for exterior door lights and for electrical equipment in pressurized control rooms.

Figure 1–25 illustrates the hazardous areas for a service station. Note that Class 1, Division 2, hazardous areas extend outward 20 feet from the dispensers and up 18 inches from the ground.

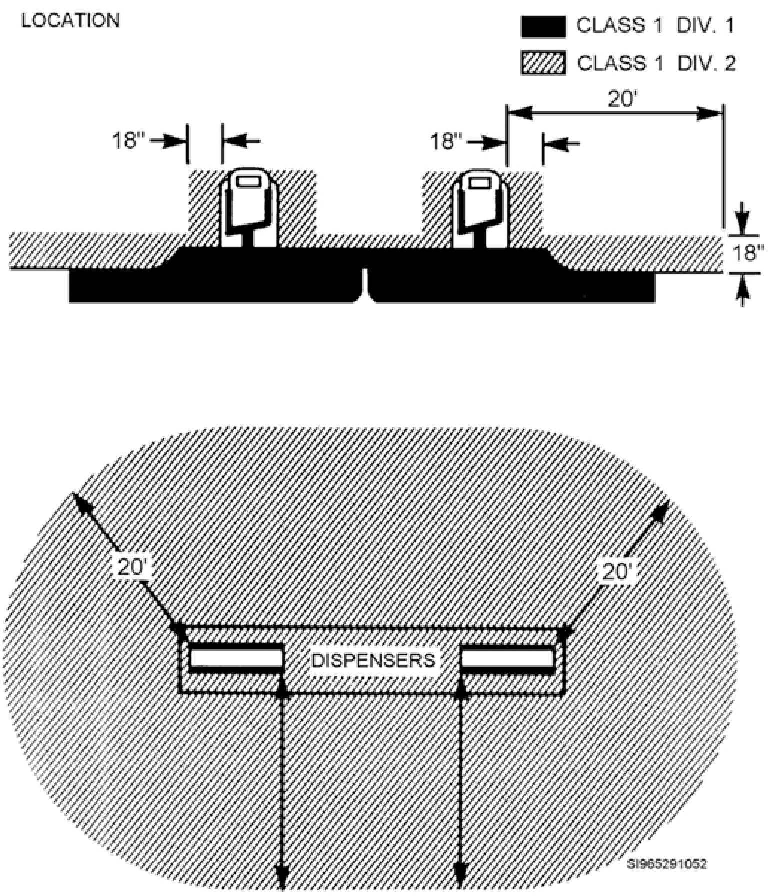


Figure 1–25. Hazard classification for service stations.

Electrical equipment in hazardous areas

The switches, circuit breakers, terminal boxes, electrical conduits, and electrical controls in hazardous areas are explosion-proof. This means the case that houses the electrical components will not rupture if a small explosion occurs inside it. However, fuel vapors can enter the explosion-proof case. All mating surfaces are metal-to-metal, as are the threaded parts. Although they are not vapor-proof, the cases are dust-tight and weatherproof. See figure 1–26 for hazardous classifications surrounding fueling equipment.

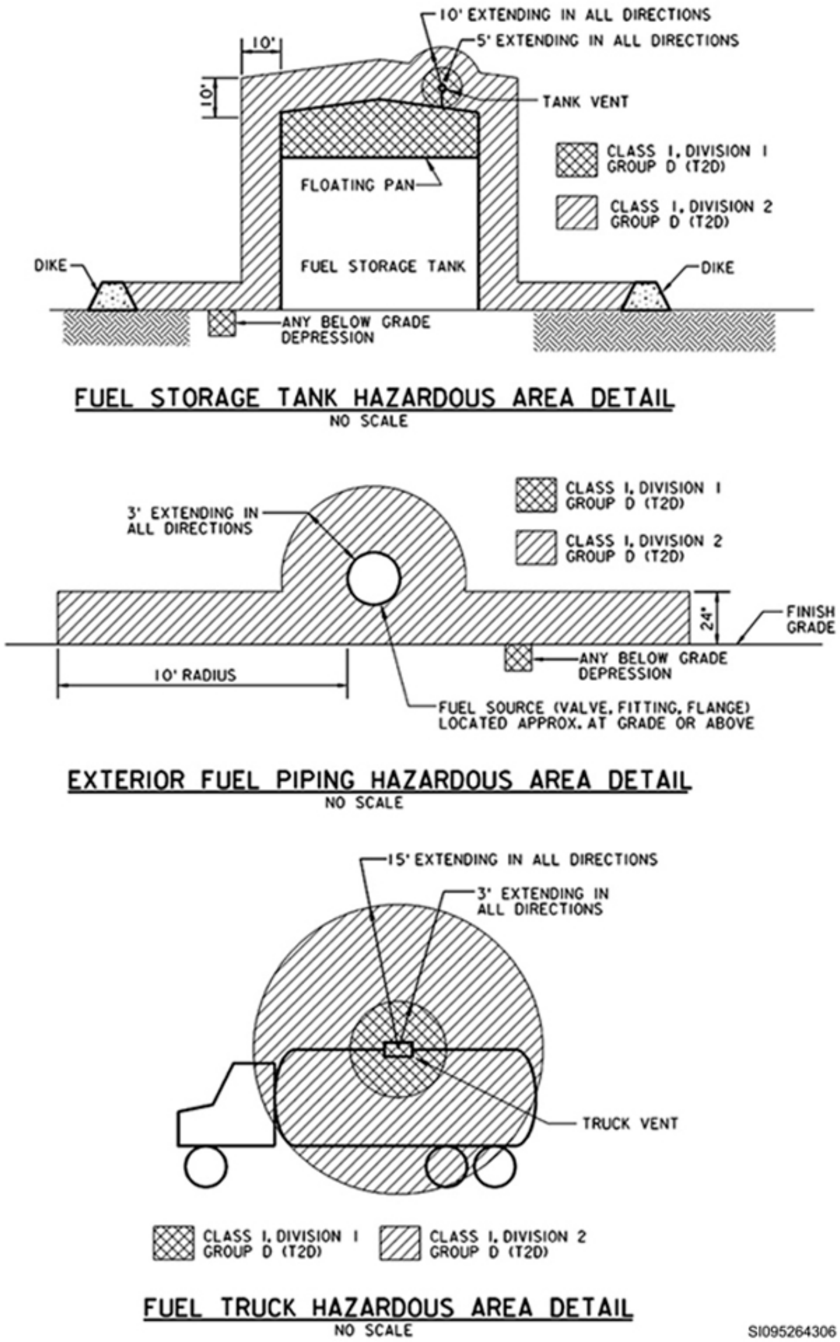


Figure 1–26. Hazardous classification surrounding fueling equipment.

Vapor-proof electrical components are similar, in many respects, to explosion-proof components. In fact, many explosion-proof units can be made vapor-proof, if necessary. The major difference lies in the addition of gaskets and seals to all mating surfaces, plugs, switch arms, and so forth, of the explosion-proof units, so that fuel vapors cannot enter. Many components that are only vapor-proof are of lighter construction. Examples are the outside lights you see above the doors of enclosed pumprooms and control rooms. These lights have suitable guards to protect them against mechanical damage, and they are enclosed and vapor-proof. The “as-built” drawings you have for the electrical system at your installation indicate which components must be vapor-proof. The electrical units and wiring in nonhazardous locations are of the general-purpose, enclosed type. This type of electrical equipment, although not explosion-proof or vapor-proof, is used in enclosed, pressurized control rooms. The electrical enclosures for outdoor equipment are weather-resistant and are installed at least 18 inches above the grade level.

All AF fuel system facilities have emergency generators collocated in the same area or have the capability for receiving emergency power from portable-generating equipment. If the facility has a collocated generator, you should become familiar with the generator and learn how to change over from the transformer (commercial or base power) to the generator in case of a power outage emergency. The electrical equipment consists of a three-pole, double-throw switch to permit selection of the transformer station or the portable generator as the source of power. A red light located just outside the control room door is used to indicate that you are receiving power from the transformer. This light is illuminated during normal operations.

All fuel piping, F/Ss, pumps, motors, and other system components are bonded together and grounded. This brings them all to the same electrical potential. All electrical equipment in an enclosed pumproom and control room is bonded together by electrical conduit. It is then grounded at the pad of a pole-mounted transformer. For additional protection, electrical motors, pumps, and F/Ss are also grounded through the pumproom floor. You can ground these components in either of two ways. The first way is to extend an exposed ground cable from the component to a ground rod driven below the floor level. The second way is to ground the component through its mounting bolts in the raised concrete platform on which the component is mounted. You place a ground rod under the concrete platform and attach the ground cable to the underside of the metallic support to which the component is bolted. If metal reinforcement is used in the foundation of the pumproom, the ground rods are often welded to the metal reinforcement. This provides better dissipation of static charges. Ground rods are not used when USTs are located under the pump house floor. In a situation like this, you ground components of this pump house directly to the underground tank with a ground cable.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

214. Vapor indicators

1. How many ppm of fuel vapors in air can produce a stage of excitement when inhaled?

2. What three common locations will you use a vapor indicator?

3. Explain where a vapor indicator may be recharged.

4. What is the voltage the MultiRAE PGM–50 vapor indicator will display when you have approximately 15 minutes before the unit shuts off?

5. A “bump test” for the MultiRAE PGM–50 vapor indicator will do *what* to the unit?

215. Air compressors

1. What fluid levels do you check before moving the MC–7 air compressor?
2. What is the purpose of the restriction indicator?
3. In what position are the side doors while the compressor is running?

216. Electrical equipment in hazardous locations

1. What does the NFPA require of all electrical equipment and wiring in hazardous locations?
2. What are the dimensions of the Class I, Division II hazardous area for an automotive service station island?
3. What are the differences between explosion-proof and vapor-proof fittings?
4. List where general-purpose, enclosed-type fittings can be used.
5. What is collocated near a fuels facility in case there is a power outage?
6. How would you ground components in a pump house for underground tanks?

Answers to Self-Test Questions

201

1. The mission of that installation.
2. DLA and the mission requirements of a base.
3. A horizontal underground tank.
4. At least 36 inches in diameter.
5. To ensure a positive blocking of the fuel during pipeline pressure testing and tank-cleaning operations.
6. A ¾-inch line, and it terminates ½ inch from the bottom of the sump.
7. A 55 or 100 gal. stainless steel PRT with a system of piping and valves connected to the water draw-off line. It also has a hand or an electric pump.
8. Nitrogen-filled bottles piped to liquid-level sensors.

202

1. A sump(s), inlet and outlet lines, vents, a liquid-level gauge, fuel and water drain-off lines, manways, a gauge hatch, and ladders and/or stairs.
2. A gauge head, float, two guide wires, and a thin float cable.
3. The all-weather tanks (cone roof with floating pan).
4. The line extends inside the tank and terminates in a vertical position 6 inches above the top of the sump.
5. It allows you to use the permanently installed refueling pump to pump the tank down to the stripping line termination level.
6. The fill line is configured this way so that every time we put fuel in the tank, we use the Coriolis force to aid in cleaning the tank by swirling the fuel to move any sediment on the tank floor toward the center sump.
7. To sound an alarm in case the high-level shutoff valve fails.
8. The low-level shutoff will sound an audible alarm, illuminate a light in the control room, and will open the circuit to shut off the refueling pump motors when the fuel in the tank reaches low level.
9. The floating pan eliminates the vapor space above the fuel.

203

1. A double deck or a pontoon roof.
2. A geodesic dome.
3. An annular (ring-shaped) pontoon around the outer edge of the roof deck. However, the deck is only of single thickness at its center. The pontoon is sectioned into compartments with bulkheads.

204

1. It prevents solid particles of sludge from entering the pump and thus damaging the moving parts inside the pump column.
2. It keeps the motor and pump from running in reverse.
3. It indicates the amount of liquid in the tank in either gal. or one-quarter-tank increments, ranging from EMPTY to FULL.
4. The mercury tube switch and cam-actuated microswitch.
5. It is a ¾-inch pipe installed at the lowest end of the tank usually next to one of the manways, extending from the sump to approximately 12 inches above ground.
6. The 124AF uses a pan-type float assembly and the 129AF uses a ball-type float assembly.

205

1. Every 6 years.
2. Every 8 years.
3. The roof may hang up and then suddenly drop as the fuel level lowers. There is danger from fire here as the result of increased vapor space and the possibility of sparks from metal sliding on metal.
4. Attach a plumb bob to a cord long enough to reach from the top of the tank to ground level. Extend the cord out from the roof of the tank and lower the plumb bob. Holding the cord steady at a set distance from the edge of the roof (about 8 inches is sufficient), measure the exact distance between the cord and the top edge of the tank shell. Let a second person at ground level measure the distance between the cord and tank shell at the base.
5. Gauge the interstitial space for fuel and water once a month to determine if there is a leak in the inner or outer walls of the tank.
6. Check and test the telltale pipes for fuel, fuel vapors, and water monthly.
7. MIL-STD 161G.
8. A lock-type gate valve on the exterior of the dike.

206

1. In the event of a fire, this spring-loaded valve will close, isolating the fuel in the pipeline; 160° F.
2. First, determine line’s deadhead pressure by closing the manual valve associated with the pressure relief, running the pump(s), and checking the pressure gauges. Turn the adjusting screw on the pressure-relief

valve clockwise to increase the pressure setting and counterclockwise to decrease it. After making the adjustment and replacing the cap, be sure to safety-wire and seal the cap. Pressure-relief valves are set to 10 percent above system deadhead pressure.

3. By the weight of each pallet.
4. From the moment you place the bob into the gauge pipe and throughout the gauging process, the tape *must* remain in contact with the top edge of the gauge pipe.
5. Check the gauge for accuracy; the gauge head for clear readable numbers moisture and signs of corrosion; and the float for holes or damage. Ensure the guide wires are secure and check the cable or tape for wear or kinks.

207

1. The roof supports, tank vents, manhole covers, roof drain system, and fabric roof seal.
2. DOWN and UP. The DOWN position is used for internal inspections and cleaning of the tank; this position is approximately 6 feet above the floor of the tank. The normal position is UP allowing the roof to stop at approximately 3 feet from the floor of the tank when empty.
3. It takes one person to position the support and another to insert the guide pin.
4. Coat them lightly with grease.
5. To keep it from freezing closed.
6. Drain and vapor-free the tank.
7. Check it for leaks. Fill the drain line with water and install the plug in the roof drain sump after bleeding the air out. Enter the tank and check the line carefully for leaks. If a swing joint is leaking, adjust the packing.
8. Keep it free of ice so that the fabric is not damaged when it freezes to the tank wall.

208

1. Empty the tank to remove the float and linkage sections inside the tank. Inside the pump house, electrically isolate the low-level control, disconnect the linkage between the liquidometer to the low-level control, and finally, unthread the gauge head from the pipe riser.
2. First, lower the fuel level in the tank to 13 inches by measuring it with a tape and bob. Turn off the power to the control, open the control cover, and loosen the set screw on either type switch will allow you to rotate the tube or cam to the set point that will shut off the pump motor. Then, tighten the set screw, replace the cover, turn on the power, fill the tank just enough so the pump will come on, and empty the tank with the deep-well pump until the low-level shuts off the pump motor. Repeat this procedure until the 13-inch level shut off is achieved.

209

1. 15 workdays.
2. Base fuels management office (POL).
3. The TES will provide the overall supervision and coordination of the cleaning project, must notify the MAJCOM of the proposed starting date and obtain permission to do the work, must be thoroughly familiar with and comply with all associated regulations, programs, plans and instructions, inspect all equipment to be used, and must notify in advance and may request assistance from POL, SEG, CEF, and BEE prior to starting work.
4. To advise the contractor of known potential hazards within the tank and surrounding area, to inspect the contractor’s equipment, to act as QAE in all technical matters pertaining to tank work, and to notify the contracting officer of any safety related violations or noncompliance on the part of the contractor regarding the contract’s statement of work.

210

1. Combustible gas or vapor indicator.
2. All fuels contain benzene.
3. The fuel tank has been properly ventilated as close to zero percent but no higher than 10 percent of the LEL. The entrant MUST wear the MEP-approved respiratory protection.
4. Vapor readings must be taken continuously and recorded every 15 minutes while workers are in the tank.

5. Upwind.
6. Matches and lighters.
7. Self-rescue, centrally located rescue team (fire department), and organizational rescue team.
8. Base fire department.
9. All.

211

1. Supervisor.
2. All AF personnel.
3. The paint may hide cracks or defects in the outer shell and destroy or degrade the insulating characteristics.
4. A blend of 50 percent cotton and 50 percent polyester.
5. The type “C” respirator; IDLH areas.
6. 300 feet; the BEE.
7. They must be Class I, Division I, Group D, with maximum temperature ratings of “T2D”–419° F.
8. Explosion-proof, portable, battery-powered lights approved by Bureau of Mines or NIOSH are the only lights authorized for use inside the tank.
9. A flame arrester and a protected ignition system; must be positioned at least 50 feet upwind of the tank.
10. Any time a worker is at a height of 6 feet or more.
11. The manufacturer’s name, identification code, and dated of manufacture.
12. Never permit a vertical fall of more than 6 feet (1.8 m) or contact with the lower level.
13. 5,000 lbs.
14. Inspect all fall arrest system equipment before each use and at least annually using the criteria found in TO 00–25–245 and the manufacturer’s manuals.
15. A 5-year service life from their date of manufacture.

212

1. Lightning sighted within 5 miles.
2. All fuel must be emptied from the line, any impressed-current cathodic protection has been turned off, and the bonding cable has been installed between pipe flanges.
3. 20 percent LEL or higher.
4. The bottom of the tank and 3 feet up the sides.
5. Workers will wash or wipe down the remainder of the tank and components that show signs of dirt or sludge residue. Workers will use buckets, shovels, scoops and rags to remove any remaining sludge from the sump and then wipe it clean.
6. BCE environmental coordinator.
7. Flow through the receipt or fill line during the initial fill should not exceed 3 feet per second until the entire fill pipe inside the tank is covered or the floating pan or roof is floating.

213

1. Rust, dirt, dust, water, heat, freezing, and fire hazards.
2. Inside the tank.
3. 4” x 4”.
4. WARNING: This tank previously contained leaded gasoline and is not safe for storage of any material destined for human or animal consumption. DO NOT ENTER THIS TANK WITHOUT THE PRIOR APPROVAL OF THE MAJOR COMMAND.
5. Drain all fuel, remove the filter elements, and thoroughly clean and lightly coat their interiors with oil.

214

1. 500 ppm.
2. In and around F/Ss, inside pits, and inside tanks.

3. In a non-hazardous area.
4. 4.4 volts.
5. Verify the calibration of the indicator.

215

1. The coolant, fuel, oil, and battery levels.
2. To indicate when the air cleaner element is dirty.
3. Down.

216

1. Must be totally enclosed and housed in explosion-proof cases.
2. 18 inches high and 20 feet out from the dispenser.
3. The addition of gaskets and seals to all mating surfaces, plugs, and switch arms in the explosion-proof units.
4. In non-hazardous locations, such as enclosed pressurized control rooms.
5. An emergency generator.
6. You ground components of this pump house directly to the underground tank with a ground cable.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (201) What is the *normal* criterion used to figure the fuel requirement of a base that is *not* used as a *primary* port?
   a. 10-day supply of fuel based on the base’s wartime commitment only.
   b. 15-day supply of fuel based on the base’s peacetime commitment only.
   c. 10-day supply of fuel based on both the base’s wartime and peacetime fuel commitment.
   d. 15-day supply of fuel based on both the base’s wartime and peacetime fuel commitment.

2. (201) The Defense Logistics Agency (DLA) determines the type, size, and number of fuel tanks needed at each base based upon
   a. Air Force (AF) standard design.
   b. the mission requirements.
   c. available construction dollars.
   d. major command (MAJCOM) recommendation.

3. (201) What will horizontal underground storage tanks and cut-and-cover tanks that issue jet fuel have on top of them?
   a. A pump house.
   b. A concrete cover.
   c. An open-air shed.
   d. Nothing, to prevent collapse of the tank.

4. (201) What component(s) should you replace before you replace a manway cover?
   a. New nuts and bolts.
   b. The old gasket if it is in good condition.
   c. A new gasket slightly thicker than the old one.
   d. A new gasket the same thickness as the old one.

5. (202) What size pipe is used as the gauge well on a cone-roof tank with a floating pan?
   a. 2 inches.
   b. 4 inches.
   c. 6 inches.
   d. 8 inches.

6. (202) The product-withdrawal line terminates inside a cone-roof tank with a floating pan in a
   a. vertical position, 6 inches above the top of the sump.
   b. vertical position, 6 inches above the bottom of the sump.
   c. horizontal position, 6 inches above the top of the sump.
   d. horizontal position, 6 inches above the bottom of the sump.

7. (202) What size is the water draw-off line in an all-weather tank, and where does it terminate?
   a. ½ inch; ½ inch from the sump bottom.
   b. ½ inch; 1 inch from the sump bottom.
   c. ¾ inch; ½ inch from the sump bottom.
   d. ¾ inch; 1 inch from the sump bottom.

8. (202) What is the slope of the stripping line inside an all-weather tank, and where does it terminate?
   a. 4 inches per 10 feet, 4 inches above the sump.
   b. 4 inches per 10 feet, 4 inches from the sump bottom.
   c. 6 inches per 10 feet, 4 inches above the sump.
   d. 6 inches per 10 feet, 4 inches from the sump bottom.

9. (202) At what level does the high-level alarm (HLA) actuate on a cone roof with floating pan?
   a. Just before the high-level shutoff level.
   b. Just after the high-level shutoff level.
   c. Just before the high-high level alarm.
   d. Just after the high-high level alarm.

10. (202) What type of vent is located on a floating pan?
    a. Slot.
    b. Open.
    c. Bleeder.
    d. Overflow.

11. (203) The roof guide is installed on floating-roof tanks to
    a. prevent the collapse of the tank shell.
    b. keep the roof from turning in a circular motion.
    c. provide a vapor recovery area under the roof.
    d. provide a path to the ground for static electricity.

12. (203) The double-deck floating-roof tank is the *most* efficient type of roof because the roof
    a. slopes to the center.
    b. support legs are adjustable.
    c. has insulating air space between decks.
    d. water drains easily toward the center.

13. (204) About how far above the tank floor is the *first* stage of the deep-well turbine pump located?
    a. 3 inches.
    b. 6 inches.
    c. 9 inches.
    d. 12 inches.

14. (204) At what level in an underground fuel tank is the low-level shutoff set to deenergize the fueling pump motor before the pump runs dry?
    a. 7 inches.
    b. 11 inches.
    c. 13 inches.
    d. 18 inches.

15. (204) What size is the cleanout line on an underground tank, and where does it terminate outside the tank?
    a. ½ inch, 6 inches above ground level.
    b. ½ inch, 12 inches above ground level.
    c. ¾ inch, 6 inches above ground level.
    d. ¾ inch, 12 inches above ground level.

16. (205) You *must* clean an operating tank that is *not* internally coated and does *not* have a receiving filter/separator (F/S) every
    a. 4 years.
    b. 6 years.
    c. 8 years.
    d. 10 years.

17. (205) What is installed on a floating-roof tank to help prevent out-of-roundness?
    a. A ring wall.
    b. A wind girder.
    c. The floating roof.
    d. The shell support beams.

18. (205) How is the product identification displayed on an aboveground tank?
    a. Yellow bands with white letters on a black background.
    b. Yellow bands with black letters on a white background.
    c. Black bands with white letters on a yellow background.
    d. Black bands with yellow letters on a white background.

19. (206) A pressure-relief valve installed around the inlet block valve of a floating-roof tank is adjusted to open at what pressure?
    a. 5 percent above system deadhead pressure.
    b. 10 percent above system deadhead pressure.
    c. 5 pounds per square inch (psi) above system deadhead pressure.
    d. 10 psi above system deadhead pressure.

20. (206) What is the inspection frequency for a pressure-relief valve?
    a. Monthly.
    b. Quarterly.
    c. Semi-annual.
    d. Annually.

21. (207) What *prevents* fuel from entering a roof drain line?
    a. Flange gaskets and Teflon ring packing.
    b. Flange gaskets and asbestos ring packing.
    c. Threaded gaskets and Teflon ring packing.
    d. Threaded gaskets and asbestos ring packing.

22. (207) When you are inspecting the fabric seal on floating-roof tanks, a gap between the metallic sealing ring and tank shell would indicate a warped sealing ring of
    a. 5 to 10 feet long.
    b. 10 to 15 feet long.
    c. 5 to 10 inches wide.
    d. 10 to 15 inches wide.

23. (207) When filling the tank to check the high-high-level alarm (HHLA), what *must* be disabled?
    a. The high-level alarm (HLA).
    b. The low-level switch.
    c. The low-level shutoff valve.
    d. The high-level shutoff valve.

24. (208) What instrument would you use to check the liquidometer accuracy?
    a. Tape and bob.
    b. Liquid-level float.
    c. Liquid-level gauge.
    d. Weighted gauge tester.

25. (209) How long before entering a fuel tank *must* you request permission from your major command (MAJCOM)?
    a. 10 days.
    b. 15 days.
    c. 10 workdays.
    d. 15 workdays.

26. (209) Who will assign a qualified tank-entry supervisor (TES) to supervise a tank-cleaning operation?
    a. Major command (MAJCOM) fuels engineer.
    b. Section superintendent.
    c. Shop supervisor.
    d. Base safety.

27. (209) To qualify for an Air Force (AF) tank-cleaning contract, a contractor must provide proof of having completed similar work on *at least* how many previous projects?
    a. 4.
    b. 3.
    c. 2.
    d. 1.

28. (209) Which is *not* the responsibility of the major command (MAJCOM) fuels engineer's representative during the contract cleaning of a fuel tank?
    a. To inspect the contractor's equipment.
    b. To advise the contractor of known potential hazards.
    c. To stop the contractor's work for contract violations.
    d. To act as the quality assurance evaluator (QAE) pertaining to the work.

29. (210) Which is *not* a safety hazard associated with tank cleaning?
    a. Fire.
    b. Explosion.
    c. Excess oxygen.
    d. Excess petroleum vapors.

30. (211) When can people cleaning Air Force (AF) petroleum storage tanks use portable oxygen tanks and masks, portable gas masks, or "walk-around" oxygen bottles and masks?
    a. During immediately dangerous to life and health (IDLH) conditions.
    b. During inert tank cleaning.
    c. During "hot" cleaning.
    d. Never.

31. (211) Communication gear *must* be used during the cleaning of an underground JP–8 tank when the
    a. tank capacity is 10,000 gallons (gal.).
    b. tank capacity is 25,000 gal.
    c. manhole access is 6 feet below ground level.
    d. manhole access is 10 feet below ground level.

32. (212) When cleaning a tank *without* dikes, an air compressor *must* be positioned upwind,
    a. at least 20 feet from the manhole.
    b. at least 50 feet from the tank.
    c. just inside the dike.
    d. just outside the dike.

33. (212) At what vapor level may workers *initially* enter a tank for tank cleaning?
    a. Below 10 percent lower explosive limit (LEL).
    b. Below 20 percent LEL.
    c. Below 40 percent LEL.
    d. Below 50 percent LEL.

34. (212) Which Air Force (AF) Information Management Tool (IMT) is used to record vapor readings during tank cleaning?
    a. 39.
    b. 72.
    c. 172.
    d. 561.

35. (213) What *must* be done to meters in a pit that is to be abandoned?
    a. Drained only.
    b. Drained and capped off only.
    c. Drained, capped off, and oiled only.
    d. Drained, removed, oiled, and placed in storage.

36. (214) What is the *minimum* recommended battery voltage for the MultiRAE PGM–50?
    a. 4.2 volts.
    b. 4.4 volts.
    c. 4.8 volts.
    d. 5.2 volts.

37. (215) What grade of oil does the oil separator on a MC–7 air compressor use if the temperature is above 40 degrees (°) Fahrenheit (F)?
    a. Oil equivalent/heavy duty oil (OE/HDO) 10.
    b. OE/HDO 30.
    c. Society of Automotive Engineers (SAE) 10W30.
    d. SAE 10W40

38. (215) What should you do if the restriction indicator on a MC–7 air compressor is tripped?
    a. Reset the indicator.
    b. Clean the air filter element.
    c. Ensure the unloader valve is open.
    d. Partially close the air discharge service valves.

39. (215) You should release the safety override switch on a MC–7 air compressor after the
    a. air pressure reaches 40 pounds per square inch (psi).
    b. water temperature reaches 140 degrees (°) Fahrenheit (F).
    c. oil pressure reaches 10 psi.
    d. engine starts.

40. (216) Electrical controls in hazardous areas *must* be proofed (protected) against
    a. dust.
    b. vapor.
    c. weather.
    d. explosion.

41. (216) The Class I, Division 2, hazardous area around a service station dispenser extends outward how many feet and upward how many inches?
    a. 20 feet; 18 inches.
    b. 20 feet; 24 inches.
    c. 50 feet; 18 inches.
    d. 50 feet; 24 inches.

42. (216) What type of electrical units and wiring is used in *non-hazardous* locations, such as pressurized control rooms?
    a. Explosion-proof; enclosed type.
    b. General purpose; enclosed type.
    c. Explosion-proof; non-enclosed type.
    d. General purpose; non-enclosed type.

43. (216) What type grounding rod, if any, is used on a horizontal fuel tank installed under the pump house floor?
    a. Copper.
    b. Galvanized.
    c. Stainless steel.
    d. Not required.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Filtration Equipment

WHETHER THE MISSION is completed depends very much on the condition of the fuel delivered to the aircraft. Foreign particles mixed with the fuel can cause engine failure. Therefore, fuel for jet aircraft *must* be clean and dry. Water in jet fuel can seriously affect jet engine performance and can cause engine failure by forming ice crystals. It can even cause microbiological contamination in both storage and aircraft fuel systems. Microorganisms survive only in water. They multiply in watered fuel systems and cause serious contamination problems. Consequently, the water must be removed both in storage and during aircraft servicing.

Equally important is the removal of solid particles from the fuel. These particles damage components of fuel systems. They also damage the fuel system components of aircraft that are serviced with the contaminated fuel. Many different types of solid particles can find their way into the fuel lines. The *most* common of these are rust, scale, sand, and particles of system components that have been chipped or damaged.

In liquid fuel systems, two basic methods are used to remove foreign particles from the fuel. In the first method, the F/S filters solid particles and separates water from the fuel as it passes through the unit. In the second method, strainers trap solid particles.

2–1. Filter/Separators

Many different models of F/Ss are found at various AF bases. There are three basic designs: (1) military specification (MILSPEC) horizontal, (2) MILSPEC vertical, and (3) API 1581, *Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators*, horizontal. We will cover all three designs of F/Ss and the automatic valves installed on them.

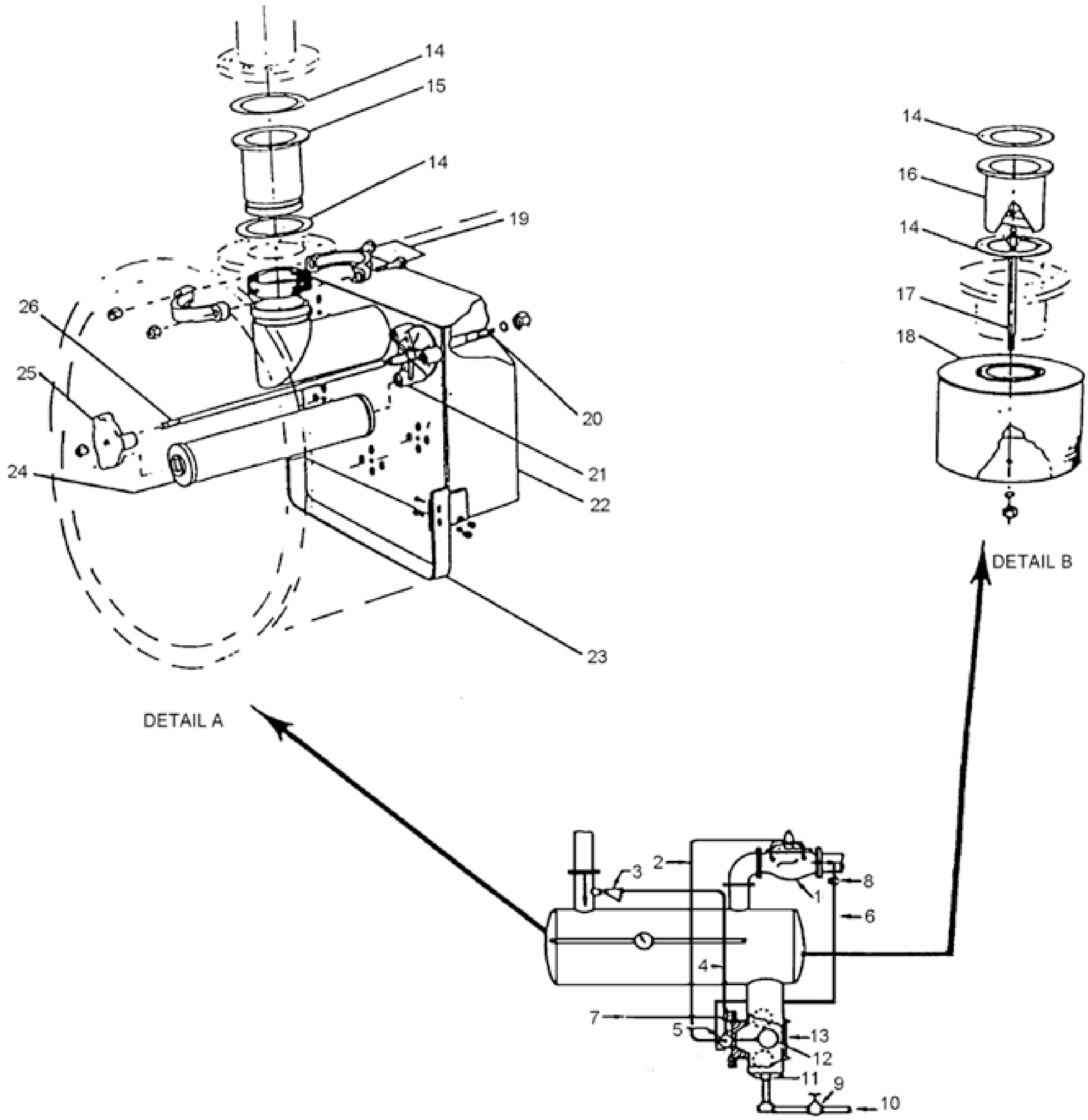
217. The components of a military specification filter/separator

Here we will discuss the components of the MILSPEC horizontal and vertical F/Ss.

MILSPEC horizontal F/S components

A MILSPEC F/S is just a unit built to military specifications and used across all services. This makes it easier to order parts and keeps everything uniform. The basic components of the MILSPEC horizontal filter/separator (HFS) are listed in the table below and shown in figure 2–1:

MILSPEC Components	
(1) Fuel discharge valve (FDV).	(8) Pilot valve drain check valve.
(2) Discharge valve control tubing.	(9) Water drain valve (WDV).
(3) “Y” strainer.	(10) Water drain line.
(4) Pilot valve supply tubing.	(11) Sump drain line connection.
(5) Float and pilot valve assembly.	(12) Float.
(6) Pilot valve drain tubing.	(13) Liquid-level gauge.
(7) Water drain control port.	



1. FUEL DISCHARGE VALVE
2. DISCHARGE VALVE CONTROL TUBING
3. "Y" STRAINER
4. PILOT VALVE SUPPLY TUBING
5. FLOAT AND PILOT VALVE ASSEMBLY
6. PILOT VALVE DRAIN TUBING
7. WATER DRAIN CONTROL (PLUGGED)
8. CHECK VALVE
9. WATER DRAIN VALVE
10. WATER DRAIN LINE
11. SUMP DRAIN LINE CONNECTION
12. FLOAT
13. LIQUID LEVEL GAGE
14. GASKETS
15. INLET FLANGE ADAPTER
16. OUTLET FLAGE ADAPTER
17. SEPARATOR HOLD DOWN ROD
18. SEPARATOR ELEMENT
19. COUPLING ASSEMBLY
20. ADAPTER MOUNTING ROD
21. CARTRIDGE ADAPTER
22. MANIFOLD
23. MANIFOLD SUPPORT
24. CARTRIDGE
25. CARTRIDGE HOLD DOWN PLATE
26. CARTRIDGE HOLD DOWN ROD ASSEMBLY

Figure 2–1. MILSPEC HFS.

The MILSPEC HFS has changed many times throughout the years to provide clean and dry fuel for modern day aircraft. Most of the changes made were on the filter arrangement inside the F/S rather than on the basic construction of the F/S.

The latest modification to the MILSPEC HFS is shown in figure 2–1. As you look at these modifications, you also see these additional components: (14) gaskets, (15) inlet flange adapter, (16) outlet flange adapter, (17) separator hold-down rod, (18) separator element, (19) coupling assembly,

(20) adapter mounting rod, (21) cartridge adapter, (22) manifold, (23) manifold support, (24) cartridge, (25) cartridge hold-down plate, and (26) cartridge hold-down rod assembly.

The modification on the 300 gallons per minute (gpm) F/S was to install 15 cartridges on the manifold. The modification made to the 600 gpm F/S was to add nine filter elements on the backside of the manifold for a total of 30 total cartridges installed. Both of these modifications were made to meet the 20 gpm per DOD NSN 4330–00–983–0998 element flow requirement.

Figure 2–2 shows how the fuel flows through an HFS. As fuel enters the unit, it goes into the manifold, goes out through the cartridges from the inside out, and is then discharged (through the separator element) into the discharge piping. Water removed from the fuel (if any) falls into the sump. As the water level rises in the sump, it raises the float, changing the position of the rotary disc. If water continues to enter the sump and raises the float to its TOP position, the change in the rotary disc will direct pressure to the FDV to close it. This action prevents water from entering the downstream piping. Water will then need to be drained from the sump through the WDV to lower the float and allow the FDV to reopen. The operation of the flanged float control and FDV will be covered in more detail later in this unit.

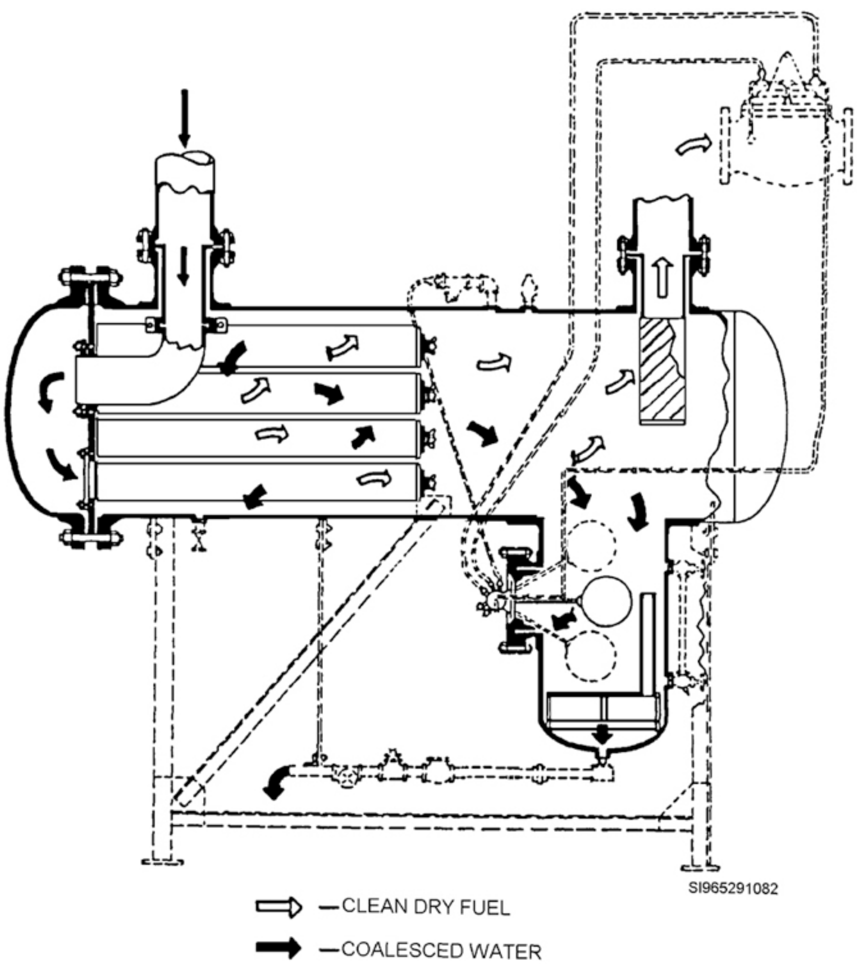


Figure 2–2. MILSPEC HFS fuel flow.

MILSPEC vertical F/S components

Figure 2–3 illustrates a typical vertical F/S. The components of this type of F/S are the cover, air eliminator valve (behind the air eliminator is a pressure-relief valve), eye bolt, liquid-level gauge (to determine the water level), gauge tube (for high pressure), differential pressure (DP) gauge, filter element, manual drain valve, manual valve on water drain line, WDV, FDV, flange float control assembly, lever used to raise the cover during filter change, and cover hinge. The remainder of the components will be discussed when we cover the operation of the pilot valve water drain procedures later in this unit.

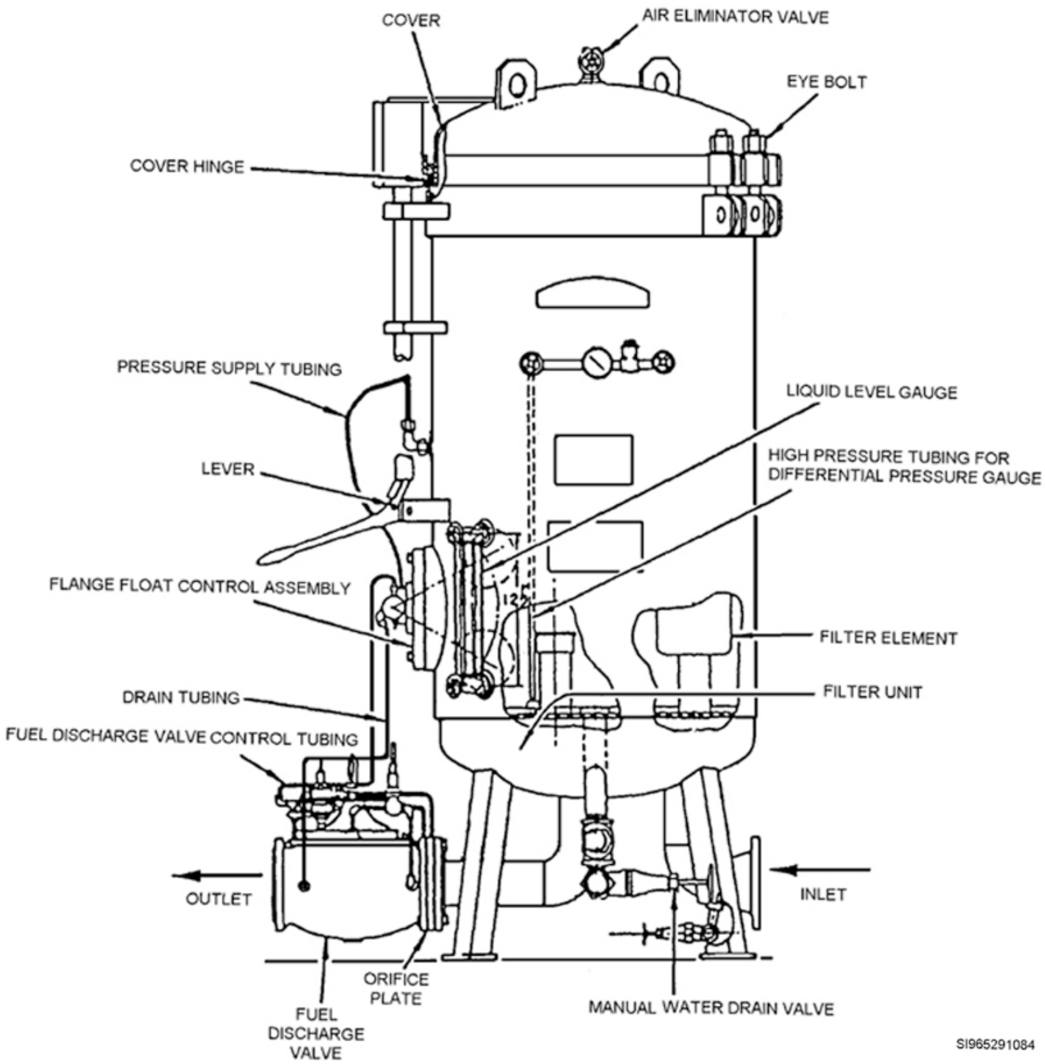


Figure 2–3. MILSPEC vertical F/S.

You can see that the components of the vertical F/S are about the same as those on the HFS. The function and purpose of both of the F/Ss is to remove solids and water from the fuel.

Fuel enters the F/S and passes through the filter elements from the inside out. Water collects on top of the baffle plate, and when the float of the pilot valve assembly reaches the TOP position, the FDV will close so that there is no flow of fuel from the F/S.

Two modifications have been made since 1989 to the vertical MILSPEC F/S.

The *first* modification was made to the vessels manufactured by the Bowser Co. The DOD coalescer elements were removed and replaced with 6-inch API coalescer elements. This required capping off half of the element nipples on the vessel bottom plate and threading the other half so that the API elements could be threaded on.

The *second* modification replaced the DOD (NSN 4330–00–983–0998) elements with the NSN 4330–00–407–3548 elements. The canister that went over the DOD element is no longer used. The

DOD elements were 20 inches long and had an O-ring at both ends. These elements were double stacked, so each stack had four O-rings that could fail. This equates to 60 locations in a 600 gpm vessel that rely on an O-ring seal to make sure free water levels do not exceed the 10 ppm levels. The NSN 4330–00–407–3548 elements are 40 inches long and have only one O-ring. The 40-inch element is the same diameter as the DOD element and has been qualified to API/IP Specification 1581, *Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators*. Some of the major areas addressed in API/IP Specification 1581 concern design codes, construction materials (including internal coating), vent and pressure relief taps, hydrostatic testing and design, and construction of elements. The 40-inch element requires a coalescer alignment pin, made by Gammon Technical Products, part number 5935M. This pin fits on the closed end of the 40-inch element to facilitate hold down of the element by the spider plate.

Both modifications required cutting off the outlet pipe inside the vessel at about 12 inches from the bottom plate, then installing a new separator stage directly on the outlet pipe. This secondary stage consists of several Teflon-coated screen canisters manifolded together and attached to the outlet pipe using a Morris coupler. The separator stage modification ensures that no water will get into the piping downstream of the F/S.

218. The components and operation of the API 1581 filter/separator

In 1990, an engineering design decision was made to delete the MILSPEC F/Ss from all new AF construction projects and to replace them with the API 1581 HFS. Within this lesson we will cover the components and operation of the API 1581 F/S. Figure 2–4 shows the newest addition to the types of F/Ss. It is the API 1581, Group II, Class B HFS. On the outside it looks very similar to the HFS we just covered.

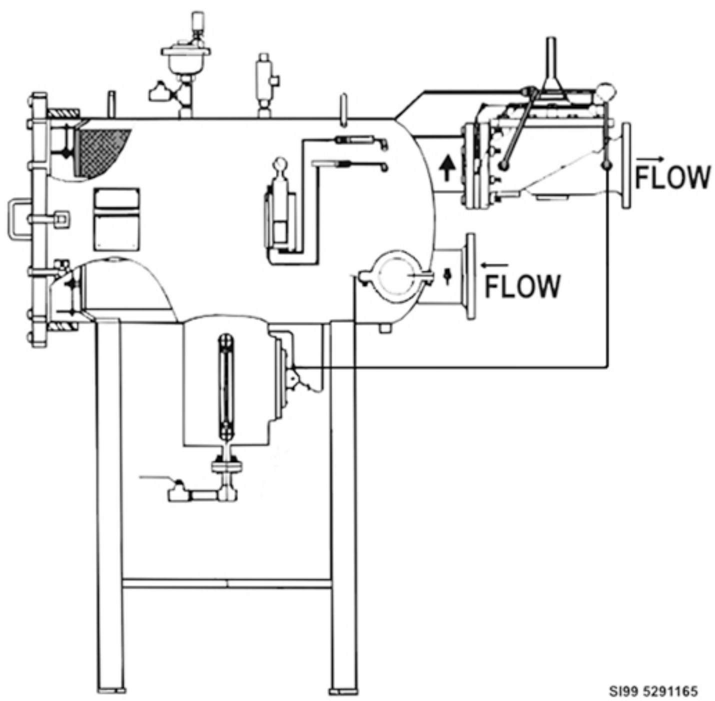


Figure 2–4. API 1581 F/S.

Description

The API 1581 F/S is fabricated from aluminum or carbon steel and is internally coated with epoxy. It is of the end-opening type with coalescers and separators mounted side by side (coalescers at the bottom and separators at the top). The head opening is equipped with a hinged or pivoting device to facilitate swinging the head to one side for servicing. The head is sealed to the body by means of an O-ring, mounted in a circular groove at the point of closure.

Components

The inlet and outlet connections are 6-inch nominal pipe size and are located parallel to each other as shown in figure 2–4.

The sight gauge is a ½-inch armored, clear Pyrex liquid-level gauge that allows you to observe the water accumulation in the sump. It is equipped with nickel-copper alloy ball checks in both the upper and lower fittings. The gauge also contains a colored density sensitive ball that will float on water but will sink in fuel.

The DP gauge is a direct-reading, piston type that measures the DP across both the coalescers and separators. The gauge cylinder has stainless steel end flanges with Viton O-ring seals. The high-pressure inlet to the DP gauge has a 10-micron pleated paper filter, and the low-pressure connection has a fine mesh stainless steel strainer. The gauge has an operating pressure limit of 300 psi, and the cylinder burst pressure will not be less than 1,200 psi. The accuracy of these DP gauges is ± 0.5 psi between 0–30 psi differential.

F/Ss must be equipped with an air eliminator and pressure relief to operate properly. The air eliminator is installed at the highest point on the F/S and will release at pressures up to 150 psi with no fuel leakage. The pressure-relief valve is a 3/4-inch angle pattern pressure-relief valve that relieves excess vessel pressure back to the tank. Failure to maintain the functionality and pressure settings could lead to rupture of the vessel; therefore, it is important to maintain this simple device properly. This can be achieved by loosening the jam nut and turning the adjustment screw clockwise to increase the pressure setting or counterclockwise to decrease the pressure setting. Once 150 psi is set, tighten the jam nut.

The coalescers and separators must be qualified under API 1581, Group II, Class B. The coalescers must be rated for a minimum capacity of 2.27 gpm per inch of length, and the separators must be rated for a minimum capacity of 8.33 gpm per inch of length. A spider plate is used to hold the coalescers and separators in position and support them firmly against vibration. The method of stabilization must ensure an electrical bond between the spider and the vessel.

219. How water is removed from filter/separators

One of the most critical safety functions of the fuel system is the proper operation of the water drain system on an F/S. When the F/S collects water in its sump, the water must be drained to provide the dry fuel necessary for proper aircraft operation.

Operation

F/Ss that receive fuel from barges or pipelines with histories of excessive water may have automatic WDVs installed. Look at figure 2–5, where you can see the main components of the water drain system. The three major components are the: (1) pilot valve (flanged float control) assembly, (2) WDV, and (3) auxiliary hytrol control valve. The auxiliary hytrol control valve is located on the FDV. These three components are connected together by control tubing. The tubing will either supply pressure or drain pressure, depending on the position of the float on the pilot valve assembly.

The tubing system can actually be broken down into three groups. First is the *supply* tubing; this tubing is connected to the body of the F/S and the pilot valve assembly. The inlet of the supply tubing is protected by a strainer that prevents any solid particles from entering the rotary disc in the pilot valve assembly. Second is the *drain* tubing; this section of tubing is connected to the pilot valve assembly and the downstream side of the WDV. The drain tubing allows pressure to be bled off the auxiliary hytrol control valve or the WDV. Third and last are the two sections of tubing that connect the cover chambers of the hytrol and WDV to the pilot valve assembly.

As you can see, the pilot valve assembly controls the water drain system. The rotary disc, which cannot be seen, is operated by a float. This float will sink in fuel but float on water. The water drain system is controlled by *three* distinct float positions. When the float is in its LOWEST position (3), pressure is applied on the cover chamber of the WDV. This holds the water drain closed and prevents loss of fuel down the drain line. Since there is no water in the F/S, the FDV can open because the hytrol cover chamber is aligned with the drain tubing.

Now, as water raises the float to the CENTER position (2), the rotary disc will realign ports. Here the WDV cover chamber is aligned to the drain tubing. This allows the WDV to open and forces the water out of the F/S sump. The FDV hytrol is still aligned to the drain tubing and, therefore, allows fuel to be pumped through it.

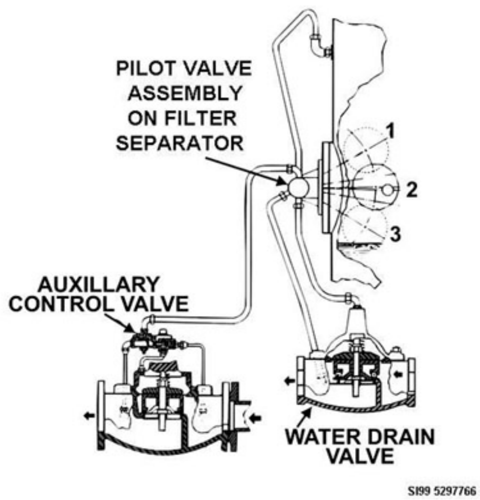


Figure 2–5. F/S control valve.

Figure 2–6 illustrates *two* valves used as automatic WDVs. Valve “A” requires only one sensing line from the pilot control. Pressure applied above the diaphragm holds the valve closed during normal operation. The same is true for valve “B”. When the float reaches the CENTER position, the cover chamber is aligned with the drain, and supply pressure under the diaphragm forces the valve open. Pressure under the diaphragm in valve B comes from the pilot valve, not line pressure.

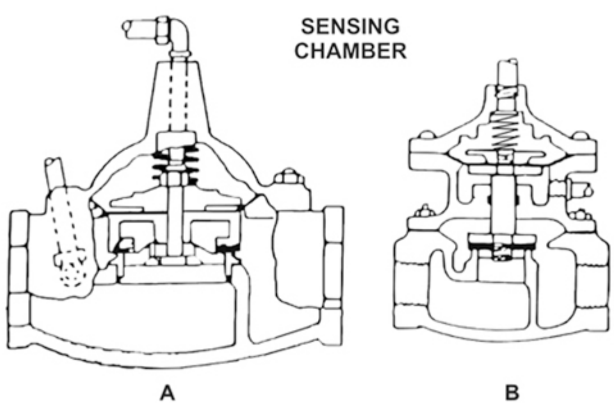


Figure 2–6. Water drain valves.

If, however, more water enters the sump than the WDV can release, the float will rise to the TOP position, shown in figure 2–5 (1). With the float in this TOP position, the rotary disc, once again, realigns ports. The cover chamber of the WDV is still aligned with the drain tubing, allowing water to be forced out of the sump. But now the water is reaching a critical height and could be pumped out with the fuel. To keep this from happening, pressure is supplied to the cover chamber of the hytrol valve and closes it. This will cause the FDV to close, and this condition will continue until the water level goes down.

As the water level goes down, the alignment of ports will change as just mentioned. Thus, with the float in the CENTER position, shown in figure 2–5 (2), both the WDV and the FDV are open; and, as the float goes to the LOWEST level, shown in figure 2–5 (3), the WDV will close, but the FDV can remain open.

Figure 2–7 shows how the F/S control system looks with the WDV removed. All F/Ss, with the exception of those that are received from barges or historically wet pipelines, will have the automatic water drain removed.

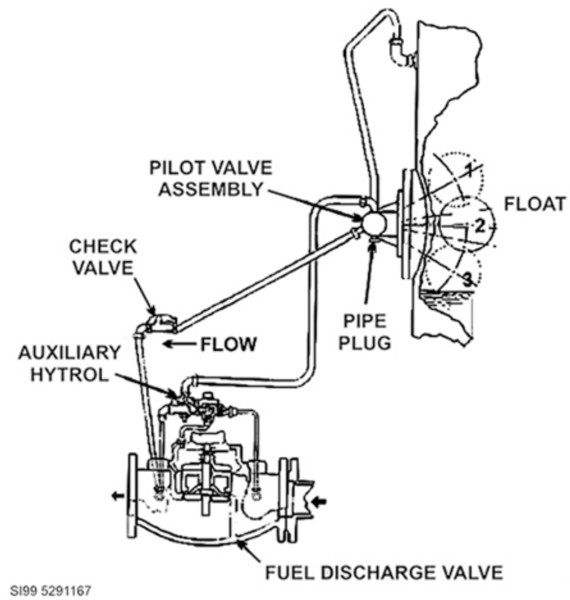


Figure 2–7. F/S control with the water drain removed.

Comparing figure 2–5 to figure 2–7, you will notice that the control tubing that once went to the water drain cover chamber is now plugged off. The control tubing that went to the inlet of the WDV is now rerouted to the downstream side of the FDV, and a check valve is installed on the tubing to prevent reverse flow.

Fuel discharge valve (40AF–2A)

The FDV, shown in figures 2–8 and 2–9, is one of the *first* valves used for this purpose. As flow increased, so did the requirement to maintain a constant rate of flow. The FDV began to serve a second purpose, that of a flow control valve. Figure 2–8 shows the valve open, which occurs when the F/S's ball float is in the bottom or middle position, and figure 2–9 shows the valve closed due to excess water in the F/S when the float will be in the top position.

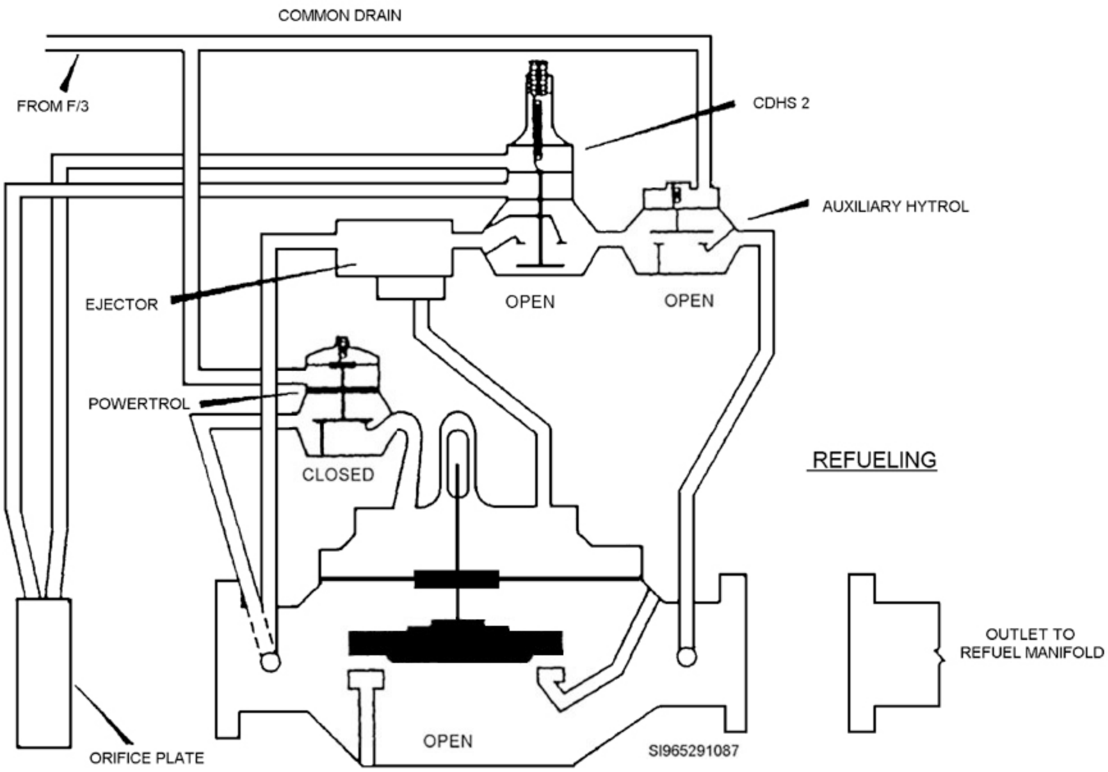


Figure 2–8. 40AF–2A, fuel discharge valve (refueling).
(By courtesy of Cla-Val Co.)

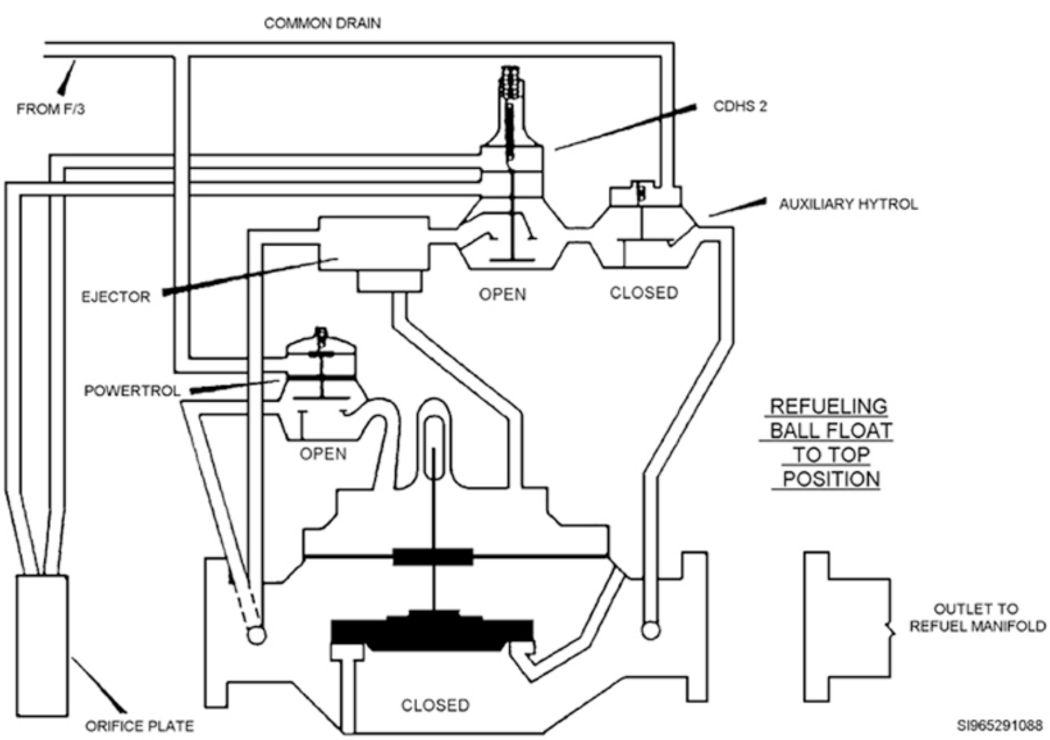


Figure 2–9. 40AF–2A, fuel discharge valve (ball float in the top position).
(By courtesy of Cla-Val Co.)

The most widely used FDV is one with a quick shutoff and flow control—the 40AF–2A. This valve has four major components that you need to learn about before going into the operation itself. The first component to be covered is the *powertrol,* shown in figure 2–10. The powertrol is very simple in design and is in either the OPEN or the CLOSED position. Fuel under pressure enters the powertrol from the right and applies pressure on the top of the disc, holding it in the CLOSED position. When pressure is applied to the underside of the diaphragm, the powertrol is forced open and fuel passes through it.

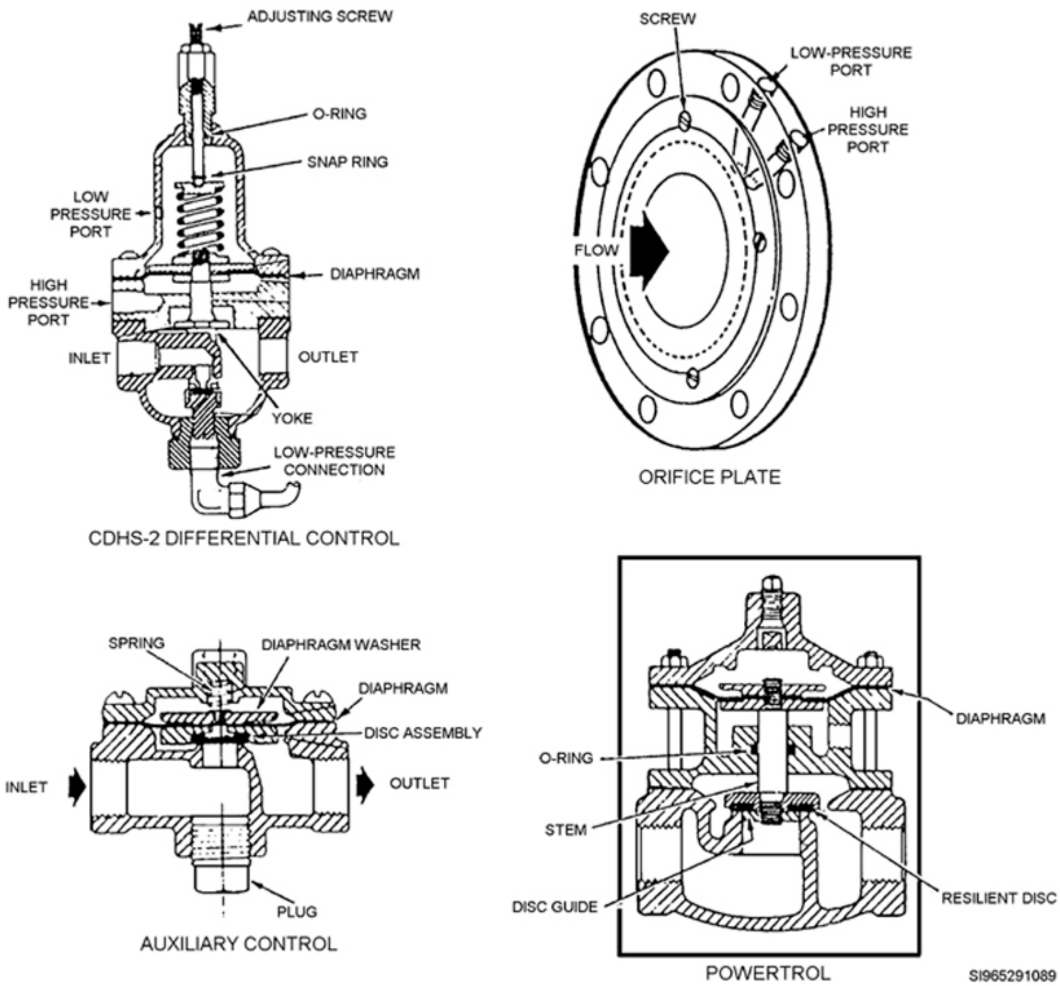


Figure 2–10. 40AF–2A valve components.
(By courtesy of Cla-Val Co.)

Also shown in figure 2–10 is an illustration of an *orifice plate.* The orifice plate is used to create a DP. Fuel passing through the smaller opening of the orifice plate increases the velocity of the fuel and reduces the pressure at the discharge side of the orifice plate. This pressure change is sensed at the low-pressure port, and pressure on the inlet side of the orifice plate is sensed at the high-pressure port. We now have high and low pressure (DP) being sensed at the orifice plate.

In addition, figure 2–10 shows the *CDHS–2 differential control*. This control uses the DP created by the orifice plate to control the flow of fuel through the control tubing of the 40AF–2A. The control has an adjusting screw, an O-ring, a snap ring, a diaphragm, a high-pressure port, and a low-pressure port.

The normal position of the differential control is fully open and the disc is held down by spring tension. Increased fuel flow through the main valve and orifice plate increases the DP sensed at the high- and low-pressure ports of the differential control. Low pressure above the diaphragm of the differential control gets lower and lower. The high pressure under the diaphragm forces the diaphragm up, and this action, in turn, draws the yoke with the disc closer to the seat, thus restricting the flow of fuel through the differential control.

The last control shown on figure 2–10 is the *auxiliary hytrol.* This control is used to stop all flow of fuel in the control tubing when there is excessive water in the F/S. The control is of simple design, consisting of a diaphragm, disc assembly, spring, and a washer. This control is either in the OPEN or the CLOSED position. Without any pressure being applied to the top of the diaphragm, fuel pressure entering the inlet will push up on the diaphragm assembly and force it open. When pressure is applied to the top of the diaphragm, the control is held closed.

Now that you have learned about the components new to you, look back at figure 2–8 and cover the operation of the 40AF–2A. Fuel pressure entering the valve through the orifice plate passes through the control tubing, ejector, differential control, auxiliary hytrol, and control tubing to the discharge side of the valve. Fuel flowing through the ejector creates a low-pressure area at its suction port. Fuel pressure under the diaphragm of the main valve forces the valve open and fuel starts to flow through the main valve. The flow of fuel increases as the valve opens wider. The increase of fuel flow through the orifice plate increases the DP, which is sensed at the differential control through the low-pressure line and high-pressure line. The increase of DP causes the yoke and disc of the differential control to be drawn closer to its seat, restricting the flow of fuel through the control tubing. This increases the pressure at the suction port of the ejector, thus putting some pressure on top of the main valve diaphragm. This, in turn, causes that diaphragm to modulate and maintain the desired flow rate set by the differential control.

When excessive water enters the F/S (see fig. 2–9), the float of the flange float assembly moves to its highest position. Fuel pressure is directed to the 40AF–2A through the pressure line to the top of the diaphragm of the auxiliary hytrol, closing it. At the same time, pressure is applied under the diaphragm of the powertrol valve. With the auxiliary hytrol held closed, no fuel passes through the ejector, and pressure is directed to the top of the main valve diaphragm through the control tubing. Opening the powertrol valve allows full-pump pressure to be applied to the top of the main valve diaphragm through the control tubing.

Fuel discharge valve (40AF–2C)

A newer fuel discharge and rate of flow valve used in the AF is pictured in figure 2–11. We mean the 40AF–2C, which has combined the powertrol valve, hytrol, and ejector into one component, the *102B–1, three-way hytrol 1/8-inch orifice.* The three-way hytrol 1/8-inch orifice pictured in figure 2–12 consists of cover, upper seat, stem nut, diaphragm washers, diaphragm, spring, stem, lower stem nut, disc retainer assembly, lower seat, body, upper stem O-ring, and lower stem O-ring.

Notice the orifice in the bridge wall in figure 2–13 and refer to ports A, B, and C during the following explanation of the operation of the 102B–1. As fuel enters the control through port A, pressure is applied to the underside of the diaphragm, raising the disc up against the upper seat. Fuel then flows through the orifice in the bridge wall and out port B. As the fuel flows through the orifice, the flow increases and creates a low-pressure area at port C. This is connected to the main valve cover chamber and allows the main valve to open. When water in the F/S raises the float to its TOP position, pressure is applied to the cover chamber of the three-way control valve, forcing the disc against the lower seat. Fuel pressure then goes from port A into port C and closes the main valve.

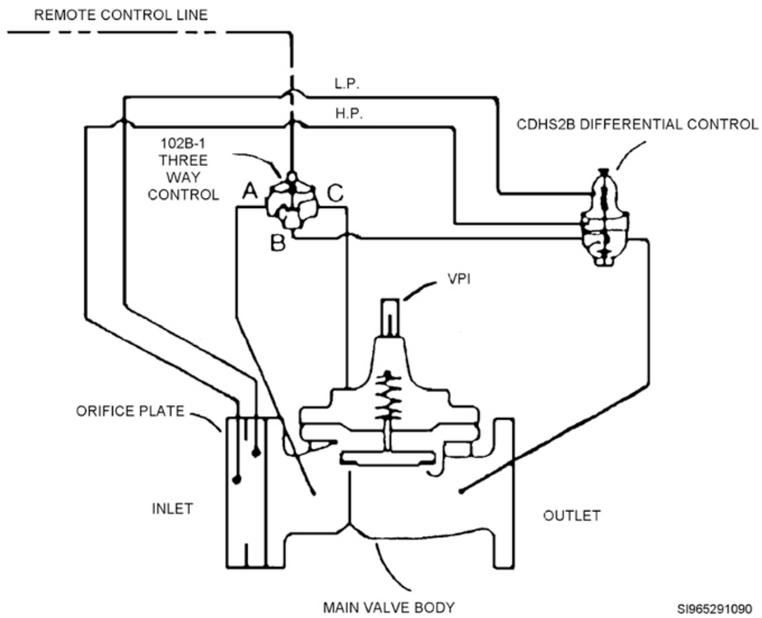


Figure 2–11. 40AF–2C, Fuel discharge valve. (By courtesy of Cla-Val Co.)

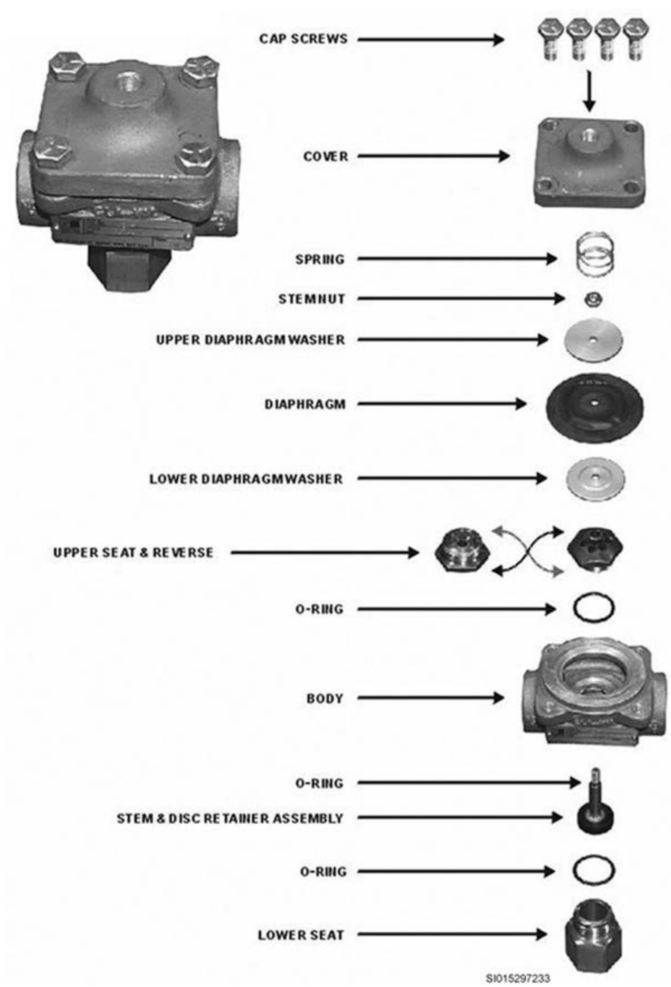


Figure 2–12. 102B–1, Three-way hytrol 1/8-inch orifice (exploded view).

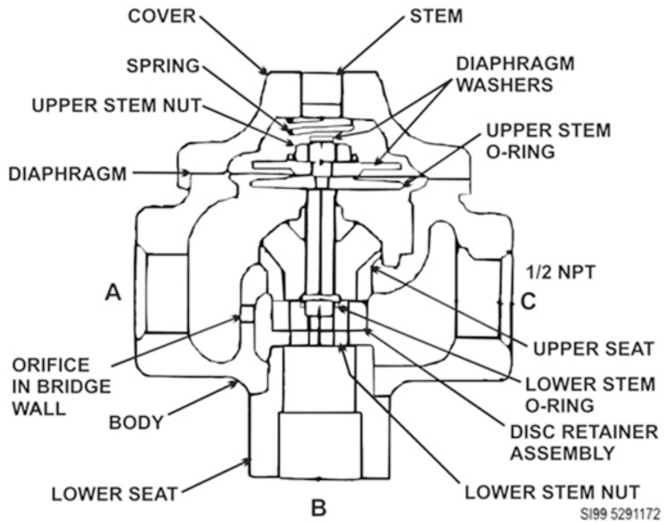


Figure 2–13. 102B–1, Three-way hytrol 1/8-inch orifice.
(By courtesy of Cla-Val Co.)

The differential control used in this valve is very similar to the one already discussed. This control does *not* have a low-pressure line under the valve disc.

The valves we have just covered are manufactured by The Cla-Val Company. Other manufacturers' valves and components may look different but will perform the same functions.

220. Filtration equipment maintenance and inspection requirements

It is imperative that we monitor and maintain our F/S units to ensure clean, dry fuel. Next we will discuss the inspections and maintenance requirements for them.

Inspections

Inspect the F/S for damage or missing parts, improper or loose connections, high DP, evidence of corrosion or leakage, and proper operation of components.

Leaks

When the system is under pressure, check the entire housing for leaks. When the F/S is subject to direct sunlight, the pressure buildup caused by thermal expansion can be of great concern. All F/Ss are designed as American Society of Mechanical Engineers (ASME) pressure vessels and therefore must be equipped with a pressure relief. Pressure reliefs must be set at 10 percent above system deadhead pressure. If the pressure relief should fail to open, there is a danger of excessive leakage. At times gaskets have "blown" because of excessive pressure.

HFS maintenance

Water tests, cartridge replacement, and initial gravity-bottom-filling procedures for the HFS will be discussed in this lesson. Close the inlet and outlet manual valves, open the air vent, open the drain valve on the sump, and drain off all water, if any. Next, drain the remaining fuel back to the tank or into a clean container for return to the tank. (See that provisions are made to drain the fuel back to the operating tanks to prevent fuel spillage in the pump house building.)

After the vessel has been drained thoroughly, remove the head flange bolts and open the vessel.

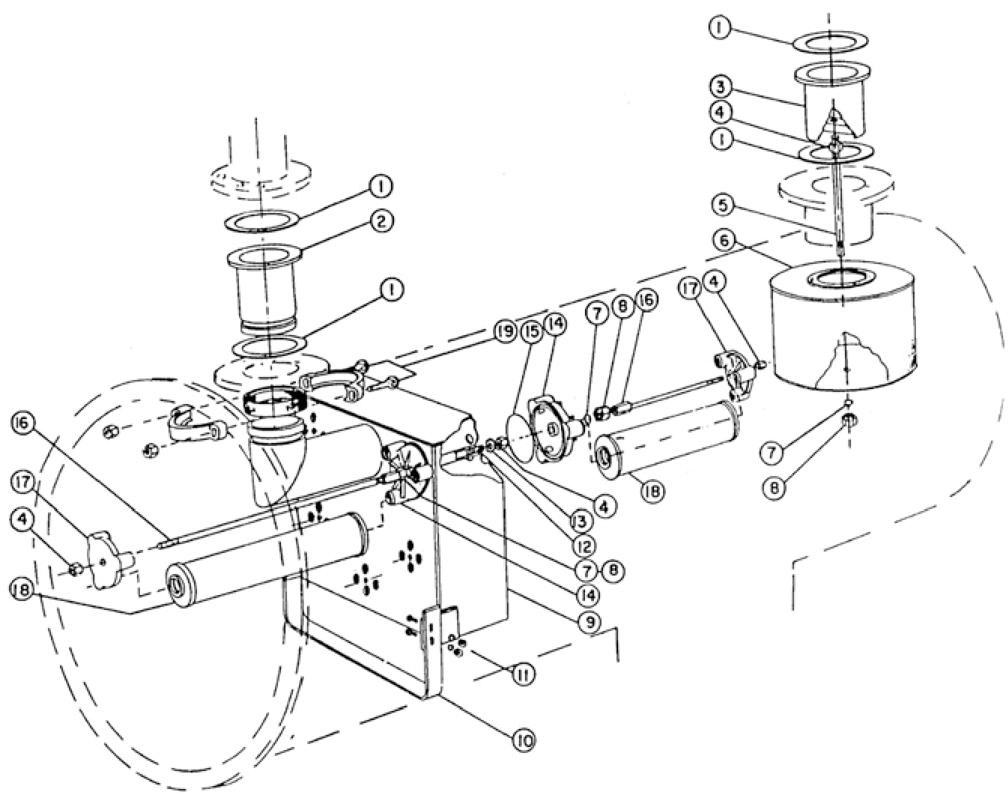
For the original KMU–416/F modification kit, use the following method:

1. Starting with the bottom (left) cartridge, loosen the 1/2-inch nut on the adapter mounting rod. Slowly drain the fuel trapped in the manifold by loosening the bottom element (cartridge).

2. After the fuel has been drained from the manifold, you can remove the 15 elements on the outlet side of the manifold.
3. To remove the cartridge hold-down plate, use a screwdriver for leverage to pry the seals outward from the elements. You can remove the O-ring seals located on the element mounts easier by applying a slight twisting motion instead of a direct pull.
4. Loosen and remove the coupling from the inlet pipe, sliding the sealing gasket down on the manifold pipe section. Be sure to use a static bending wire.
5. Remove the manifold. This requires two people to slide the manifold forward, using the protruding element hold-down rods as handles to assist in removing the manifold. Dispose of the used cartridge (filter elements) in an approved manner. Do not allow fuel-soaked cartridges to remain in the area or to be disposed of in any manner that can create a safety or fire hazard. (Be careful when handling used cartridges because they are toxic and combustible or flammable, depending on the fuel's flash point.)

For modified KMU–416/F (300 gpm) kits with nine additional elements on the backside of the manifold, remove only the bottom front six elements, instead of all 15 elements. This will balance the manifold, and you can remove it more easily. Then remove the manifold from the vessel.

For KMU–417/F (600 gpm) kits (fig. 2–14), leave all of the elements in place when removing the manifold. This provides balance and lets you remove the manifold easily.



1. GASKET, FLANGE
2. ADAPTER, INLET
3. ADAPTER, OUTLET
4. NUT 1/2 INCH
5. ROD, SEPARATOR HOLD DOWN
6. SEPARATOR ELEMENT
7. SEAL
8. SEAL NUT
9. MANIFOLD
10. MANIFOLD, SUPPORT
11. MANIFOLD, SUPPORT HARDWARE
12. ROD, ADAPTER MOUNTING
13. WASHER 1/2 INCH
14. ADAPTER, CARTRIDGE
15. SEAL, O-RING
16. ROD ASSEMBLY, CARTRIDGE HOLD DOWN
17. PLATE, CARTRIDGE HOLD DOWN
18. FILTER ELEMENT, CARTRIDGE
19. VICTAULIC COUPLING ASSEMBLY

SI965291093

Figure 2–14. KMU–417/F F/S modification.

Inspect the inside of the vessel. If there is an accumulation of contaminants there, clean the inside thoroughly. Remove and clean the separator element, or the *second stage screen*, as it is sometimes called.

NOTE: It is necessary for one person to get inside the F/S vessel when the separator second stage is removed or installed. Always allow adequate time for ventilation. Use an air blower to remove vapors if necessary. Use a vapor indicator to determine vapor concentrations, and then don a respirator before entering the unit, if required.

Follow the applicable manufacturer's recommended procedures for removal or installation of the separator second stage.

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

CAUTION: Do not touch the coalescer elements with your bare hand. Keep the plastic cover on the element until it is installed. Oil from your hand will deteriorate the coalescing ability of the element.

Clean and inspect the head (dome) assembly and gasket. If the gasket is compressed or broken, install a new gasket. Position the cover and tighten the cover bolts and nuts.

Safe fill modification of HFS

To reduce the chances of an ignition, all 300 or 600 gpm aviation turbine fuel F/Ss in fixed fuel facilities must be modified as directed here.

Two or more collocated HFS

Modify the existing bottom drain underneath each installed HFS according to figure 2–15. All HFSs shall be equipped with $^3/_4$-inch ball valves (preferred) and quick-disconnect hose fittings. This will provide for initial gravity filling through the bottom connection and will allow the liquid levels in the two vessels to equalize.

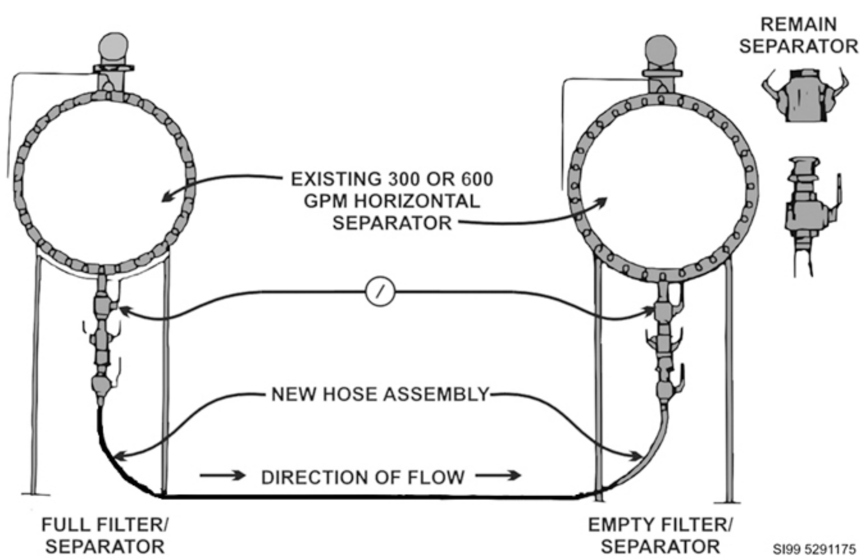


Figure 2–15. Initial filling of HFSs.

Isolated HFSs

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

Unique installations

If installation of 3/4-inch piping to the discharge side of a pump is required, use the valve and hose arrangement shown in figure 2–15. Before any modification can proceed, the BCE, in cooperation with the command civil engineer (CE) and the base fuels management office (FMO), will evaluate the requirement.

Initial filling procedures for HFSs

You must follow certain procedures when you initially fill HFSs. We cover those procedures for collocated HFSs first followed by the procedures for isolated HFSs.

Collocated HFSs

When you initially fill collocated HFSs, first connect a 3/4-inch service station hose between the empty and full separators. Close all main inlet and outlet line valves to isolate the HFS from the fuel system. For gravity flow, open the manual air-release valves on top of both HFSs during the initial filling operation. Open the separator drain valves and hose valves to allow fuel to gravity feed from the full to the empty separator. Wait 10 minutes for the separators to equalize and the new HFS elements to absorb fuel.

Close all drain, hose, and manual air-release valves. Refill the supplying separator, and then again close all main inlet and outlet line valves, open the manual air-release valves on top of both HFSs, open the separator drain valves and hose valves, and wait 10 minutes for separators to equalize and the new HFS elements to absorb fuel.

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

Open the receiving HFS’s (new elements) manual air-release valve to one-half opening and allow the vessel to bottom-fill. Close the manual air-release valve immediately when the liquid starts to come out of it. Wipe off any fuel spilled onto the HFS housing. When the new element vessel is full, secure all valves on both vessels in the CLOSED position and then remove the hose assembly from each separator. Finally, set the main refueling and defueling manifold valves to permit fuel to circulate through both separators.

Isolated HFSs

When you initially fill isolated HFSs, first connect a modified over-the-wing nozzle to the *bottom* of the HFS. (A full refueling unit will gravity feed in the flow mode to fill the HFS vessel.) Shut off the valve after liquid flows out of the air vent valve. Shut down the closed system, replace the nozzle assembly with a standard nozzle, and pressurize the HFS vessel.

NOTE: For systems with the ASTs, fill the HFS vessel by gravity feed through the modified *bottom* connections.

Notify the base fuels service center (FSC) that the F/S is ready to be put back into service and is awaiting quality control (QC) flushing and sampling. (This is necessary to make sure the fuel meets quality requirements.) After receiving FSC’s approval, follow these steps:

1. Data decals are provided with new elements. Cut off the *bottom* portion of the manufacturer’s decal under the words “Element Change Criteria,” and attach *only* the *upper* portion of the decal (indicating the element part number, NSN, etc.) to the F/S vessel.
2. Record on the vessel the next change date (month and year) and maximum allowable DP. If data decals are not provided with the new elements, record *only* the *next* change date and maximum DP on the F/S vessel. Be sure to record the information in a highly visible location.
3. Set up and keep a log book or wall chart in the WFSM shop.

Record the pump house facility number, F/S number, month and year the replacement cartridges were installed, NSN of the cartridges, the number of elements, and the manufacturer's cartridge number, if available, in the log book.

Maintenance

The procedures for performing preventive maintenance include inspecting the F/S, cleaning the strainer screen, and cleaning the F/S vessel. These procedures are necessary to make sure of safe and effective filtration of aviation fuel.

As you inspect the F/S before and during F/S filling operations, check for indications of conditions that affect the operation of the equipment. Clean the strainer screen to ensure free flow of fluid through the strainer to the control system. Also clean the F/S vessel periodically to remove dirt and corrosion from the vessel's interior. If the F/S operational check shows that the filter elements should be changed, replace them when you do the scheduled cleaning of the vessel.

CAUTION: Before you do maintenance on F/Ss, be sure that the valves in the F/S supply pipeline are closed and that the manual air-release valve is open to remove all pressure from the vessel.

Inspect the F/S for damage or missing parts, improper or loose connections, and evidence of corrosion or leakage. If you detect any condition that affects safe and effective operation of the F/S, remedy that condition as soon as possible. When inspecting the F/S, check all valves and pipe fittings for evidence of leakage and corrosion, check the control tubing for any kinks or loose connections, check the gauge glasses for damage, make sure the cover-lifting mechanism is not corroded, and check the area around the cover of the F/S for evidence of leakage or gasket failure.

Replacement of vertical F/S cartridge

To replace a filter element and separator, first drain the F/S completely and then raise the cover. Unbolt and remove the spider plate. The spider plate holes will only line up with the element alignment pins one way, so make note of which side is up and which bolt holes in the plate match up to which bolt holes in the separator. Now remove the outer coalescing canister (if installed) and set it aside for future use, remove and discard the old elements in an approved manner, and insert a new expendable cartridge into the canister.

CAUTION: Do not touch the filter elements or the separator canisters with your bare hand. The oil on your hand will cause damage to the water-removal capability of these components.

Check the adapter gasket and the adapter to make sure that the gasket and adapter threads are clean. Complete installation of the F/S cartridge assemblies by lowering each of the filter element assemblies into one of the deck plate nipples. Make sure that each element assembly is screwed down onto its deck plate nipple so that the gasket is seated properly for a tight seal. Then apply the following five procedures:

1. Close the manual WDV.
2. Inspect the cover gasket. If the cover gasket is *not* in serviceable condition, replace it with a new gasket of the same grade and manufacturer as the old gasket.
3. Swing the cover back into position, lowering the lifting handle as you do so.
4. Swing the eye bolts up into place and tighten the nuts, tightening diagonally opposite nuts equally and alternately. Do this so that the cover gasket and cover are seated properly. When tightening cover bolts and nuts on aluminum F/Ss, use a torque wrench. Tighten nuts just enough to prevent leaking through the dome cover seal (about 50 to 60 pounds of torque). Do not risk possible damage from over-tightening.

5. Slowly refill the vessel using one of the methods described earlier. Pressurize the vessel to inspect all gasketed and screwed connections for leakage. Tighten any loose connections.

NOTE: Remember, once a system is opened for any reason, it must be sampled before the aircraft is serviced.

Notify FSC that the F/S is ready to be put back into service and is awaiting QC flushing and sampling. This is necessary to make sure the fuel meets quality requirements. After the cartridges (elements) have been replaced and the F/S is ready to put back into service, follow these procedures:

1. Data decals are provided with new elements. Cut off the bottom portion of the manufacturer's decal under the words "Element Change Criteria," and attach *only* the *upper* portion of the decal. This indicates the element part number, NSN, etc., to the F/S vessel.
2. Record on the F/S the *next* change date (month and year) and the maximum allowable DP. Make sure to record the information so that it is highly visible.
3. Set up and keep a log book or wall chart in the WFSM shop. Record the following information in this book or chart: pump house facility number, F/S number, month and year replacement cartridges were installed, NSN of the cartridge, number of elements, and manufacturer's cartridge number, if available.

CAUTION: Explosions and fires can result from static discharge ignition of vapors when F/Ss are filled rapidly after element change and other maintenance. You can reduce this hazardous condition by filling the F/S vessel slowly after each element change.

Differential pressure

Check the F/S for DP during normal operation. Check the DP listed on AFTO Form 422, Differential Pressure Log, which should be kept with the F/S. You should check the differential readings to make sure that the F/S is still within the specifications noted on the data plate.

Contaminants in fuel affect the filtering surface of F/S coalescer elements. During fueling operations, the filtering surface collects solid contaminants, and there is a corresponding increase in DP across the coalescer elements. An increase in DP is reflected as psi on the DP gauge installed on the vessel.

It is important to understand that the DP limit for an F/S is established when flow is at the rated capacity of the vessel. Thus, when a 15 psi DP limit is set for a 600 gpm F/S, that limit must be applied when the flow is at 600 gpm. Should the flow rate be considerably less than the designed flow rate, refer to the table below to determine the maximum allowable DP.

Observed Differential Pressure	Percent of Rated Flow			
	25	50	75	100
	Actual Differential Pressure			
20	80	40	27	20
19	76	38	25	19
18	72	36	24	18
17	68	34	23	17
16	64	32	21	16
15	60	30	20	15
14	56	28	19	14
13	52	26	17	13
12	48	24	16	12
11	44	22	15	11
10	40	20	13	10
9	36	18	12	9
8	32	16	11	8

Observed Differential Pressure	Percent of Rated Flow			
	25	50	75	100
	Actual Differential Pressure			
7	28	14	9	7
6	24	12	8	6
5	20	10	7	5
4	16	8	5	4
3	12	6	4	3
2	8	4	3	2
1	4	2	1	1

Troubleshooting a F/S

Even though the system may operate properly for a long period of time, you should be ready to troubleshoot the controls. Knowing how the controls operate is the most important factor in the troubleshooting procedure. We have already covered the control operations. If you are unsure of how they work, go back and review that section.

Troubleshooting should be a methodical thought process, not an automatic wrench-turning job. Always look for the simplest and easiest solution to the problem. There is no sense disassembling an entire 40AF–2C FDV only to find later the F/S sump is full of water. It is much easier to look at the sight gauge on the F/S than to remove the cover chamber of an automatic valve. Unless the problem is a severe leak, set the system up to circulate fuel. You will be surprised at how often a closed manual valve up- or down-stream from an F/S is the problem.

The following table shows likely malfunctions and possible solutions:

Malfunctions	Solutions
The 40A–2A FDV fails to open.	This condition is caused by fuel pressure applied to the top of the main valve diaphragm. That situation can be caused by water in the F/S sump, by a defective diaphragm in the main valve or hytrol, or by the powertrol valve's being stuck open. To correct these troubles, drain water from the F/S, replace the diaphragms, or free the powertrol valve. How can you tell whether the diaphragm is defective? With regard to the hytrol, you can determine this by the flow of fuel out the drain line of the pilot valve assembly because fuel will go through the diaphragm, tubing, pilot valve, and out to drain. Suspect main valve diaphragm failure only after all other possibilities have been eliminated.
The 40AF–2C FDV fails to open.	Once again, here you have either a defective main valve diaphragm or water in the sump. A defective diaphragm in the three-way valve could keep the main valve closed. Some remedies listed earlier for the 40AF–2A apply here.
The FDV fails to maintain proper rate of flow.	The causes for this could be a defective diaphragm in the differential control, clogged sensing lines, or an out-of-adjustment condition on the differential control. To correct the trouble, replace the differential control diaphragm, clean the sensing lines, or adjust the control.
F/S fills with water and the FDV does not close.	Usually this condition is caused by failure of the pilot control. If the pilot control float has a leak, or if it is stuck in the lowest position, pressure cannot be directed to the hytrol on the FDV. There is only one thing to do: drain the F/S and pull the pilot control for inspection. Since this inspection is time consuming, you should check the float assembly every time you change filters.

One way of checking the float is to fill the F/S sump with water. If the float rises easily, it's all right. However, whenever you use this method, be sure to dry the sump thoroughly—leave *no* water in the F/S. Another way of checking the float is to remove it and place it in a bucket of water. Remember, this float is designed to float in *water only*. You cannot use fuel to test the float.

The newest pilot control now in service is called the *CFF21 flange float control* (fig. 2–16). This new pilot control operates in the same way the old one does, with one major difference—the CFF21 has a float that will float in fuel. Instead of the ball float that is weighted, a ballast weight rests on the float arm. This new feature gives you the capability of testing the pilot control, FDV, and WDV. A lever attached to the ballast is located on the outside portion of the pilot control. When you push down on this lever while fuel is circulating through the F/S, the float will rise because it is able to float in fuel. Now look at figure 2–16. In normal operating position (1), the float ball ballast is fixed to the float for automatic water level control. By removing the ballast from the float (2), you allow the float ball to float in fuel (3 & 4). The sequential operation of the WDV and FDV verify the integrity of the float ball and proper functioning of the pilot control mechanism. This unique approach is the *only* positive means of checking the control function totally while the F/S is in service.

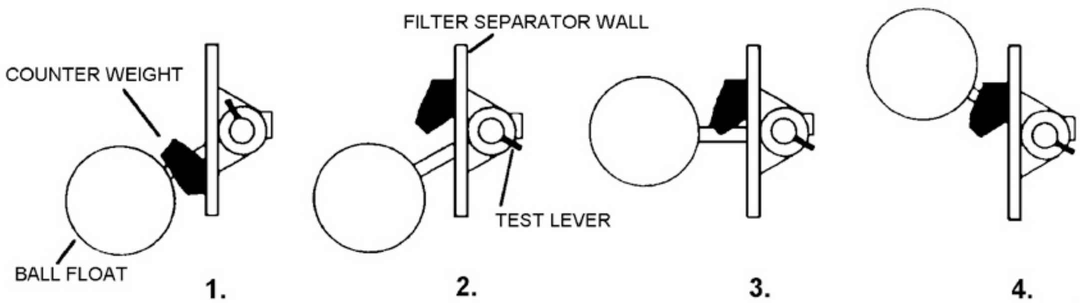


Figure 2–16. CFF21 flanged float control.
(By courtesy of Cla-Val Co.)

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

217. The components of a military specification filter/separator

1. List the basic components of the HFS unit.

2. List the filter arrangement components for the HFS modification.

3. How does fuel pass through the filter cartridges?

4. Explain the effects on the FDV when the pilot valve assembly float rises.

5. What happens to the water that is removed from the fuel?

6. List the components of the vertical F/S.

7. Where does the water collect in a vertical F/S?

8. What occurs when the float of the pilot valve assembly reaches the TOP position?

218. The components and operation of the API 1581 filter/separator

1. What material is the API 1581 F/S made of?

2. What type DP gauge is installed on an API 1581 F/S?

3. How do you adjust the pressure relief on the API 1581 F/S?

4. What is the minimum capacity of the API 1581 coalescers and separators?

5. What is the purpose of the spider plate in an API 1581 F/S?

219. How water is removed from filter/separators

1. What are the three major components of the water drain system?

2. How are the three major components connected to each other?

3. What component protects the inlet supply tubing?

4. How many distinct positions are there of the float that operates the rotary disc in the pilot valve assembly of the water drain system? What happens at each position?

5. Match each function of the 40AF–2A components, in column A, with the component responsible for that function, in column B. Column B components may be used more than once.

Column A	Column B
____ (1) Creates a differential pressure.	a. Flow clean strainer.
____ (2) Opens when pressure is applied under the diaphragm, closing the FDV.	b. Ejector.
____ (3) Controls the flow of fuel through the control tubing.	c. CDHS–2.
____ (4) Closes when pressure is applied to the top of the diaphragm, closing the FDV.	d. Auxiliary hytrol.
____ (5) Creates a low-pressure area at its suction port allowing pressure under the diaphragm to open the main valve.	e. Orifice plate.
____ (6) Insures clean fuel through the control tubing.	f. Powertrol.
____ (7) Shows the position of the main valve disc assembly.	g. Valve position indicator.
____ (8) Restricts flow through the control tubing, causing the main valve to modulate.	
____ (9) When it is aligned to drain, it opens and allows fuel to flow through the control tubing.	
____ (10) When it is open, it applies full pump pressure to the top of the main valve diaphragm.	

6. What component found on the 40AF–2C FDV is different from that on the 40AF–2A? What components did it combine?

220. Filtration equipment maintenance and inspection requirements

1. List the inspections required for F/Ss.

2. What maintenance may be required when the following FDVs fail to open?

   a. 40AF–2A.

   b. 40AF–2C.

3. The pressure-relief valve installed on an F/S is set at what pressure?

4. After changing elements in the F/S, who must you notify? Why?

5. After changing the F/S, what information must you record on the F/S vessel?

6. What is the probable cause if the 40AF–2A FDV fails to open?

7. What is the probable cause if the 40AF–2C FDV fails to close with water in the separator?

8. What is the probable cause if the FDV fails to maintain the proper rate of flow?

2–2. Strainers

Normally strainers are placed in fuel-dispensing systems to prevent foreign material from entering aircraft fuel tanks. While this is certainly true, it is not the only reason for using strainers. You will find strainers installed on loading and offloading facilities. Also, strainers are installed on the downstream of each pump, unless an F/S is adjacent to the pump as well as in the dispensing nozzles. In addition, strainers are placed before some pumps, automatic valves, and meters to prevent damage and excessive wear on these units by such unfiltered materials as rust and dirt.

221. Strainer construction features and maintenance requirements

Strainers are determined by the mesh openings per linear inch. There are three different mesh screens generally used in fuel systems:

1. The *100-mesh* that is used in the single point dispensing nozzles.
2. The *60-mesh* that is used before meters and in flow clean strainers of automatic valves.
3. A 7-*mesh* strainer that is used upstream of pumps, if required.

Design

Generally, just three types of strainers are used: (1) the Y type, which is shaped like a Y and is used as a line strainer, (2) the cylindrical type, which is shaped like a cylinder and is also used as a line strainer in the pipeline, and (3) the basket type, which is similar in appearance to the cylindrical type, with one end closed and used as a line and/or fill line strainer (fig. 2–17).

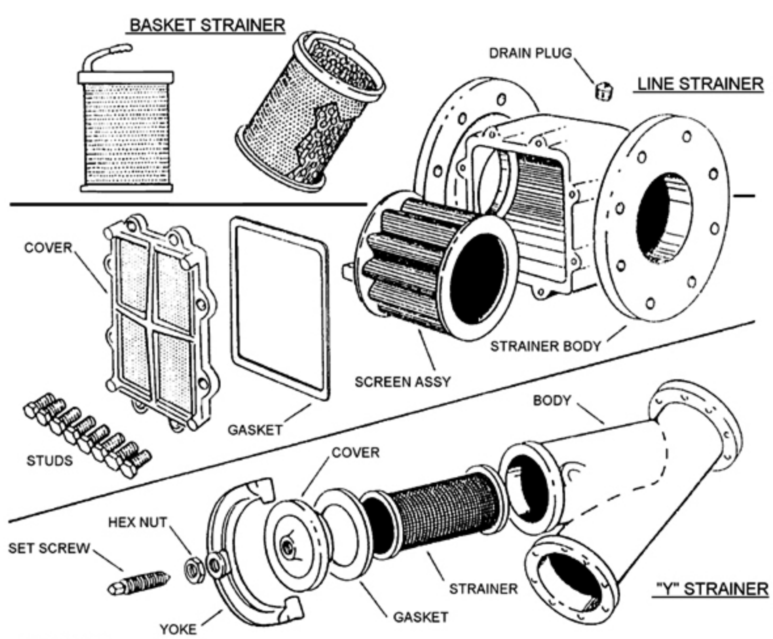


Figure 2–17. Strainers.

As you come into contact with newer or older systems, you will find strainers that differ in appearance from the three shown. All, however, are readily recognizable and easily opened for maintenance. In studying figure 2–17, note that each strainer consists of a rugged basic frame (generally brass, stainless, or bronze), a heavy and rather coarse wire mesh, and the fine screen. Where flow is heavy and pressures are high, a heavy shell provides additional reinforcement. Normally, the direction of fuel flow through a strainer is from the center to the outside of the strainer.

Inspection and maintenance

Straineres equipped with DP gauges must be cleaned when the DP reaches 10 psi. It is good practice to keep a few sets of basket-type (internal portion) strainers on hand to replace each basket-type strainer as it is removed and to permit all dirty strainers to be cleaned. If valves are mounted on each side of the strainer body, close them before removing the strainer canister unit for cleaning. Place a container in a position to catch fuel when you remove the strainer cover.

When removing the strainer canister unit, be careful not to damage the canister unit or to drop sediment into the strainer body. After you have removed the strainer canister unit, replace the cover while the canister unit is being cleaned. Batten down the cover until the basket is replaced.

Air pressure or a stream of water from a hose is usually most effective in removing dirt from an internal canister strainer. Normal flow for a strainer is center to outside. Always clean a screen against the normal direction of flow through it. To do this, direct the flow of air or water against the outside of the screen, and force the dirt away from the inside and outside of the basket. A solvent (one of high flash point, such as clean kerosene) may be necessary. If so, apply it with a soft brush against the outside of the screen surface.

The bracket or handle attached to the top of the canister unit is installed so that the strainer cover or inspection plate will hold the canister unit tightly in the strainer body. The bracket holds the flange or lip on the strainer body canister unit tightly against its gasket. This arrangement ensures passage of fuel inside the canister unit and out through the screen so that all dirt is trapped inside the strainer. Do *not* bounce a strainer canister unit to dislodge dirt; if you do, the jar of the impact may damage the bracket or handle and keep the cover from holding the canister unit tightly in the strainer body. Some unstrained liquid would thus bypass the strainer and carry dirt into the newly cleaned product.

When you clean the strainers, inspect screens for rust, corrosion, or damage. Replace any screens showing signs of rust or corrosion. After replacing the strainer canister unit and tightening the cover bolts, check the strainer for leaks. There may be times when one particular delivery of fuel is highly contaminated. (For example, a barge load of fuel may contain a foreign thread-like metallic substance.) If so, the unloading line strainer will become very dirty. If you find such an instance, you will see that even though the unloading line strainer has become clogged with the material, some of it has passed through and will be found in the other strainers and filters in the system. Some of the material will still be in-transit in the lines after several hours of operation. In such an event, inspect the screens and filters more frequently until all signs of the especially heavy contamination are gone.

Contamination by microorganisms or biological growths has been mentioned earlier. Sometimes such contamination can be difficult to spot. Let us emphasize this difficulty by relating an experience.

A barge load of fuel had been offloaded. The unloading line strainer was pulled for inspection. (This is standard practice after each offloading operation.) Dark, greasy-looking spots were found on the strainer. Several maintenance personnel, including the foreman, examined this substance. At first, it appeared that plug valve lubricant had somehow gotten into the fuel as it was being loaded onto the barge. However, because the substance did not feel quite like grease, one of the maintenance personnel was not convinced. To resolve the matter, the strainer was sent to a fuel laboratory for analysis. The laboratory found the dark substance to be a fiber of a growing mold living in the fuel. The same substance was subsequently found in all strainers and filters in the system.

Because of the occurrence of situations like that just described, many bases make it a standard operating procedure to remove and inspect the strainer in the unloading lines after each operation. This may seem like extra work, but it has repeatedly prevented possible contamination of the complete system.

Normally, the strainers are inspected and cleaned by operator personnel. If unusual or heavy deposits are found, maintenance personnel are notified.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

221. Strainer construction features and maintenance requirements

1. List three types of strainers.

2. How is the basic strainer constructed?

3. When are strainers equipped with DP gauges cleaned?

4. How are strainers cleaned?

Answers to Self-Test Questions

217

1. (1) FDV, (2) discharge valve control tubing, (3) ”Y” strainer, (4) pilot valve supply tubing, (5) float and pilot valve assembly, (6) pilot valve drain tubing, (7) WDV control tubing, (8) pilot valve drain check valve, (9) WDV, (10) water drain line, (11) sump drain line connection, (12) float, and (13) liquid-level gauge.
2. Gaskets, inlet flange adapter, outlet flange adapter, separator hold-down rod, separator element, coupling assembly, adapter mounting rod, cartridge adapter, manifold, manifold support, cartridge, cartridge hold-down plate, and cartridge hold-down rod assembly.
3. From the inside to the outside.
4. As the float reaches the top position, the FDV closes.
5. Water will be drained from the sump through the WDV.
6. Cover, air eliminator valve, pressure-relief valve, eye bolt, sight gauge, gauge tube, filter element, manual drain valve, manual valve, flow indicator, WDV, FDV, float-pilot valve assembly, lever, cover hinge, and DP gauge.
7. On top of the baffle plate.
8. The FDV will close so that there is no flow of fuel from the F/S.

218

1. Aluminum or carbon steel, and it is internally coated with epoxy.
2. A direct-reading, piston type that measures the DP across both the coalescers and separators.

3. By loosening the jam nut and turning the adjustment screw clockwise to increase the pressure setting or counter clock wise to decrease the pressure setting. Once 150 psi is set, tighten the jam nut.
4. The coalescers must be rated for a minimum capacity of 2.27 gpm per inch of length and the separators must be rated for a minimum capacity of 8.33 gpm per inch of length.
5. To hold the coalescers and separators in position and support them firmly against vibration.

219

1. Pilot valve (flange float control) assembly, WDV, and auxiliary hytrol control valve.
2. By control tubing.
3. A strainer.
4. Three. Lowest—WDV closed, FDV open; Center—WDV open, FDV open; Top—WDV open, FDV closed.
5. (1) e.
   (2) f.
   (3) c.
   (4) d.
   (5) b.
   (6) a.
   (7) g.
   (8) c.
   (9) d.
   (10) f.
6. Three-way hytrol $^{1}/_{8}$-inch orifice. Replaces the ejector, powertrol valve, and auxiliary hytrol.

220

1. Inspect the F/S for damage or missing parts, improper or loose connections, high DP, and evidence of corrosion or leakage.
2. a. Remove water from the F/S, replace main valve diaphragm, hytrol diaphragm, or powertrol diaphragm, and free the stuck open powertrol.
   b. Remove water from the F/S, replace the main valve diaphragm, and replace the three-way hytrol diaphragm.
3. 10 percent above system deadhead pressure.
4. FSC. To have the QC personnel flush and sample the F/S.
5. The next change date (month and year) and the maximum allowable differential pressure.
6. By water in the F/S sump, by a defective diaphragm in the main valve or hytrol, or by the powertrol being stuck open.
7. The flanged float control is defective.
8. A defective CDHS–2 diaphragm, clogged sensing lines, or an out-of-adjustment condition on the differential control.

221

1. “Y,” cylindrical, and basket.
2. Rugged basic frame, a heavy and rather coarse wire mesh, and then a fine screen.
3. When the DP reaches 10 psi.
4. By air pressure or a stream of water from a hose against the normal direction of flow; or in some cases, a high flash point solvent may be required.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

44. (217) When the float in a military specification (MILSPEC) vertical filter/separator (F/S) rises to the top position, what happens?
    a. The water drain valve (WDV) closes.
    b. The fuel discharge valve (FDV) closes.
    c. The nonsurge check valve opens.
    d. Nothing; fuel is allowed to flow normally.

45. (218) Coalescers in an American Petroleum Institute (API) 1581 filter/separator (F/S) are rated for what *minimum* gallons per minute (gpm) per inch of length?
    a. 1.27.
    b. 2.27.
    c. 7.33.
    d. 8.33.

46. (219) Which component controls the water drain system?
    a. Water drain valve (WDV).
    b. Fuel discharge valve (FDV).
    c. Pilot valve assembly.
    d. Auxiliary control valve.

47. (219) When the float of a filter/separator (F/S) is in its lowest position, supply pressure is directed to what component?
    a. Powertrol.
    b. Auxiliary hytrol.
    c. Water drain valve (WDV).
    d. Fuel discharge valve (FDV).

48. (219) When the water drain valve (WDV) is removed from the filter/separator (F/S), where is the control tubing that once went to the water drain cover chamber rerouted?
    a. Nowhere; it is plugged off.
    b. Upstream of the fuel discharge valve (FDV).
    c. Downstream of the FDV.
    d. To the cover chamber of the FDV.

49. (220) If a fuel system has a *maximum* deadhead pressure of 125 pounds per square inch (psi), at what psi should the filter/separator (F/S) pressure relief be set?
    a. 132.5.
    b. 135.
    c. 137.5.
    d. 142.

50. (220) When removing the KMU–416/F modification kit with 9 additional elements, how many elements *must* you remove from the front side to balance the manifold?
    a. 3.
    b. 6.
    c. 9.
    d. 15.

51. (220) If the 40AF–2A fuel discharge valve fails to open, what should you check first?
    a. Main valve diaphragm.
    b. Pilot valve assembly.
    c. Three-way valve diaphragm.
    d. Water in the filter/separator (F/S) sump.

52. (220) The new CFF21 flange control differs from the old pilot valve assembly in that it
    a. has two supply lines.
    b. uses an external float.
    c. does not use a Y strainer.
    d. has a float that floats in fuel.

53. (221) If required, what mesh strainer is used before (upstream of) pumps in fuel systems?
    a. 5.
    b. 7.
    c. 60.
    d. 100.

54. (221) What type of strainer is normally used as a line strainer in a pipeline?
    a. "Y."
    b. Basket.
    c. Flange.
    d. Cylindrical.

55. (221) What is the *normal* flow of fuel through a strainer?
    a. Outside-to-center.
    b. Center-to-outside.
    c. Outside-to-center-to-outside.
    d. Center-to-outside-to-center.

Please read the unit menu for unit 3 and continue ➔

Unit 3. Meters and Gauges

WHEN YOU ARE ABOUT to make a long trip in your car, you may write down the mileage so that you can later figure the miles per gallon (mpg) your car is giving you. Just how much gas you get in your car is measured by the meter on the gas pump at the corner station. What would it be like if there were no meter at your corner station? Instead of figuring the mpg, you might have to figure the gal. per mile. The meter, as you can see, is a very important instrument any time fuel is moved from one unit to another.

Just as the gauge in your car tells you the amount of gasoline that is in your car's tank, the oil gauge gives you the pressure of the oil, and the water gauge lets you know the temperature of the water. Just these few examples make it obvious that it would be difficult to operate a car properly without meters and gauges to keep a check on how the engine is performing.

The same principle—the need for meters and gauges—applies to a fuel system. A fuel system may dispense hundreds of thousands of gal. of fuel each day, and a close record must be kept for accounting purposes. The amount of fuel remaining in the storage tank is shown on the liquid-level gauges. How well the system is running can be determined by the use of pressure gauges installed throughout the fuel system.

3–1. Meters

In everyday shop conversation, meters, like other fuel system components, are identified by the name of the manufacturer. Let us use shop nomenclature in our discussion of meters. The meters you will come into contact with are designed to measure the issuance of fuel or other petroleum products. You find meters on MOGAS pumps, hose carts, and in the bulk storage area. All meters used in AF liquid fuel systems are positive-displacement meters. This means that all of the liquid actually passes through the meter-measuring chamber. A fixed amount of fuel passes through the meter with each revolution of the meter's measuring mechanism. Therefore, the meter simply records the number of revolutions made by the measuring mechanism, reflecting this count by calibrations in gal. Meters are normally found on truck fill-stands, hose carts, and the mastermeter cart that we use to calibrate the fill-stand meters.

222. The maintenance and calibration mechanisms of meters

The AF uses a variety of different meters to measure fuel. We use them on service stations, bulk storage receipt pipelines, and issue lines going out to the flight line. It is very important that we make sure all of the fuel is accounted for. In the following paragraphs you will learn how to maintain and calibrate different types of fueling meters.

Maintenance of meters

When you calibrate a meter, you are simply deciding whether the meter is slow or fast, thereby changing the meter adjustment accordingly. Sometimes these procedures seem extremely complex and difficult to understand. Remember, also, that even with a well-designed calibrating mechanism, it is nearly impossible to get a perfect reading. If the meter reading is correct to within 0.2 percent of total fuel displaced, it meets AF standards. Meters must be calibrated, at a minimum, once a year. Calibration must also be done any time improper performance is suspected, when unusual sounds or peculiar register actions develop, and after repairs that could affect a meter's performance.

A meter should be removed from the pipeline only as a last resort. In any event, generally, the overhaul of meters is handled by contract with the manufacturer or at depots. This contract method is also true for units located overseas and in remote areas. There are two advantages to this policy. First, the manufacturer or depot has the necessary parts and facilities to do the job; second, the personnel who do the work are highly proficient. The meter usually requires very little maintenance. Therefore, it is difficult for a maintenance specialist, such as you, to get experience in performing major maintenance on the different meters.

Normally, your maintenance is limited to such minor repairs as replacing gaskets, seals, or packing glands; calibrating the meter; and occasionally replacing meter registers or interconnecting gear drives. However, you should *not* attempt even minor repairs unless you have been checked out thoroughly on the job and have a copy of the complete instructions governing the maintenance of the particular meter you are attempting to repair.

Dirt and air are the two *greatest* enemies of any meter. Air causes meters to over-register. Dirt and pipe scale cause excessive wear on moving parts. Normally, a meter with dirt in the measuring chamber does not slow down. However, the dirt can bind the meter because of the close tolerance in its moving parts. In addition, meters that are not designed for a two-way flow can be damaged (in the drive mechanisms) by back pressures caused by hydraulic shock.

Principles of calibration mechanisms

Although a meter is a relatively simple measuring device, you may become confused when you try to change or calibrate one. To calibrate a meter, we change the gear train ratio.

To refresh your memory about gears and gear ratios, look at the gear train shown in figure 3–1. The meter-measuring device is little more than a wheel rotated by the fuel being pumped past it. We connect a gear train and drive to a rotor and register. Let us assume that the wheel will turn one revolution for each quart of fuel that passes it. Four turns, then, would equal 1 gal. The gear train ratio is such that for each four turns of the rotor, the register will add one gal. to the reading on the register.

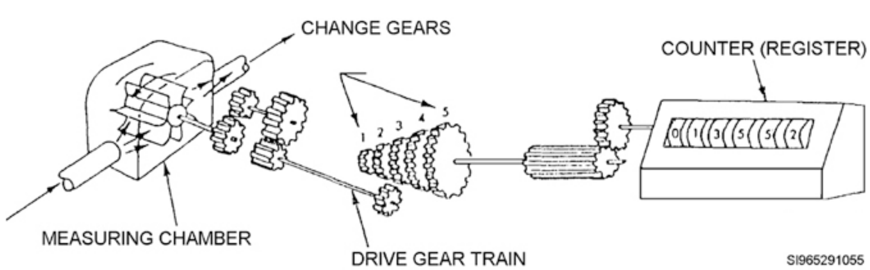


Figure 3–1. Simplified gear ratio calibration mechanism.

If the gears are not lubricated, the gear ratio may change from wear; therefore, you must lubricate these gears periodically. Many little things can cause the register to add too rapidly or too slowly. Normally, replacement of parts is unnecessary; calibration can correct this slight change. For example, suppose that the register shows 9 gal., when 10 gal. have actually passed through the measuring chamber. The meter register is slow. It is not showing all of the fuel that has passed through the chamber. You need to make the gears turn just a little bit faster with respect to the rotor. By doing this, you can have the counter showing 10 gal. when 10 gal. have actually passed through the chamber.

Thus, *calibration* is simply the process of changing the drive or register in some way to make it add faster or slower with respect to the action of the measuring chamber.

Now assume that you have a meter using a gear train calibration. In our last example, the meter register did not show the correct amount of fuel that had passed through the measuring chamber. Notice, in figure 3–1, that each of the change gears has a different diameter. This means that each gear has a different number of teeth (ratio) with respect to the drive gear. Assume that gear 3 is being used. Say that you need to alter the gear ratio higher to obtain a correct count on the register. Which gear should you change to speed up the counter with respect to the measuring wheel?

Consider these factors: Being more nearly the size of the drive gear, gear 2 would turn more quickly than gear 3. In contrast, gear 4 would turn more slowly. So the answer is, use gear 2, because the counter *will* add more quickly. Therefore, it should reflect 10 gal. for each 10 gal. of actual flow. But the counter would slow down if you engaged from gear 3 to gear 4.

223. Major components and calibration procedures for the Smith meter

The Smith meters are made in several different sizes, and one of them is pictured in figure 3–2, A. The meter can be obtained in a compact design to install where space is limited, and it can be used in gravity flow or pressurized systems. The flexibility of these meters permits them to fit into all piping arrangements. The model shown is a 600 gpm meter and its components include the following:

- Inlet and outlet openings that are identical in size and shape and are located 180° apart.
- A measuring chamber containing the meter rotors can revolve in either direction, making the meter reversible for two-way flow without making any physical changes to the meter. A register and calibration lever is located on top of the meter.

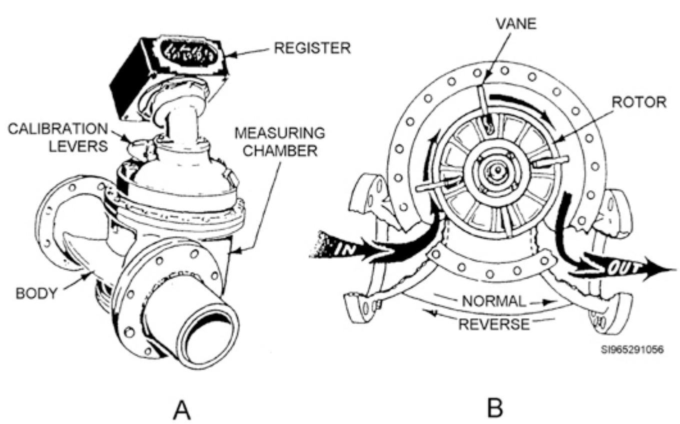


Figure 3–2. Smith meter.
(Courtesy of FMC Technologies.)

The Smith meter is a positive-displacement rotor type. An accurately machined body (fig. 3–2, B) contains a rotor that revolves on ball bearings and serves as a carrier for the evenly spaced vanes. The tips of the vanes contain Teflon inserts. The Teflon tips form a tight seal against the inside wall of the meter body. Fuel flows through the meter radially, and the successive movement of the vanes outward toward the wall forms a measuring chamber of precise volume between the vanes, rotor, and body. A continuous series of closed chambers is produced—four for each revolution. Flow through the Smith meter is undisturbed while fuel is being metered. When fuel flow is reversed through the meter, the vane operation is the same; only the direction of rotation changes. The register subtracts when fuel flow through the meter is reversed.

Inspection and maintenance of Smith meters

Your inspection of the Smith meter is limited to visual inspections unless the meter is opened for minor maintenance. Thus, the register may be removed for inspection of the gear train components that connect it to the rotor assembly, but send the meter to the applicable manufacturer when major repairs are required. When the meter is clean and the top cover is removed, as shown in figure 3–2, B, you can turn the rotor by hand. If rotor drag exists, you will hear a scraping sound. This could be caused by worn vanes or bearings. Check for and remove dirt by flushing the rotor assembly. Meter gaskets are of special thickness and are often made of special materials. Use only the proper factory replacements when replacing gaskets because you can affect the internal clearances by using other gasket materials. Also, do *not* try to disassemble this meter or register without getting the assistance of a qualified technician. Likewise, keep an applicable repair manual readily available.

Calibrating Smith meters

The Smith meter calibration mechanism is located in the upper housing of the meter case. Figure 3–3 shows the calibration levers, which are covered by a protective cap and secured in place by a slide bar. The total effective range of calibration is 20 percent of the maximum rated capacity of the meter. When more fuel passes through the meter than the meter register shows, you need to increase the reading. The meter is under-registering. Conversely, if the register shows more fuel than flows through the meter, it is over-registering, and you decrease the reading. Do *not* try to move the levers when the meter is rotating.

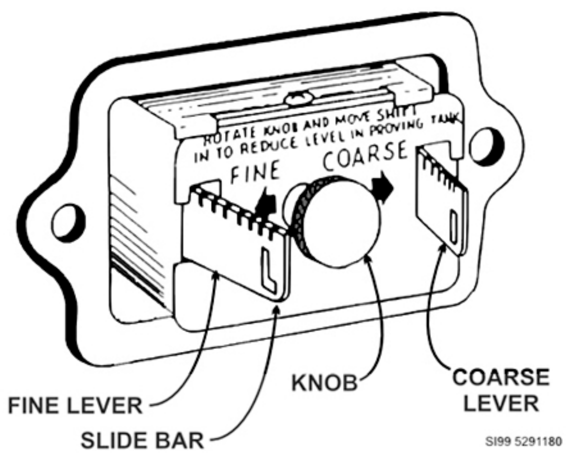


Figure 3–3. Smith meter calibration. (Courtesy of FMC Technologies.)

The *coarse lever* will change the calibration 138.8 cubic inches per 100 gal. for each notch of the lever. By comparison, the *fine lever* will change the calibration 11.5 cubic inches per 100 gal. for each notch of the lever. So moving the levers “in” *in*creases the register reading, and pulling them “out” *de*creases the register reading. For example, if you move both levers “in” one notch, you would have an increase of 150.3 cubic inches per 100 gal. On the other hand, if you move the coarse lever “in” one notch and pull the fine lever “out” one notch, you would have an increase of only 127.3 cubic inches per 100 gal.

When you are using a mastermeter to calibrate a Smith meter, flush about 100 gal. through the equipment to get all of the air out; then make the test run by transferring exactly 600 gal. through the mastermeter. Note the register reading on the meter you are checking for accuracy. If the reading is between 598.8 and 601.2 gal., no calibration is required. So we can do a little figuring. Suppose the meter register reads 594 gal. *First*, make adjustments “per 100 gal.,” and convert the gallonage error to cubic inches. In the 600 gal. test run, the meter was under-registering 6 gal. This is equal to an error of one gal. per 100 gal. Since there are 231 cubic inches in one gal., there is an error of 231 cubic inches. This means you must move the calibrating levers to correct this error. However, because the meter is under-registering, you need to increase the meter register reading. Accordingly, move the coarse lever "in" two notches. This will change the calibration 277.6 cubic inches, and this is 46.6 cubic inches more than you need. Now pull the fine lever "out" four notches to make up the difference. This adjustment will subtract 46 cubic inches. After the adjustment, make another 600 gal. test run and double-check the accuracy of the meter.

Using the same example as in the last paragraph, you can move the levers in a different way to make the calibration. *First,* move the coarse lever "in" only one notch. This will still leave a difference (between 138.8 and 231 cubic inches) of 92.2 cubic inches. Now, *second*, move the fine lever "in" eight notches; this equals 92 cubic inches. Your result will be an error of only 0.2 cubic inch. As you can see, by moving the levers in this manner, you can obtain a more accurate calibration. However, because there are only 12 notches to a lever, it will not always be possible to use this method of moving both levers "in." Consider that you have moved the fine lever "in" eight notches. But if you already have five or six notches showing, there is no way you can move the fine lever in eight more notches. This means you will have to move the coarse lever "in" an additional notch and start pulling "out" on the fine lever, as we just indicated in the last paragraph.

Whatever the situation, your hardest problem when calibrating a meter is to remember which direction to move the levers. For example, when you use a mastermeter, if the meter you are calibrating registers over 600 gal., you need to start by pulling the levers "out." When it registers under 600 gal., start pushing the levers "in." Remember, you may run into situations where you have to move the coarse lever an additional notch and the fine lever in the opposite direction. The knob is used to align the gear with the levers for easy movement.

224. Liquid control meter operating principles and calibration requirements

The liquid control meter (fig. 3–4) operates on the positive-displacement principle. It has a blocking rotor and two displacement rotors that turn in synchronized rotary movement. The total reading on the register of the fuel displaced by the rotor is transmitted to the register by a gear train. The speed of the rotors is caused by the fuel flowing through the meter. The rotors make no metal-to-metal contact to cause drag. Consequently, there is no compression of the fuel and very little pressure drop during operation.

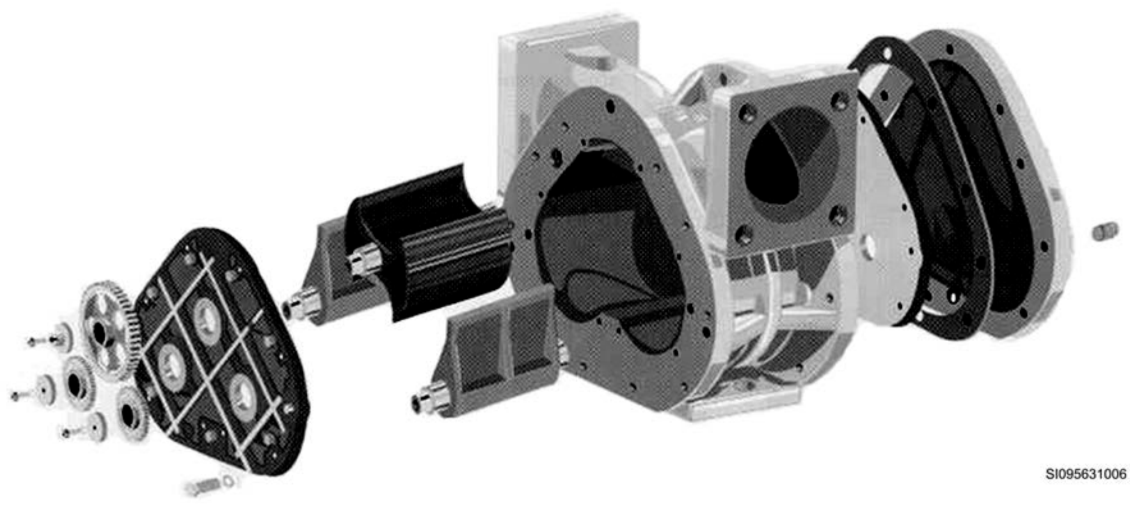


Figure 3–4. Liquid control meter.
(Courtesy of IDEX Corporation.)

Inspection and maintenance of liquid control meters

Inspect the meter visually for leaks. Sometimes the O-ring inside the back of the meter begins to leak. To replace this packing, break the meter seal and take off the adjuster cover plate. Then remove the two screws that hold the seal retaining plate to the back end cover. Next, carefully pull the packing assembly far enough out of the cover to replace the O-ring. To assemble the packing assembly, reverse the order of disassembly. Install the adjuster cover plate and seal the meter. If the housing begins to leak, you may be able to stop the leaking by tightening the bolts. If, however, this tightening does *not* stop the leaking, replace the gasket. But do *not* try to do major meter repairs. Consult the applicable manufacturer's technical manual for any minor repairs to this meter, including gasket replacement.

Calibrating liquid control meters

After installing a new meter in the fuel system and performing the necessary maintenance, check the meter to determine whether it is operating correctly. When using a mastermeter to calibrate a liquid control meter, you flush about 100 gal. through the equipment to get all of the air out. Then operate and adjust the meter, using a 600 gal. test run until the meter register shows a reading equal to that shown on the mastermeter, or equal to prover tank capacity. If the amount registered on the meter is not equal to the amount registered on the mastermeter or in the prover tank, make the adjustments.

To get to the adjuster assembly on which you make the adjustments, break the meter seal and remove the adjuster cover plate. Then read and record the position of the adjuster assembly micrometer.

If the meter reading is *less* than it should be, add the percentage difference (between what it is and what it should be) to the micrometer of the adjuster assembly. If the meter reading is *more* than it should be, subtract the percentage difference from the micrometer. To adjust, loosen the setscrew and turn the micrometer barrel and thimble far enough to add or subtract the difference. Then tighten the setscrew at the new reading.

The barrel of the micrometer (fig. 3–5) is marked in whole-number percentage increments (1 through 5). The thimble is marked in parts of whole percentage calibrations—0.10 percent and 0.02 percent increments. Always keep the play in the micrometer in the same direction. The locking clamp carries instructions indicating the direction the thimble is to be turned to make the calibration.

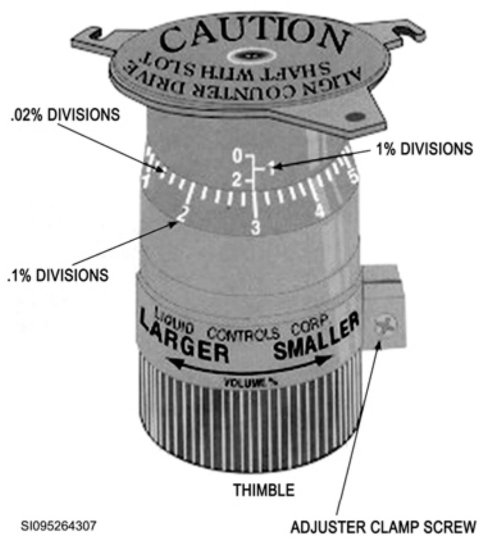


Figure 3–5. Liquid control calibration.
(Courtesy of IDEX Corporation.)

225. The Brodie meter and how to calibrate it

Although Brodie meters have not been used as much as some other meters have, you may encounter them in our fuel systems. The meter-measuring chamber, shown in figure 3–6, contains two meshed spiral rotors that are turned by fuel pressure. The calibration mechanism, with its calibrating levers, is located in the drive between the meter body and the register.

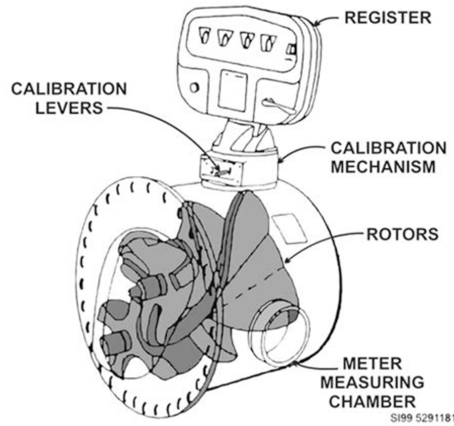


Figure 3–6. Brodie meter.
(Courtesy of Brodie Meter Co., LLC.)

Inspection and maintenance of the Brodie meter

Only visual inspections are required for Brodie meters, unless the meter must be opened for repairs. If you find it necessary to open a meter, you should also inspect it for cracks, wear, scoring, and corrosion. Replace worn parts with new ones. Use new gaskets throughout the meter. Use only factory replacement gaskets—those of the proper thickness and material. It is best to send the meter to the factory or depot for major repairs.

Calibrating the Brodie meter

The calibration mechanism of the Brodie meter includes two grooved knobs. In figure 3–7, you can see them protruding from the calibrating mechanism. These knobs are locked into position by a lock plate that drops down into the grooves. The lock plate is, in turn, locked into position by a screw at each end of the plate. These fit into the elongated slots in the plate. By loosening the screws, you can raise the lock plate and move the knobs in or out. Note that one of the knobs is for fine adjustment (left) and one for coarse adjustment (right).

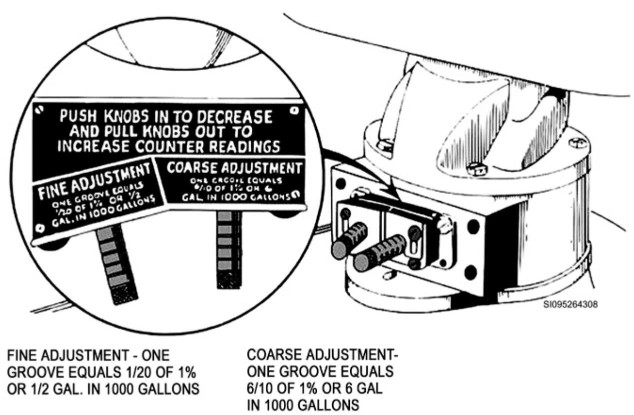


Figure 3–7. Brodie meter calibration.
(Courtesy of Brodie Meter Co., LLC.)

Since the knobs are not connected, you can move either one in or out without moving the other. This permits you to get a fine setting. You calibrate this type of meter in a way similar to the way you calibrate the Smith meter.

Study the enlarged view of the data plate in figure 3–7; it shows the values for each groove on the two knobs. When using the mastermeter to calibrate the Brodie meter and after flushing the system with 100 gal. of product, make your test run, using 1,000 gal. This practice will make adjustment easier for you; there will be less arithmetic for you to do. The only problem is that you may fill a fuel truck too quickly. Always make sure you have an empty truck before starting because you always have to flow about 50 to 100 gal. through the installed meter and mastermeter to fill the lines and to ensure that all air is out of the hoses. This is done on all meters.

After making the 1,000 gal. test run and the subsequent adjustment, you need to run another 1,000 gal. through the meter to verify the adjustment. We will discuss calibrating this meter on a 1,000 gal. test run.

Just remember that each groove on the coarse knob represents 6 gal. per 1,000 gal. Each groove on the fine knob represents 0.5 gal. per 1,000 gal. Thus, if the register of the meter you are calibrating reads 1,005 gal., you want to *decrease* the register reading by 5 gal. Push the coarse knob in one groove, and pull the fine knob out two grooves. Throughout this section, you have been learning procedures for calibrating meters and had the mastermeter briefly explained to you. Let us now look at this piece of equipment and see how it is used to check the installed meters.

226. How to use a mastermeter

In this lesson, we discuss the components of the mastermeter and the meter calibration procedures using a mastermeter.

Components of the mastermeter

Figure 3–8 shows the components of the mastermeter. The mastermeter is equipped with two hoses—one is on a hose reel located on the discharge side of the cart, and the other hose is placed in U-hooks around the cart. Both hoses are connected to the discharge or outlet side of the cart. The hose you use is determined by the flow control valves shown in the bottom of figure 3–8.

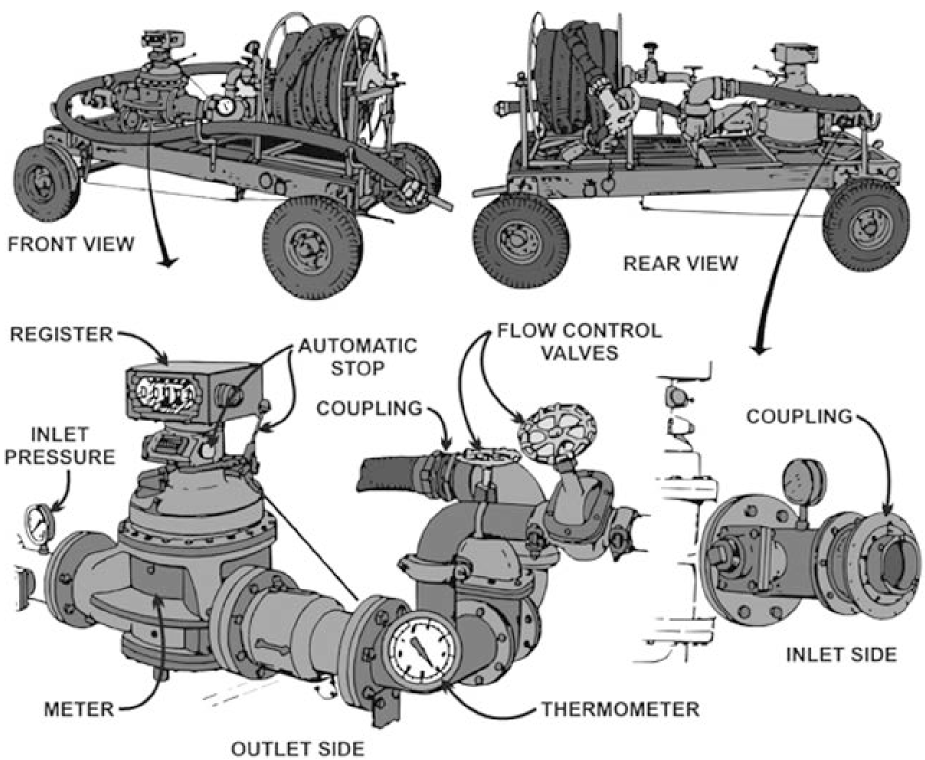


Figure 3–8. Mastermeter.

The hose on the reel has an over-the-wing nozzle attached on one end. Use this hose when you cannot adapt to a truck connection or defueling stub. The lower valve directs fuel through the hose stored on the U-hooks. Both flow control valves should not be open at the same time.

Figure 3–8 shows no single-point nozzle installed on the end of the hose. The hose stored on the U-hooks is for hooking to truck bottom-loading connections or for hooking to defuel stubs. The meter (usually a Smith or liquid control meter) is equipped with an automatic stop that trips a valve immediately downstream of the meter. This automatic stop can be set so that the flow can be halted at a predetermined amount of fuel (usually 600 or 1,000 gal.).

The coupling on the inlet side of the mastermeter is a single point receptacle (SPR). A pressure gauge is installed on the inlet line to make sure the system is operating at the correct pressure. When you calibrate a meter, the temperature of the fuel must be converted to 60° F because the fuel passing through the installed meter may have a temperature higher or lower than it is when it passes through the meter on the cart. This is the purpose of the thermometer installed on the outlet side of the mastermeter.

Meter calibration procedures using a mastermeter

What you actually must do to calibrate an installed system meter may vary, depending on your system and the type of meter you are checking. In general, you first move the mastermeter cart to the meter location and ground and bond all equipment. Then you connect the system hose containing the meter to be tested to the mastermeter inlet port. To do this, you would use either the hose reel or the hose stored on the U-hooks as necessary. Open the flow valve accordingly.

Next, set the system up to dispense fuel. Tape a thermometer to the pipeline near the installed meter. Reset the mastermeter and the installed meter to zero. Set the automatic stop to cut off at a predetermined number of gal. (usually 600 or 1,000 gal.).

Energize the system, creating equal pressure up to the automatic stop. Activate the automatic stop by lowering the lever. Dispense the set number of gallons. Deenergize the system. Read the two thermometers. Read both meters.

NOTE: If the temperature readings are not the same, convert the readings to 60° F and then make your corrections. The conversion tables are found at base fuel accounting office. Like any other meter, the mastermeter must be calibrated annually.

Fuel is a valuable commodity, and its acquisition, movement, and usage must be strictly accounted for. Accurate metering is necessary for the AF to control this resource. It is your responsibility to make sure that fuel meters are working and measuring correctly.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

222. The maintenance and calibration mechanisms of meters

1. How is major maintenance performed on a meter?

2. What maintenance processes will you perform on a meter?

3. How are meters damaged?

4. What is the basic principle of calibration mechanisms?

223. Major components and calibration procedures for the Smith meter

1. List the major components of the Smith meter.
2. List inspections required on the Smith meter.
3. What maintenance is performed on the Smith meter?
4. What is the value of the coarse and fine adjustments on the Smith meter?
5. If the mastermeter reading is more than the meter you are calibrating, in which direction must you move the calibrating levers?

224. Liquid control meter operating principles and calibration requirements

1. On what principle does the liquid control meter operate?
2. What inspections are made on the meter?
3. How is the meter calibrated?

225. The Brodie meter and how to calibrate it

1. List the major components of the Brodie meter.
2. List visual inspections made on an opened Brodie meter.
3. What routine maintenance is performed on the Brodie meter?
4. Describe the calibration procedures.

226. How to use a mastermeter

1. How many hoses does the mastermeter have? Briefly explain their use.

2. What is used to isolate the hose you are *not* going to use?

3. How can you ensure only 600 gal. will flow through the mastermeter?

4. What is the purpose of using the installed thermometer and a taped thermometer on the pipeline?

3–2. Gauges

When we speak of gauges, we cover a large area. There are many types of gauges throughout the fuel system, but the main function of all of them is to tell us how well the system is operating. Among these gauges are the (1) *liquid-level gauges*, that we have already discussed in the tank section; (2) *pressure gauges*, which tell us the pressure throughout the system; and (3) *differential gauges*, which tell us the condition of the elements in the F/S.

Without these gauges, we would be unable to tell the actual condition of the fuel system and would have a difficult time locating—much less resolving—trouble.

227. Automatic tank gauging

Electronic ATGs come in two different basic styles: magnetostrictive probe and pneumatic probe.

Magnetostrictive probe

Ground product fuel tanks and small product-recovery tanks use magnetostrictive probes. This is a metal rod with one or two floats on the rod and circuitry in a housing on top. The probe is then connected to a control box located away from the tank. The top float is for fuel and, if there are two floats, the bottom float is weighted to sink in fuel but float on water. The probe senses the floats' positions on the rod, and the control terminal translates this into both inches and gal. of fuel and water.

Using electrical relays, the probe and terminal can control several tank operations. It can disconnect power to the fuel pumps if there is not enough fuel in the tank. It can activate alarms if the fuel level is too low or if the fuel or water level is too high. More advanced models can test the tanks for leaks. Consult the manufacturer's manual for your model of ATG to see how to program it.

To calibrate an ATG, check its reading against a manual gauging of the tank. If the fuel level is off, first make sure the floats are clean, since debris on the floats can weigh them down and cause a low reading. To change the level of fuel the probe is reading, change the height of the probe in the tank. If the reading is too high, raise the probe. If the reading is too low, lower the probe.

Removing the probe requires disconnecting the wiring from the probe to the terminal as close to the probe as possible. Then pull the probe out of the tank.

CAUTION: Be careful not to bend the rod on the probe. This may damage the float sensors and ruin the probe.

Pneumatic-type automatic gauge

The primary ATG normally installed on AF bulk jet fuel systems is the pneumatic-type. It consists of a tank control unit (TCU) located in close proximity to the tank, and a pneumatic probe assembly that extends to the bottom of the tank. Figure 3–9 shows a typical TCU, which takes its readings through the pneumatic probe assembly shown in figure 3–10.

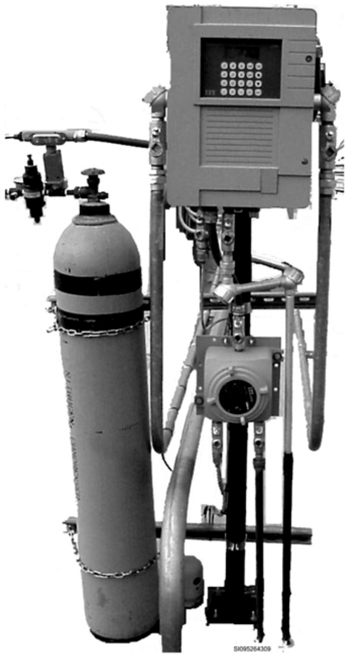


Figure 3–9. Pneumatic-type TCU.

Figure 3–10. Pneumatic probe assembly.

The pneumatic probe works by using nitrogen gas to sense fuel pressure at several different points along its length. The differences in fuel pressure at different heights, along with the temperature of the fuel, allow the TCU to calculate fuel depth as well as API density. The pneumatic-type ATG system was purchased under an AF–wide contract that included an extended warranty. The only reason you will need to remove the tank probe is if it would interfere with tank cleaning or repairs. If this is the case, the probe can be gently pulled up and out of the tank. The probe portion of the gauge consists of plastic nitrogen gas tubes connected to stainless steel tubes, all suspended on a stainless steel chain. If you must disconnect the probe from the tank, make note of the exact chain link so that you can reinstall it properly.

228. Pressure gauges and their maintenance requirements

Three kinds of basic pressure gauges are used throughout the fuel systems: (1) *high-pressure gauges*, (2) *pressure-vacuum gauges*, and (3) *low-pressure or DP gauges*. High-pressure and pressure-vacuum gauges use a bourdon tube, movement, dial, and pointer set in a case with a window to indicate pressure (fig. 3–11). As we have explained earlier, pressure sensed in the bourdon tube tries to expand or straighten the tube, while vacuum tries to contract it. The expansion or contraction of the tube is transferred to the pointer by means of the movement—a system of mechanical linkages.

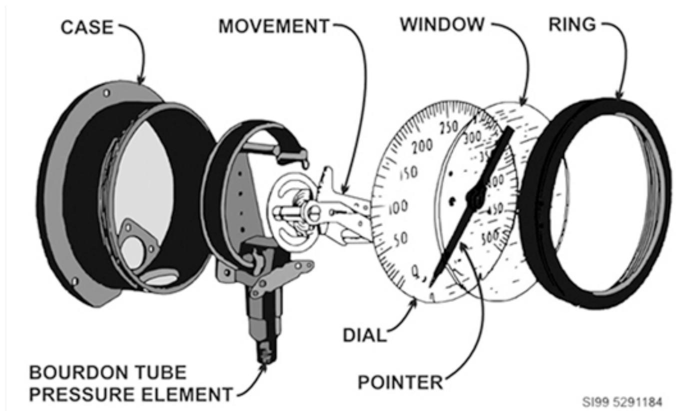


Figure 3–11. Typical bourdon tube pressure gauge.

Low-pressure or DP gauges use either bellows or a diaphragm, where two different sources of pressure fight against each other. The expansion and contraction is also transmitted through a movement to a pointer.

High-pressure gauges

Figure 3–12 shows one type of high-pressure gauge used in the fuel systems. Notice that this gauge ranges from 0–600 psi. The type of system pumps you have will determine the range your pressure gauges have. There is no reason to have a gauge with a range of 0–600 if the maximum pressure output of your pumps is only 72 psi.

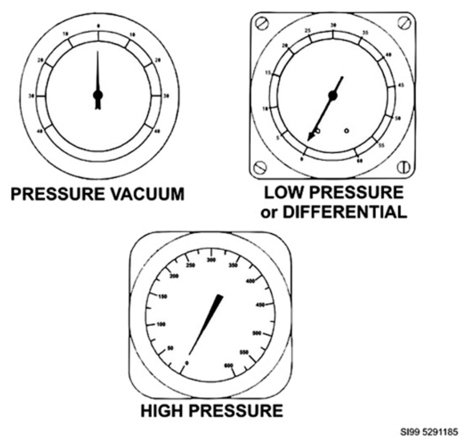


Figure 3–12. Pressure gauges.

Pressure-vacuum gauges

Pressure-vacuum gauges (fig. 3–12) are often found in locations subject to periods of pressure and vacuum. The defueling pump, located in the pit of the type II hydrant system (Pritchard), is one of these locations. When the pump is pulling against a closed line, it will create a vacuum. The pump is equipped with a vacuum switch that shuts the pump off at a preset vacuum. To check the switch, you would have to know what vacuum the pump is pulling, and you can do this only by using a vacuum gauge.

Low-pressure or differential pressure gauges

We have already mentioned the importance of the DP gauge when we covered filtration equipment. A differential gauge reads the difference between the higher inlet pressure and lower outlet pressure of an F/S or strainer. These types of gauges usually have a range of 15–30 psi. Figure 3–13 shows the piston-type DP gauge used in the field.

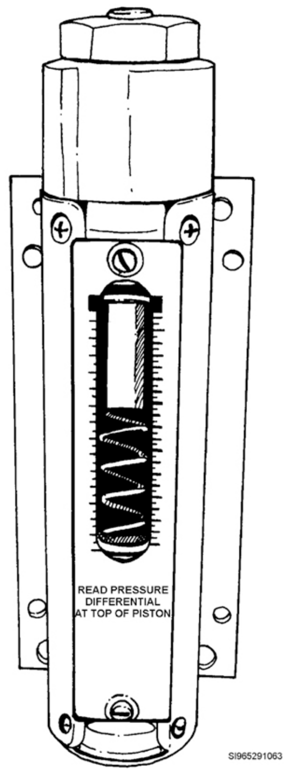


Figure 3–13. Gammon model GTP–534 DP gauge.
(Courtesy of Gammon Technical Products, Inc.)

229. Calibration of pressure gauges

Gauge calibration is an integral part of fuel system maintenance. Some can be calibrated while others have to be disposed of and replaced.

Maintenance of pressure gauges

Most gauges will give you many years of service, but you will have to inspect these gauges to assure their accuracy. Simple pressure gauges must be calibrated at least once each year. You can do this at the job site or in your own shop by using a static pressure gauge tester.

There are several types of static pressure gauge testers on the market. A cutaway view of one of them is shown in figure 3–14. Study the figure for a moment. The setup and operation of the tester is fairly simple. The set comes with a series of gauges, fitting adapters, wrenches, and assorted weights. Oil under pressure is applied to the gauge under test, which is connected to the gauge union assembly. The pressure is controlled precisely by the use of weights. The displacement screw is backed off, by the handle, to permit filling of the chamber, and then is screwed in until the weights are just floating free on the confined oil (leakage of fuel around the handle stem is prevented by the packing washer, packing, and packing nut). This weight is then transferred to the gauge as pressure. The needle valve controls the movement of oil to the gauge. The gauge reading is adjusted to match the weight "pressure." This type of pressure gauge tester is known as a deadweight tester.

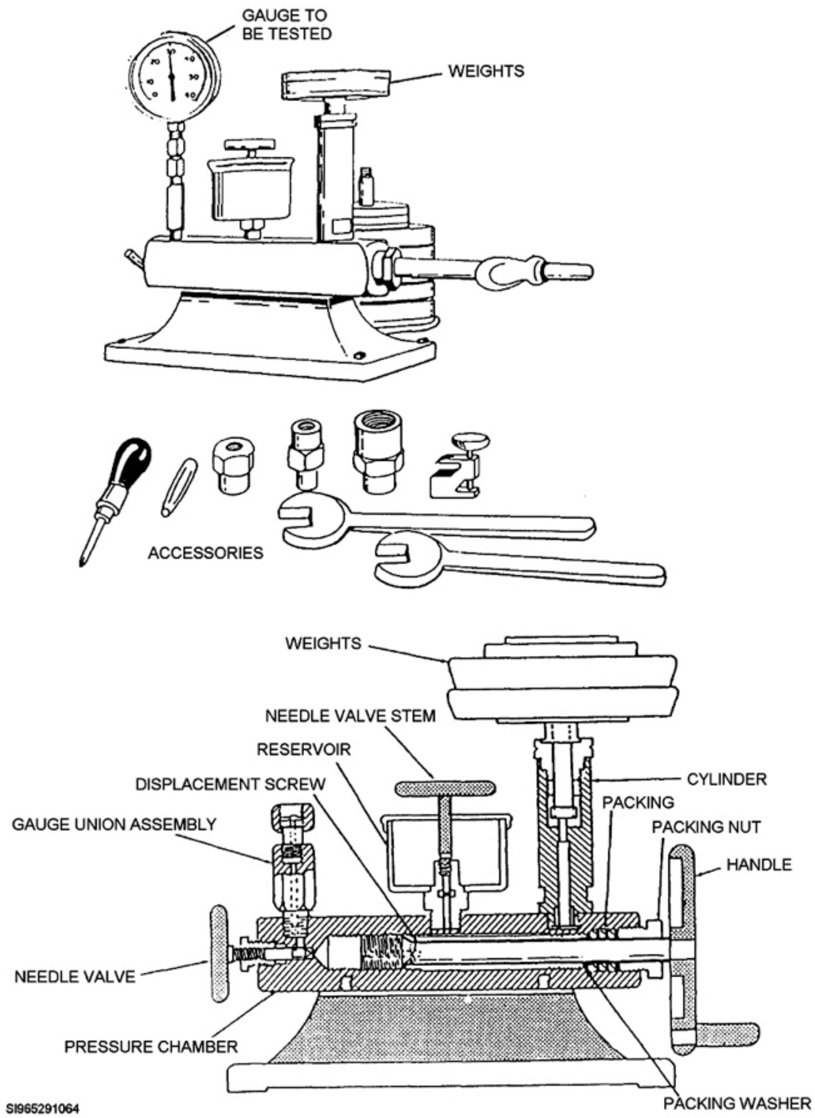


Figure 3–14. Deadweight gauge tester.

One other tester you may come into contact with is the hydraulic tester, which uses a small hand pump to create the pressure. A complete set of calibrated gauges will be included with the hydraulic tester to be used to calibrate your gauges. Commercial testers will come with a complete set of instructions. These instructions are detailed and must be followed if you are to obtain accurate readings and adjustments.

Calibration of differential pressure gauges and vacuum gauges is usually done by the PMEL and will be scheduled by PMEL. Each month your shop will receive a list showing the gauges requiring calibration. Gauge maintenance consists primarily of cleaning the gauge glass, removing moisture from the face of the glass, recalibrating the gauge by using a tester, and inspecting for leaks.

How to calibrate a gauge

For this lesson we will walk through the steps used to calibrate a high-pressure gauge using a hydraulic gauge tester. The following are the 7 steps used to calibrate a high-pressure gauge.

1. Unscrew the relief valve (the T shaped handle) to relieve any hydraulic pressure in the testing unit. Center the vernier valve (the X shaped handle) halfway between its length of travel (i.e.,

halfway between in and out). This will allow for maximum fine adjustment of calibration pressure.

2. Unscrew the nuts on the testing unit. Remove the plug adapters from the unit.
3. Screw the offset tube to the outside post of the tester. This tube gives the necessary clearance between the system gauge (the one being calibrated) and the master gauge.
4. Select the master gauge with the closest scale higher than the gauge being tested. This is done to minimize the risk of damage to the system gauge by over-pressurizing it. Attach the master gauge to the inside post.
5. Tighten the relief valve and SLOWLY pump the hydraulic unit to fill the offset tube. This minimizes the amount of air inside the system gauge. Stop once oil reaches the top of the tube.
6. Screw the system gauge to be tested into the adapter and attach the adapter to the offset tube.
7. Pump the handle to pressurize the gauge being tested to 25%, 50%, 75%, and full pressure. Turn the vernier valve to make fine pressure adjustments. The tested gauge should match the master gauge throughout the range.

If the gauge is off, there are two ways to calibrate it. If the gauge has an adjustment screw, turning the screw will move the needle. Move the needle until it matches the master gauge, and then retest to make sure the gauge reading is consistent.

NOTE: Often a gauge will have screws on the back of the case. Most of the time, these are NOT calibration adjustment screws, they are for holding the gauge body to the mechanicals of the gauge.

If the gauge does not have an adjustment screw, the gauge needle may be pulled of the face of the gauge and replaced at the correct pressure. The best way to do this is to use a needle puller (fig. 3–15). Slip the legs of the base under the needle on either side of the gauge post. Then screw the wheel in, and the legs will slowly pull the gauge needle off the center post. Pulling the needle off by hand or prying it off with a screwdriver risks damaging the linkage inside the gauge.

Figure 3–15. Gauge needle puller.

Retest to make sure the gauge reads correctly throughout its pressure range. A gauge that cannot be calibrated usually has a bent bourdon tube or damaged linkage and must be replaced.

Gauges are useful diagnostic tools for WFSM. Tank gauges monitor fuel levels in a tank on a continuous basis. Some models can control the pumps or even test the tank for leaks. Pressure gauges allow you to see inside the fuel system while it is operating. Both of these items give you insight to what is happening inside the tanks, pipes, strainers, and F/Ss.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

227. Automatic tank gauges

1. How do you remove a magnetostrictive probe?

2. What does a pneumatic probe measure?

3. What is the primary pneumatic tank gauge used by the AF?

228. Pressure gauges and their maintenance requirements

1. What are the different types of gauges found in the fuel system?

2. What types of gauges are often found in locations subject to periods of pressure and vacuum?

3. What type of gauges use either bellows or a diaphragm?

229. Calibration of pressure gauges

1. What maintenance is required on gauges?

2. Why do you center the vernier valve?

3. What is the purpose of the offset tube?

4. Why should you use a needle puller to remove a gauge needle?

5. Why would you be unable to re-calibrate a gauge?

Answers to Self-Test Questions

222

1. By contract with the manufacturer or at depots.
2. Such minor repairs as replacing gaskets, seals, packing glands; calibrating the meter; and occasionally, replacing meter registers or gear drives.
3. By air and dirt back pressure on one-way flow meters.
4. That of a gear train.

223

1. Rotor, ball bearings, vanes, body, and register.
2. Visual inspection of meter assembly.
3. Removal of dirt, replacement of gaskets, and calibration of meters.
4. Coarse, 138.8 cubic inches per 100 gal.; fine, 11.5 cubic inches per 100 gal.

5. Outward.

224

1. Positive displacement principle.
2. It is visually inspected for leaks and calibration.
3. By using a mastermeter and making the necessary adjustment to the micrometer.

225

1. Two meshed spiral rotors, calibration mechanism, body, and register.
2. Visual inspection for cracks, wear, scoring, and corrosion.
3. Replacement of worn parts and calibration.
4. Dispense 1,000 gal. of fuel through the meter and the mastermeter. If the reading on the Brodie meter is more than the amount of fuel dispensed and beyond the allowable limit, push the coarse knob in one groove and pull the fine knob out two groove.

226

1. Two hoses. One is on a hose reel located on the discharge side of the cart and the other hose is placed in U-hooks around the cart.
2. Flow control valve.
3. Set the automatic stop at 600 gal.
4. To ensure the fuel through both meters is the same temperature; if *not,* you must convert to 60°F.

227

1. Disconnect the wires close to the probe and then pull out of the tank.
2. Fuel height or depth, temperature, and density.
3. The pneumatic-type ATG system.

228

1. High-pressure, pressure-vacuum, and low-pressure or differential pressure.
2. Pressure vacuum gauges.
3. Low-pressure or differential-pressure gauges.

229

1. Cleaning gauge glass, removing moisture, calibration, and leak check.
2. To allow for maximum fine pressure adjustment.
3. To give clearance between the master and system gauges.
4. Pulling or prying the needle may damage the gauge linkage.
5. Bent bourdon tube or damaged mechanical linkage.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

56. (222) Meters *must* be within what percent of total flow displaced to meet Air Force (AF) standards?
    a. 0.02.
    b. 0.2.
    c. 0.5.
    d. 2.0.

57. (222) What is the *most* probable cause for a meter to over-register?
    a. Air in the line.
    b. Dirt in the line.
    c. Excessive flow.
    d. Excessive pressure.

58. (223) What maintains a tight seal in the measuring chamber of a Smith meter?
    a. Carbon vanes.
    b. Teflon vane inserts.
    c. A coating on the inside wall.
    d. A film of oil on the inside wall.

59. (223) Who should do the repairs when a Smith meter requires *major* maintenance?
    a. Manufacturer.
    b. Refueling maintenance shop.
    c. Liquid fuels maintenance shop.
    d. Department of weights and measurement.

60. (223) How much will each notch of the Smith coarse adjustment lever change the calibration?
    a. 138.8 cubic inches per 60 gallons (gal.).
    b. 138.8 cubic inches per 100 gal.
    c. 231.0 cubic inches per 60 gal.
    d. 231.0 cubic inches per 100 gal.

61. (224) Leakage inside the back of a liquid control meter is caused by a faulty
    a. Viton seal.
    b. Teflon seal.
    c. O-ring.
    d. square ring.

62. (225) If you changed the Brodie coarse adjustment one position, what change would be made to the register reading?
    a. 3.6 gallons (gal.) per 100 gal.
    b. 6 gal. per 100 gal.
    c. 3.6 gal. per 1,000 gal.
    d. 6 gal. per 1,000 gal.

63. (225) If a Brodie meter reads 1,005 gallons (gal.) on a 1,000 gal. run, push the coarse knob in one groove and
    a. push the fine knob in one groove.
    b. push the fine knob in two grooves.
    c. pull the fine knob out one groove.
    d. pull the fine knob out two grooves.

64. (226) How many hoses does a mastermeter have and where are they connected?
    a. 2 hoses; inlet side.
    b. 2 hoses; outlet side.
    c. 3 hoses; 1 on the inlet, 2 on the outlet side.
    d. 3 hoses; 1 on the outlet, 2 on the inlet side.

65. (226) The mastermeter is calibrated every
    a. 6 months.
    b. 12 months.
    c. 6 months or 1,200,000 gallons (gal.).
    d. 12 months or 2,000,000 gal.

66. (227) Which type of tank gauge can test a tank for leaks?
    a. Manual.
    b. Mechanical float.
    c. Pneumatic probe.
    d. Magnetostrictive probe.

67. (227) The pneumatic tank probe works by using what kind of gas?
    a. Diesel.
    b. Nitrogen.
    c. Propane.
    d. JP–8.

68. (228) Where can you find a pressure-vacuum gauge on the Type II (Pritchard) hydrant system?
    a. By the defuel pump.
    b. By the deepwell pump.
    c. Upstream of the tank outlet valve.
    d. Downstream of the hydrant outlet valve.

69. (228) A differential pressure (DP) gauge installed on a filter/separator (F/S) measures the difference between the inlet
    a. low pressure and the outlet low pressure.
    b. high pressure and the outlet high pressure.
    c. low pressure and the outlet high pressure.
    d. high pressure and the outlet low pressure.

70. (229) The deadweight tester is used to calibrate
    a. meters.
    b. pressure gauges.
    c. pneumatic probes.
    d. liquid-level gauges.

Please read the unit menu for unit 4 and continue ➔

Unit 4. Loading/Offloading Facilities, Bonding and Grounding, and Pipelines

YOU HAVE BEEN LEARNING about all types of equipment used to store, move, block, and filter fuel as it goes through the fuel systems. However, you have not learned about how fuel gets into our systems in the first place. An AF base can receive fuel by tank truck, tank car, or pipeline. Some bases may receive fuel by two or even all three of these methods. The location of your base and the requirement for fuel will determine the source of your fuel.

Once it is received on base, the government's responsibility for the safe handling of the fuel begins. The offloading equipment is such that sure and positive hookups can be made with the carrier to make sure there are no leaks. Grounding and bonding equipment helps to dissipate that old menace—static electricity.

As you study this unit, you will become more familiar with the type of equipment found in the loading/offloading areas and with procedures used to ground and bond that equipment. You will also learn about pipelines, pipeline maintenance, and cathodic protection of pipelines.

4–1. Loading/Offloading Facilities

The loading/offloading facilities are the areas of the fuel system where fuel is transferred from a movable carrier to the fixed fuel system and then to another movable carrier. In these areas, the danger of fuel spills is always present. To help reduce chances of fuel spills, these facilities must be maintained to a high degree.

230. Construction and maintenance requirements of truck and tank car loading/offloading facilities

In this lesson, we discuss construction and maintenance requirements of truck and tank car loading and offloading facilities.

Truck and tank car offloading

Where more than one type of fuel is unloaded, separate pipelines and unloading facilities are provided for each type of fuel, except for multiproduct cross-country pipelines and barge or tanker unloading facilities. Separate unloading couplings, distinctively marked, are provided for each type and grade of fuel. A shutoff valve and a check valve will be installed at each coupling.

Unloading manifolds will be installed underground where possible and will be a minimum size of 8 inches. Where both truck and rail delivery is required, the same unloading manifold will be used for both. The spur track will be on one side of the manifold, and a paved truck unloading road will be on the other. In a combined unloading facility, the unloading couplings will be spaced 40 feet apart. The pipes running from the manifold to the pump suctions will slope downward continuously toward the pumps. If this is not possible because of topography, the unloading piping will slope upward continuously toward the pumps. Do not exceed the available suction head of the pump (maximum 20 feet). These branch pipes will be of the same size as the manifolds. Water drain-off valves will be provided at low ends of manifolds. Where unloading lines do not drain dry, a shutoff valve will be installed in the pump suction upstream of the strainer.

Tank truck unloading

Where fuel is received by tank truck, turnouts and unloading facilities are provided. The design permits continuous forward driving. A paved apron is adjacent to the 8-inch unloading manifold. The distance from the edge of the pavement to the unloading coupling is a maximum of 10 feet. For multiple unloading, the unloading couplings are spaced 60 feet apart. In addition to the standard tank truck unloading couplings, a special locking-type nozzle adapter is provided at all truck unloading manifolds. This is for defueling AF refueler vehicles directly back into storage, using the vehicle's single-point aircraft nozzle for connection.

Railroad tank cars unloading

For tank car unloading, a separate spur track will be provided to permit simultaneous unloading of *not more than* 10 tank cars. The length of the spur will be determined by allowing 40 feet of track for each unloading point plus 10 feet overrun at the dead end. A minimum clear distance of 65 feet will be provided between the unloading spur and another service or main line track. At locations where additional unloading facilities may be required, a second spur track will be provided parallel to the first. The unloading manifold will be installed on the pump house side of single spur tracks and between the tracks when double spur tracks are installed. Withdrawal of the product from tank cars will be by means of 4-inch hoses connected to a 4-inch valved coupling riser from the underground manifold at each unloading position.

Pumps

Unloading pumps will be provided at all truck or railroad tank car unloading facilities. These pumps will be of either the self-priming centrifugal or the positive-displacement type. All receiving pumps will have a capacity of 300 gpm. One pump will be provided for each type of ground fuel, and two pumps for each type of aviation fuel.

Hoses

Hoses for unloading fuels will be provided. Covered storage racks will also be provided for protecting the hoses against the weather when they are not in use. Hoses will be of the 4-inch inside diameter, API Standard 1529, *Aviation Fueling Hose, Noncollapsible Type*. The type of hose must be compatible with the product being pumped. Aviation hoses are classified according to internal diameter, working pressure, operating temperature, and conductivity. Always specify that hoses meet the requirements in the most current edition of API 1529. API 1529 hoses have permanent serial numbered ends attached and are hydrostatically tested at the factory. They do not need to be tested prior to installation but must still be hydrostatically tested annually. Check hoses monthly for cracks, abrasion, bulging, and cuts.

Dry break couplings

Dry break couplings provide a fast, clean, dry disconnection from two hoses. This helps reduce the hazards involved in the connection/disconnection process of transferring liquids. They require a coupler and adapter to work. If either of these is missing, the dry break adapter will not work. To operate it, you simply connect the two Kamlok pieces together, lock the ears down, and rotate the handle 180° to open the line. Ensure you close the valve before disconnecting to avoid any leaks.

Truck loading fillstands

The truck loading fillstands receive fuel from the bulk storage tanks through a pump house. The header consists of a raised concrete platform and the piping and components required for loading the trucks. A separate loading header is needed for each grade of fuel to be dispensed. Most loading headers have the same basic components. The only exception is that some bases have the F/S installed near the loading header. All AF fillstands are required to use the bottom-loading method of filling.

For our discussion of the truck loading fillstand, we assume that the F/S is located in the pump house. Each loading header has block valves installed for isolating the components and loading hose. A pressure gauge is located in the piping to indicate the fuel system delivery pressure. A line strainer is installed in the inlet piping to the meter unless an F/S is installed within 100 feet upstream, in which case the strainer is not required. The strainer traps foreign particles before they enter the meter. The fillstand will have non-lubricated swivel joints and a 4-inch API 1529 hose. Some of the newer fillstands will use a pantograph arm in place of the hose.

Fillstands must have a means to immediately shut off the flow of fuel to the truck in case of emergency. One such method is placing an automatic valve at the fillstand with a hydraulically controlled *deadman* that the operator must depress to maintain fuel flow. Another approach is to control the same fillstand valve by means of an electrically activated solenoid. This approach allows more functions to be tied into the operation of the solenoid. Commonly known as the Scully system, this system is tied into the truck overfill and grounding system and will not allow the fillstand valve to open if the truck is not grounded or a high-level condition exists.

All piping at the truck-loading header must be identified properly, per MIL-STD-161G, as to the grade of fuel to be dispensed. An electrical on/off switch is provided at ground level. To protect the hose or pantograph arm from excessive pressure, a pressure relief switch is installed to relieve static pressure buildup. Also, some bottom loaders are equipped with a pressure switch that cuts off the transfer pumps at a predetermined pressure.

Maintenance of loading/offloading equipment

Maintenance of loading and offloading equipment is dictated by variations in installed equipment. Maintenance may include stopping leaks, replacing and repairing hoses, calibrating the meter, repairing and/or lubricating of swivel joints, and changing F/S elements if an F/S is installed.

Hoses and couplings

Hoses used in fuel systems may be suction hoses or pressure hoses. They must meet the requirements of API 1529. Hoses may require pressure testing periodically. This test is made by hydrostatic testing.

Hose tester

Figure 4–1 is a drawing that illustrates the configuration of the hose tester and the location of the various operating instruments and controls. The Fuel Hose Assemble Tester is NSN 4940–01–359-7624, part number 9201. The numbers in parentheses in the following discussion refer to item numbers in this figure.

Here’s what you do before starting: Check the fluid level in the reservoir by examining the level indicator (1). Check the oil level in the lubricator (4). Close the air shut off valve (12), and open the vent valve (19). The shutoff valve is closed when the handle is perpendicular to the valve body and open when it is in line with the valve body and the tubing. The vent valve is rotated counterclockwise to open and clockwise to close. Turn the regulator knob (9) counterclockwise to minimum value. A sudden reduction in the knob friction will be felt at this point as the opposing spring is relaxed. Turn on or connect shop air to the inlet filter (7).

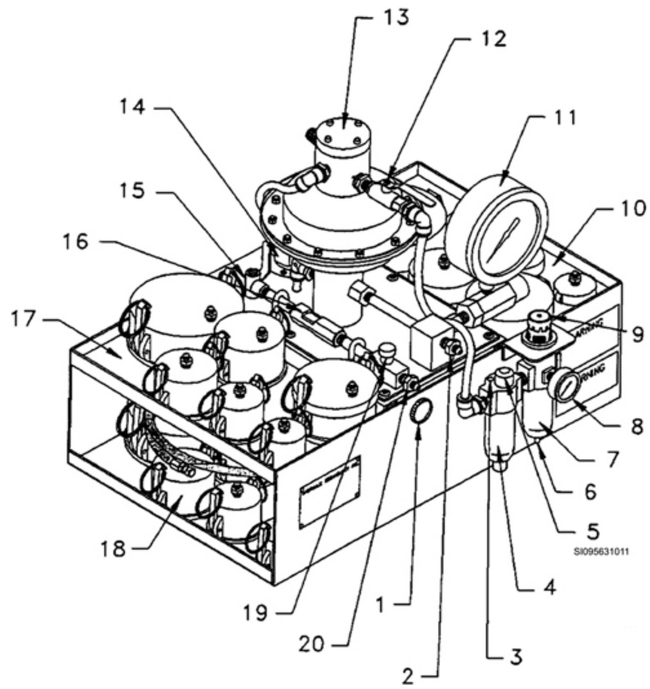


Figure 4–1. Hydrostatic hose tester.

To operate the hose tester, select the appropriate hose adapter from those supplied with the unit (18). Connect the hose to be tested between the outlet port (2) and the return port (20). Open the air shutoff valve (12), and rotate the regulator knob clockwise until the pump (13) starts to reciprocate. Select return selector valve (15) to return to reservoir or externally as required. Observe the returning fluid in the sight glass (16) for air bubbles and close the vent valve (19) when all the air has been bled from the hose under test.

WARNING: All air must be bled from the hose under test. Entrapped air has an explosive effect. If the hose under test should rupture, this could cause injury.

Next, you rotate the regulator knob clockwise and observe the output pressure to the hose under test on the gauge (11). Increase the pressure in this manner to the required values of the hose test specification. Inspect the hose under test as required by its test specification. When the test has been completed, rotate the regulator knob (9) counterclockwise until the pump inlet air pressure, as observed in the regulator gauge (8), goes to zero. Open the vent valve (19) to permit the pressure in the hose under test to dissipate, and disconnect the hose under test. This concludes the complete operating cycle of the hose tester.

Depending on local base requirements, your shop may be assigned the responsibility for maintaining and pressure testing all hoses except those that are part of fueling trucks. All information pertaining to the various types of hoses used and the method to be used when hydrostatic testing can be obtained from TO 37A–1–101, *Fuel, Water, and Lubricant Dispensing Equipment.*

When you handle fuel hoses, do not drag them across concrete or other rough surfaces; dragging will cause damage to the hose and coupling. Couplings should be capped when the hose is not in use and especially when you are moving the hose. This will keep the coupling threads from being damaged.

API 1529 hoses come with an API 1529 coupling, and the entire assembly will come with a hydrostatic test certificate. Only authorized dealers can repair an API 1529 hose. If you have a defective API 1529 hose, you must send it to the authorized dealer for repairs or replace the entire hose assembly.

Single-point nozzles

One of our jobs is to periodically repair the single-point nozzles used to fill trucks and aircraft. As with all repair jobs, it gets easier the more often you do it. To disassemble a single-point nozzle (fig. 4–2), remove the nozzle from the end of the hose at the quick disconnect. Remove the six screws and six washers to permit the removal of the swivel adapter. Remove the cover assembly (20) from the nozzle. Remove the collar bumper (10). Push at one end of the collar bearing (9) to cause the other end to protrude from the groove. Using pliers, pull the collar bearing out of the groove. Remove the nozzle collar (17) from the body assembly (21) by aligning the groove in the collar. Turn the crank handle (18) to open the valve (16). Remove the cotter pin (23) and unscrew the valve (16) from the shaft assembly (19). You may now remove the nozzle seal assembly (12). Remove the snap ring (11) from the seal (12). Take off the plate (13).

You can now remove the three lock pins (15), three lock pin springs (1), three index pins (14), and the O-ring (29). Visually inspect the pins (14) for cracks and deformation. Roll the pins on a flat surface and check for any signs of a bend. Replace any pin that you even suspect may be bent.

After you remove the socket head cap screw (26) and the lockwasher (24), you can remove the crank handle (18) and washer (5). Remove the lockwire (25) from the crank bushing (3). Note the method of lockwiring so that you can duplicate it on reassembly. Insert needle-nose pliers into the flange end of nozzle body (21) and remove the cotter hairpin (6). Remove the crank bushing (3). You can now remove the O-ring spacer (2), the O-ring (28), the two washers (7), the two wave washers (8), and the gasket (27). After that, remove the valve crank (4) and valve shaft assembly (19) from the flange end of the body. The following parts need not be removed unless replacement is necessary: the grounding cable assembly, the plugs or vacuum breaker, the hex head bolt, the $^{1}/_{8}$-inch diameter ball, or the carrying handles. If the two collar handles need replacing, remove the two locknuts, the two flat washers, the two hex head bolts, and the handles.

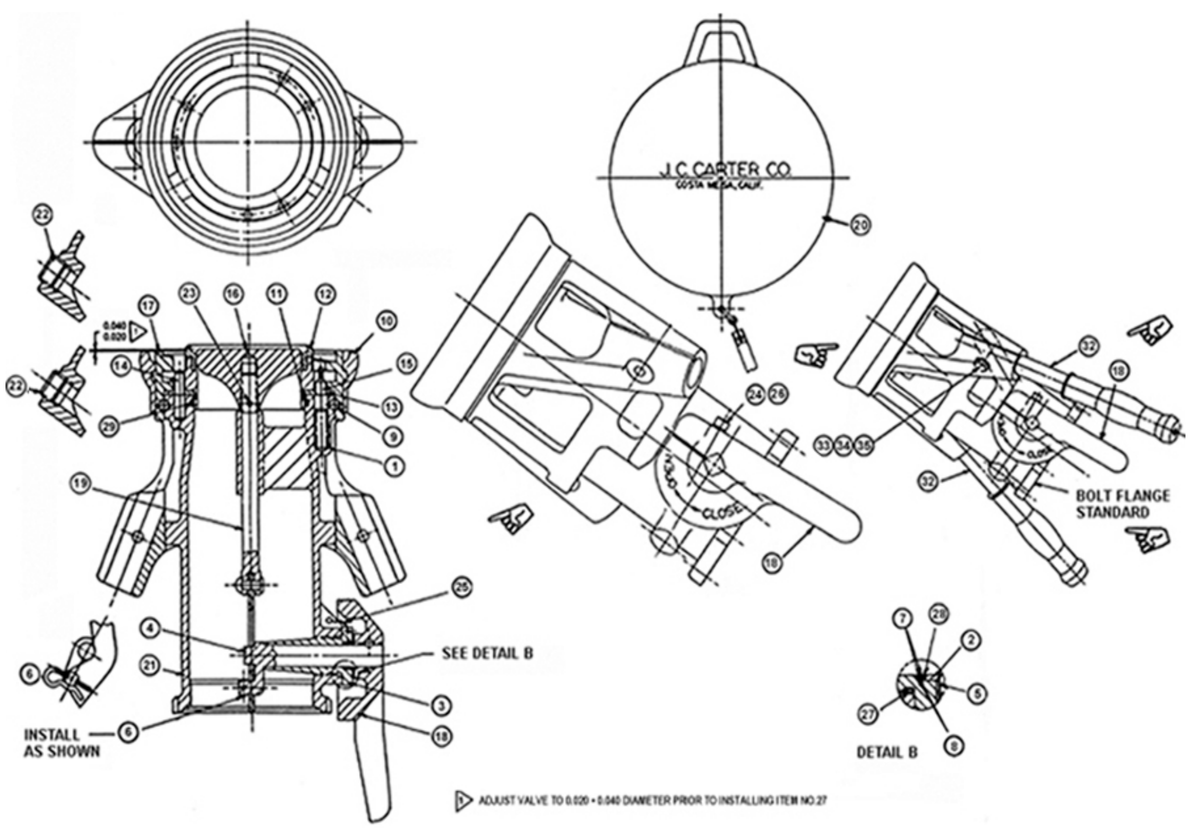


Figure 4–2. J.C. Carter single-point nozzle.
(By courtesy of Argo-Tech.)

The design of the J.C. Carter single-point nozzle has changed over time, and nozzles may come from different manufacturers. Figure 4–3 shows a single-point nozzle by the Cla-Val Company. Remember to use the instructions for your model of single-point nozzle for guidance to overhaul it!

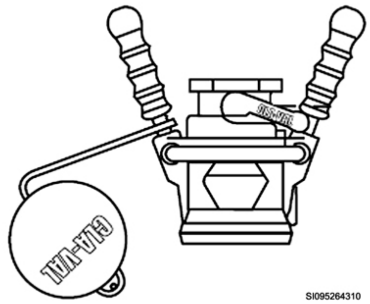


Figure 4–3. Cla-Val single-point nozzle. (By courtesy of Cla-Val Co.)

Swivel joints

Swivel joints are used on pipe and hose connections at various locations in a fuel system. One example is at the truck loading and offloading headers. There are two types of swivel joints—lubricated and non-lubricated. Non-lubricated swivel joints are sealed units that do not require maintenance, but cost more than lubricated ones. The OPW model 3200 swivel joint (fig. 4–4) is lubricated and provides a less expensive means to manipulate a truck fillstand hose to connect it to a refueling truck. Of course, lubricated swivel joints must be maintained properly to prevent leaks. You will have to lubricate the ball bearings periodically. Lubrication is very important to the smooth running of the bearings, which allow the tail of the joint to turn in the body. When a swivel joint does leak, the trouble is usually the failure of the O-ring.

To take an OPW swivel joint apart, you first remove the cotter pin from the retaining plug and then, second, remove the retaining plug. Remove the ball bearings from the joint and put them into a clean container. Make certain that you remove all of them from the joint. Then pull and rotate the tail until it comes out of the joint body. Next, take the worn O-ring out of the body. Then clean the body and bearings, using any approved cleaning solvent.

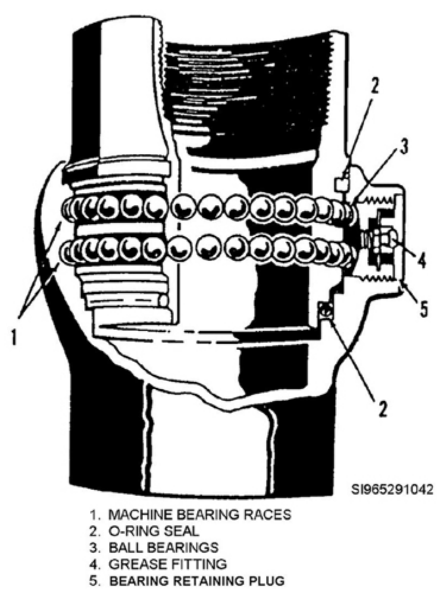


Figure 4–4. OPW swivel joint. (Courtesy of OPW, A Dover Company.)

When the joint parts are dry, reassemble them. Lubricate the ball bearings through the retaining plug, using a hand-operated grease gun. Determine what type and grade of grease you should use by looking in the manual containing the instructions for inspecting and maintaining OPW swivel joints. As you apply the grease, turn the joint and listen for the dragging noise. This noise will diminish as the joint fills with grease. You can also tell when the joint contains enough grease by the ease with which the tail turns in the body. If the joint turns very tightly, it may be that the ball-retaining plug is not adjusted properly.

231. Electrical switches used in the loading/offloading area

The two electrical switches used in the loading/offloading area include the emergency-top switch and the remote pump switch. We discuss both switches in this lesson.

Emergency-stop switch

Each truck loading area is equipped with an emergency-stop push-button switch. Installations for loading tank cars also have emergency-stop switches installed. They are wired together to permit all related electrical pumping equipment to be shut down simultaneously under circumstances warranting such action. The emergency-stop switches are explosion-proof and are mounted on a pole or metal support no closer than 25 feet from the loading headers. Normally, the emergency-stop switches have closed contacts that complete the low-voltage control circuit for the related fuel transfer pumps. When you push the button momentarily, you open the switches and break the electric control circuit. This action stops all related pumping equipment.

To restart the fuel transfer pumps, you must reset the circuit breakers in the pump house. Each emergency-stop switch is easy to recognize because it is painted red and has a single push button. The “as-built” electrical drawings for your system installation will show you how the switches are wired. They also show the pumps that they control. The drawings show the circuit breakers that must be reset. With some systems, you may have to reset only the main circuit breaker. In other systems, you may have to reset a circuit breaker for each pump.

Remote pump switch

A remote pump switch is installed at each loading header to start or stop the fuel transfer pumps in the pumproom. The pump switches are explosion-proof and are either the dual push-button (START/STOP position) type or the switch (ON/OFF position) type. A light alongside each pump switch gives you a visual indication when the pump is running. The remote pump switches can be used only when the pump selector switch in the control room is in the AUTO position. If you have to use the emergency-stop switch, the pump light will go out. This indicates that the low-voltage control circuit has been broken.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

230. Construction and maintenance requirements of truck and tank car loading/offloading facilities

1. Describe the construction of railroad tank car offloading facilities.

2. What is the purpose of a dry break coupling?

3. List the components of a refueling truck fillstand.

4. What maintenance may be required for loading/offloading facilities?

5. How would you repair a single-point nozzle with a leaking nose seal?

6. List the steps for rebuilding an OPW swivel joint.

231. Electrical switches used in the loading/offloading area

1. Where are emergency-stop switches located?

2. Are emergency-stop switches normally open or closed?

3. What must be reset when an emergency-stop switch is pushed?

4. What color are emergency-stop switches?

5. When the pump select switch is turned to AUTO, what switch must be used to operate the pump?

4–2. Grounding/Bonding

As you will soon read, grounding and bonding are critical to personnel safety and the protection of multi-million dollar fuel systems. Failure to adhere to these principles or maintain these systems can result in injury, death, and environmental catastrophes.

232. Grounding and bonding principles

Static electricity is extremely dangerous because static charges are generated within the petroleum products themselves and are usually discharged in the presence of petroleum vapors. Jet fuel (JP–4 or JP–8) produces the greatest hazard—first, because of its high potential to generate static charges and, second, because its vapors are usually in the explosive range. Static charges are generated by the movement, contact, or separation of two dissimilar materials. The rate of charge is about equal to the square of the velocity of the material in motion.

Flow of fuel through equipment and transfer pipes will generate sufficient static electricity to create a potential hazard. Tests have shown that a normal flow of fuel through an F/S will produce sufficient static electricity to create a spark.

Personnel and clothing (wool, rayon, and synthetic materials) accumulate static electricity from normal body movement. Nylon, for example, has been found to generate up to 600-volt potential. These charges can be discharged through your clothing, skin, tools, and equipment as they come into contact with components of the fuel system.

You can, however, greatly reduce the dangers of static electricity by properly bonding and grounding equipment throughout the fuel system. *Bonding* is connecting two items with a conductor in order to equalize their electrical potential. *Grounding* is attaching an item or a series of bonded items to the earth in order to neutralize its electrical potential.

Truck loading and offloading

Both the truck loading and the offloading headers are bonded and grounded—and both in the same way. The fuel system piping is bonded together by flanged connections, and the electrical conduit is bonded to the fuel system piping. The piping is then connected by a $^{3}/_{32}$-inch, nylon-covered, stainless steel wire rope ground cable to an approved ground rod. The ground cable may be connected to a buried metallic water pipe if there is one available. Each loading and offloading header has a flexible cable for grounding the truck before any hose connections are made. The $^{3}/_{32}$-inch stainless steel cable is about 10 feet long. One end of this flexible cable is connected to the permanent ground cable at the piping or at the ground rod. The other end, which you attach to the truck, is fitted with a clamp. The double-outlet-type of loading header is equipped with two flexible grounding cables, one on each side of the header. This allows two trucks to load simultaneously. Brackets suitable for holding the coiled ground cable are provided.

Tank car offloading

When a tank car is positioned on the spur track for loading, operator personnel must attach a flexible grounding cable securely to a clean connection on the tank car. Before the dome cover is opened or the fuel hose connection is made, the tank car must be grounded to prevent sparking. Rail-joint insulators are provided at the first rail joint beyond each turnout from the related main line or base railroad track. These insulating joints prevent stray electrical currents on the main track from coming into the spur track. The rail joints in the spur track beyond the insulated joints are bonded together. The rails of the bonded spur track are connected to ground cables that are, in turn, connected to ground rods. The fuel system piping is also bonded together and grounded. One end of the ground cable is connected to the piping, and the other end is connected to the spur track ground rod. There is no requirement to connect a bonding cable between the tank car and the stand or fuel line header during offloading operations because both the tank car and the offloading stand are grounded to the spur track ground rod.

Aboveground fuel storage tanks

Regarding the current design criteria on new aboveground tanks that rest on the earth (i.e., primarily vertical tanks that rest on oil-treated sand), these tanks do not require the use of ground rods unless a plastic liner is placed between the oil sand and native soil. If necessary, a grounding system will be installed using galvanized steel ground rods and $^{1}/_{4}$- to $^{3}/_{8}$-inch galvanized guy wires as the grounding conductor. No copper can be used in the grounding system. The purpose of this requirement is to eliminate corrosion caused by steel reacting with copper. On existing aboveground tanks in contact with the earth (including oil treated sand)—where grounding is provided by copper ground rods or copper grounding conductors—the grounding system should be removed and treated in the same way as prescribed for new installations.

The floating roof is bonded to the tank shell by bonding shunts (straps) installed over the fabric seal. The shunts are made of aluminum or stainless steel and have one end attached to the floating roof.

The other end is attached to the metallic sealing ring. The shunts are about 18 inches long and are flexible. They are installed every 6 to 10 feet around the perimeter of the roof.

System piping and components

Normally, the bolts and nuts used to connect the flanges will provide a suitable bonding connection. However, when maintenance requires a valve or component to be removed from the pipeline, you will have to use a bonding jumper similar to the one shown in figure 4–5.

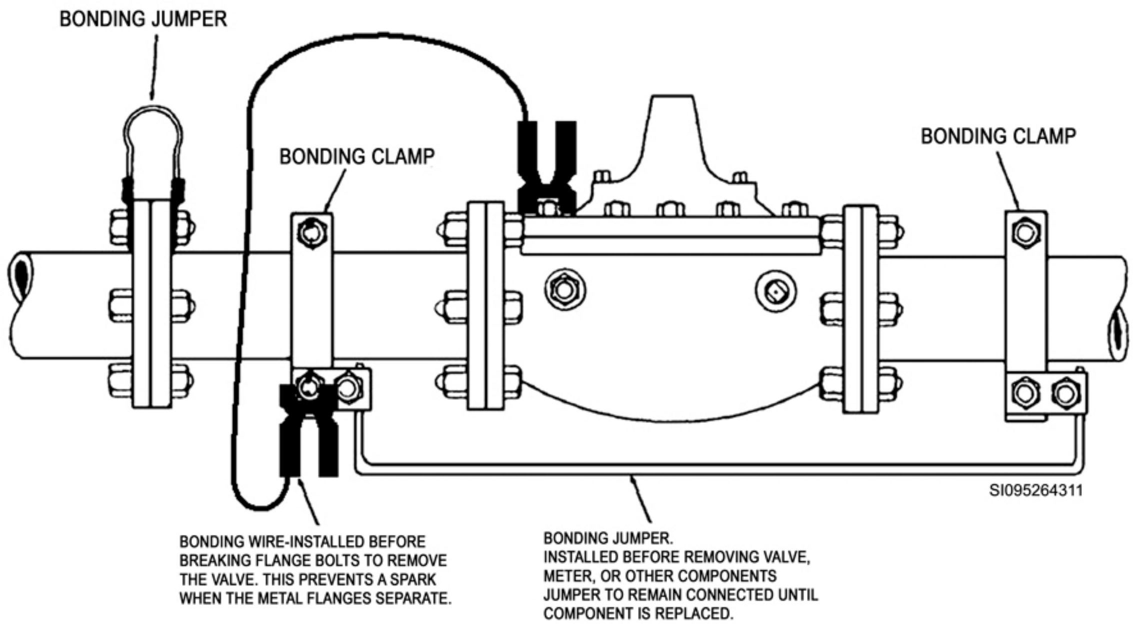


Figure 4–5. Bonding jumpers.

Adding the bonding jumper and the bonding wire in the manner shown in figure 4–5, equalizes the electrical potential during valve removal and across the gap between the flanges when the valve is gone. A perfect example of electrical potential is static electricity. By rubbing your shoes on the carpet, you have a greater electrical potential than the door knob you are about to touch. Since you and the door knob are separate objects and not connected, when you reach for the knob, the static spark arcs from your hand a split second before you grab the knob. Think about the same example, but now, you are in a pump house filled with fuel vapors. That one static charge could ignite those vapors. This is why bonding is so important whenever components are taken apart in a fuel system.

Fuel is expensive and an environmental pollutant. Proper measures must be made to ensure that pipes don't leak. Proper construction and diligent corrosion control go a long way towards that goal. By placing a protective coating on our pipes and valves, we are merely breaking the electron path into the air. Oxygen reacting with the steel creates oxidation, which is another word for rust. Whenever you chip the paint during maintenance or put in a new component, always apply a new coat of primer and paint suited to the conditions in your area.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

232. Grounding and bonding principles

1. Match each item in column B with its description in column A. Items in column B may be used once, more than once, or not at all.

Column A

____ (1) Generated by movement of dissimilar materials, such as fuel through a pipe.
____ (2) Made of nylon coated stainless steel.
____ (3) Prevents stray current from traveling from the main line to the spur.
____ (4) Connects the spur rail, fuel header, and ground.
____ (5) Not required for fuel tanks if they sit on soil.
____ (6) Electrically connects the tank roof to the sealing ring.
____ (7) Installed before removing a component from the pipeline.

Column B

a. Grounding rod.
b. Rail-joint insulator.
c. Bonding shunt.
d. Grounding wire.
e. Static electricity.
f. Bonding jumper.

2. How is the piping at truck loading and offloading headers connected and grounded?

3. When and why should a tank car be grounded?

4. Why is copper *not* used in a grounding system?

4–3. Pipelines

Normally, cross-country pipelines are owned, operated, and maintained by civilian agencies. They vary in size, construction, and operation. Terrain features and the year of system installation are factors that influence the operation and type of the cross-country pipeline system. Government-owned or -leased cross-country pipeline systems and marine facilities are in common use in overseas areas. Normally, the systems are maintained by AF personnel. Also, with increases in fuel storage requirements and with the commercial facilities now available, pipeline systems are becoming more economical for use in the US. The few cross-country government-owned pipeline systems in use now are usually maintained under a contract with civilian agencies. This depends on the size of their system. However, if a particular base has the necessary equipment and personnel, the maintenance responsibility may be delegated to the WFSM shop. When a pipeline system is under contract to a civilian agency, civilian responsibility for maintaining the pipeline usually terminates at some point near where the pipeline enters the base. From this point to the bulk fuel storage area, the responsibility for maintenance is assigned to your shop.

233. Design features and maintenance requirements of piping systems

Pipelines are manufactured in different sizes and types. Some will be black iron, and some will be stainless steel. They are used for distributing different products such as JP–8, diesel fuel, and so forth.

Cross-country pipelines

Cross-country pipelines are often of the multiproduct type. The various fuel products are transferred through one common pipeline, one at a time. The system consists of one pipeline and a series of pumping stations. The pumping stations have pumps, strainers, pressure regulators, valves, scraper sand traps, and a sump tank to collect sludge and debris. The number of pumping stations in the cross-country system depends on the distance the fuels must be transferred. Terrain conditions are also considered when determining pumping station requirements.

When the fuel products are received at the air base from the cross-country pipeline, the first requirement is to have the pipeline fuel pressure reduced to a pressure compatible with the bulk storage area piping. Normally, cross-country pipelines transfer fuels at various pressures, depending upon the product. Sometimes a pressure-reducing valve is installed in the piping entering the bulk storage area. The using activity determines the setting of the pressure-reducing valve to meet system requirements. All equipment and piping on the tank farm side of the pressure-reducing valve are rated for the working pressure of the tank farm piping system.

After the incoming pipeline pressure has been reduced, the fuel must pass through a duplex, jet-type, self-cleaning line strainer or a centrifugal-type solids separator with sump tank and auxiliary pump. On the downstream side of the line strainer or solids separator, strict product segregation or separation must be maintained. This is done by means of a manifold connected to the strainer piping at one end and to the storage area piping at the other end. At this point the different fuels are directed and routed through the proper pipeline and to their respective storage tanks. Each storage area product line has a spectacle flange and block valves for isolating the lines at the manifold. Each spectacle flange serves two functions. The first is performed by the blank end of the flange, which is inserted into the line to isolate the product. The second is performed by the opposite end, which is open and inserted into a line when fuel flow is required through that particular line.

Inspecting aboveground piping

Aboveground portions of on-base pipelines are inspected visually for leaks or drips; this is done at the same time that other maintenance tasks are being performed in these areas. Fuel leaks constitute an emergency condition for which immediate repair is justified. The type of repair is determined by the nature of the leak. A corrosion leak in an aboveground pipeline requires welding for permanent repair. (Approval through local work management processes is required before beginning welding or hot work in connection with repairs.)

Inspecting underground piping

All WFSM personnel should know the underground pipeline routes and to make a general visual surveillance whenever they are driving by or working in these areas. The pipeline should be walked at least twice a year. Leaks in underground pipelines can sometimes be detected by fuel surfacing on the ground, fuel run-off in the storm drainage system, detection of fuel in underground pits or manholes, or the continuous odor of fuel in a particular area. Any suspicious circumstances are justification for immediate investigation. This includes pressure-testing of the line in question and excavation, if soil conditions permit.

Annual pressure test

All on-base (above- and below-ground) fuel-piping systems are pressure-tested once a year, using installed pumps in the various fueling systems. Unloading, transfer, truck loading, and hydrant dispensing piping systems are pressurized by running the appropriate centrifugal or vertical turbine pumps against a closed system for about 30 seconds. Appropriate valves are closed to trap pressure in the system while pressure gauge readings are taken. Also, all aboveground piping and piping located in concrete pits are checked visually for leaks. Closed valves are checked for sound indication of an internal leak through the valve. If there are no visible or audible leaks, then pressure gauge readings are taken every 15 minutes for the first hour and once every half hour for the next hour. The total time of the test will be 2 hours. All pressure tests are recorded and includes the following information:

1. Name of the system tested (refuel header, defuel header, lateral pipelines) and the facility number.
2. Date of the test and the weather conditions (sunny and 80° F, cloudy and 65° F, etc.). (**NOTE:** Record any weather change during the test period.) These pressure readings are as follows:
   a. Start (approximate local time) pressure.
   b. 15 minutes (approximate local time) pressure.
   c. 30 minutes (approximate local time) pressure.
   d. 45 minutes (approximate local time) pressure.
   e. 1 hour (approximate local time) pressure.
   f. 1.5 hours (approximate local time) pressure.
   g. 2 hours (approximate local time) pressure.

NOTE: Keep these records on file in the WFSM shop for 5 years. Send copies to the MAJCOM liquid fuels engineer when requested.

Hydrostatic pressure test

A hydrostatic pressure test is performed every 5 years on all underground aviation fuel transfer pipelines. The specific year is set by the MAJCOM liquid fuels engineer. A hand-operated hydraulic pump with a built-in reservoir tank supplies hydrostatic pressure.

To test the pipe, first isolate the section being tested with a blind or spectacle flange. If MILSPEC 12003 DBB valves are used and they hold the pressure, a flange is not required.

Using a hand-operated hydrostatic pump, do a static pressure test at 150 percent of the system deadhead pressure, not to exceed 275 psi, for a minimum of 4 hours.

Record the pressure every 15 minutes for the first hour, then every hour thereafter. If, at this point, no leaks are indicated, further testing is not required. If, instead, a leak or excessive pressure drop is indicated, conduct a flow test. Do this by repressurizing the line to 150 percent of the system deadhead pressure with the hydrostatic pump. Measure and record the amount of fluid required to maintain this pressure for 4 hours. Send copies of all test results to the appropriate MAJCOM liquid fuels engineer as an attachment to AF Form 172, Tank Inspection Summary.

Pipeline cleaning

Long, fairly straight lengths of pipeline, usually located in cross-country piping systems, are cleaned with line scrapers forced through the line by the liquid being pumped. The time intervals between the cleanings vary with the size of the pipe and the type of liquid being pumped. A drop in both flow rate and pressure usually indicate a loss of efficiency and the need for pipe cleaning. Although line scrapers vary in design, usually they are spring-mounted wire brushes fastened on the scraper to contact the inner walls of the pipeline. The rubber cups on the scraper fit the pipe snugly, thus permitting the scraper to be forced through the line by the fuel.

Pipeline scrapers are inserted into a pipeline through scraper traps. The scraper is placed into a slightly oversized pipe that is isolated from the incoming or outgoing line by a valve and piping. The oversized pipe or trap also contains pressure lines. The lines are valved and so arranged that you can drain the scraper trap before inserting the scraper. You then insert the scraper, seal the trap, and apply fuel behind the scraper to shoot it into the main line. The flow through the main line carries it to the next pumping station, where a scraper trap is provided for its removal.

You bypass meters while scraper sediment is in the line or when your cleaning operations are underway. Once you place a scraper in a pipeline, its minimum speed should be 2 miles per hour, and you should not shut down the fuel line under any circumstances while the scraper is still in the line. If the pipeline flow stops while the scraper is in the line, the dirt and debris may settle in front of the scraper, causing it to stick. You can determine the scraper location in a pipeline by timing. Because you know the rate of flow in the particular line, it is easy to calculate the distance that the line scraper has traveled in a given period of time, as well as the time it will arrive at its destination. Also, you may use such special devices as noise makers attached to scrapers, radioactive material that can be located with a Geiger counter, or magnetized cores in scrapers that can be detected with a magnetometer.

Corrosion control

Every 6 months, you inspect the paint on the piping system to note its condition. Actually, you should observe the condition of the paint whenever and wherever you are working. In this way, you can keep bare spots touched up with paint and have the markings and symbols in legible condition. Also, you can catch corroded spots on the piping when they begin. First, hand sand or wire brush the bare spots until the paint edges are clean and the metal is bright. Second, apply one coat of primer and at least two coats of paint (of the approved type and color) over the spots. Let each coat of paint dry before applying the next, and sandpaper lightly between paint coats. Preparing corroded surfaces for painting is done in the same way. Make sure that all corrosion has been scraped properly and wire-brushed to bare metal. Then apply the primer and paint.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

233. Design features and maintenance requirements of piping systems

1. How is the number of pump stations to be used on a pipeline determined?

2. What components are found on the pipeline after it enters the base bulk storage area?

3. How are permanent repairs made to corrosion leaks on aboveground pipeline?

4. Name some methods for detecting leaks on underground pipelines.

5. What is used to pressurize a pipeline during the annual pressure test?

6. List what must be recorded during an annual pressure test.

7. Where are the annual pressure tests kept? How long must they be maintained?

8. How often is a hydrostatic pressure test required?

9. At what percent of the normal operating pressure is the hydrostatic pressure test performed?

10. What type of test must be performed if leak or excessive pressure drop is indicated during the hydrostatic pressure test?

11. What would indicate the need for pipeline cleaning?

12. What is the *minimum* required speed of a pipeline scraper during cleaning?

13. Why is it important *not* to shut down the fuel flow while a scraper is moving through the line?

14. Briefly state the procedures for painting corroded spots on a pipeline.

Answers to Self-Test Questions

230

1. Spur track, 40 feet between couplers, 10 feet overrun, 65 feet between spur and main line, and 4-inch hoses connected to a 4-inch valved coupling riser.
2. It provides a fast, clean, dry disconnection from two hoses.
3. Block valves for isolation, pressure gauge, line strainer before the meter if an F/S is *not* installed within 100 feet, positive displacement meter, a refuel control valve, a swivel joint and a 4-inch API 1529 hose or pantograph arm fitted with a single-point nozzle are attached to the system; an electrical on/off switch is provided at ground level to start and stop the refueling pumps, a pressure relief is installed to protect the system from thermal expansion, and a pressure switch is installed to cut off the transfer pump at a predetermined pressure.
4. Stopping leaks, replacing and repairing hoses, calibrating the meter, repairing and/or lubricating of swivel joints, and changing F/S elements if an F/S is installed.
5. Remove the nozzle from the end of the hose at the quick disconnect. Remove the cover assembly from the nozzle. Remove the collar bearing. Open the nozzle. Remove the poppet. Remove the snap ring from the nose seal. Remove nose seal plate.
6. Remove the cotter pin from the retaining plug and then remove the retaining plug. Remove the ball bearings from the joint and put them into a clean container. Make certain that you remove all of them from the joint. Then pull and rotate the tail until it comes out of the joint body. Next, take the worn O-ring out of the body. Then clean the body and bearings, using any approved cleaning solvent.

231

1. At truck and tank car loading installations. They must be no closer than 25 feet from the loading headers.

2. Closed.
3. Circuit breaker.
4. Red.
5. Remote pump switch.

232

1. (1) e.
   (2) d.
   (3) b.
   (4) d.
   (5) a.
   (6) c.
   (7) f.
2. By means of a $^{3}/_{32}$-inch, nylon-covered, stainless steel wire rope ground cable; to an approved ground rod.
3. During tank car loading operations before the hose is connected or the dome cover is opened.
4. Copper causes corrosion when reacting with steel.

233

1. By the distance and terrain features.
2. Pressure-reducing valve; a duplex, jet-type, self-cleaning line strainer or a centrifugal-type solids separator; and manifold with valves.
3. By welding.
4. Fuel surfacing on the ground, fuel run-off in the storm drainage system, detection of fuel in underground pits or manholes, or the continuous odor of fuel in a particular area.
5. Installed pumps.
6. a. Name of the system tested (refuel header, defuel header, lateral pipelines) and the facility number.

   b. Date of test and weather conditions (sunny and 80° F, cloudy and 65° F). (**NOTE:** Record any weather change during the test period.)

   c. Pressure readings.

      (1) Start (approximate local time) pressure.
      (2) 15 minutes (approximate local time) pressure.
      (3) 30 minutes (approximate local time) pressure.
      (4) 45 minutes (approximate local time) pressure.
      (5) 1 hour (approximate local time) pressure.
      (6) 1.5 hours (approximate local time) pressure.
      (7) 2 hours (approximate local time) pressure.
7. Kept on file in the WFSM shop for 5 years.
8. Every 5 years.
9. 150 percent.
10. Flow test.
11. A drop in flow rate and pressure.
12. 2 miles per hour.
13. The dirt and debris may settle in front of the scraper, causing it to stick.
14. Hand sand or wire brush the spots to bare metal, and then apply a primer and paint.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

71. (230) What is the *minimum* size, in inches, of the unloading manifolds on Air Force (AF) installations?
    a. 4.
    b. 6.
    c. 8.
    d. 10.

72. (230) Tank truck unloading headers will be spaced about how many feet apart?
    a. 40.
    b. 60.
    c. 80.
    d. 100.

73. (231) The emergency-stop switches have what type of contacts and complete which circuits?
    a. Open; low-voltage for the fuel transfer pump control.
    b. Closed; low-voltage for the fuel transfer pump control.
    c. Open; high-voltage for the fuel transfer pump control.
    d. Closed; high-voltage for the fuel transfer pump control.

74. (231) What color are the emergency-stop switches?
    a. Red.
    b. Amber.
    c. Orange.
    d. Yellow.

75. (232) Truck loading and offloading headers are grounded by what size and type of cable?
    a. $^{1}/_{4}$-inch galvanized steel.
    b. $^{1}/_{16}$-inch stainless steel.
    c. $^{1}/_{8}$-inch galvanized steel.
    d. $^{3}/_{32}$-inch stainless steel.

76. (232) Which fuel system headers has no requirement to connect a grounding cable during servicing?
    a. Truck loading.
    b. Truck offloading.
    c. Tank car loading.
    d. Tank car offloading.

77. (232) What type of grounding rods are used on aboveground fuel tanks?
    a. Copper.
    b. Aluminum.
    c. Stainless steel.
    d. Galvanized steel.

78. (233) During an annual pressure test, what is used to pressurize a piping system and for how many hours should the pressure be maintained?
    a. Hand pump; 2.
    b. Hand pump; 4.
    c. Installed pumps; 2.
    d. Installed pumps; 4.

79. (233) The records for annual pipeline pressure tests are kept on file for how many years?
    a. 1.
    b. 5.
    c. 10.
    d. 20.

80. (233) During the 5-year pressure test, what is used to pressurize a pipeline, and for how many hours should the pressure be maintained?
    a. Hand pump; 2.
    b. Hand pump; 4.
    c. Installed pumps; 2.
    d. Installed pumps; 4.

81. (233) At what percent of system deadhead pressure will pipelines be tested during the hydrostatic test?
    a. 100.
    b. 125.
    c. 150.
    d. 175.

82. (233) What is the *minimum* speed in miles per hour for a scraper when cleaning a pipeline?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

Please read the unit menu for unit 5 and continue ➔

Unit 5. Automotive Dispensing Systems

SO FAR YOU HAVE BEEN studying and learning the components of a fuel system. The components mentioned earlier in this volume could be used in almost any fuel system. Now it's time to look at different fuel systems and see how these components interact. Systems may look different or be laid out differently, but the end task will be the same—to dispense fuel.

We have aircraft that require thousands of gal. of fuel each time they are refueled, and we have trucks and other equipment that may require only small quantities of fuel each time they are refueled. It would be impractical for us to have a big hydrant system designed and installed to meet this condition. The system used to refuel vehicles is a small dispensing system like many gas stations. The basic design of the automotive dispensing system is very similar at all AF bases.

5–1. Automotive Systems and Dispensing Units

Besides keeping our aircraft flying, we also keep our vehicles rolling. We take care of everything from where the MOGAS or diesel tank truck hooks up to the offloading header to the fuel nozzle the customer sticks in their gas tank, and everything else in between. The base automotive systems we maintain are not as fancy as what you see off base, but that only means the off base technicians have more features they have to fix when problems arise.

234. Constructional features of automotive dispensing units

The quantity of ground fuels dispensed on a base is generally small compared to jet fuel. So, at most bases, the only storage tanks required for ground products are those located underground adjacent to the service pumps. At locations where additional fuel is required, such as in overseas areas, larger quantities of ground products are stored in the bulk storage area. Fuel is received at the automotive storage system by trucks and is offloaded directly into the tank by gravity flow. Generally, one 10,000 gal. capacity storage tank for each product is sufficient However, if requirements are greater, then more tanks may be installed. You will have to check with the "as built" drawings to determine the storage at your base. Figure 5–1 shows a typical drawing of a vehicle service station.

Vent line

The storage tanks are all constructed in the same way and have similar accessories. The tank vent is connected to the top of the tank and is fitted with a UL-approved vent cap. The cap helps to keep the vent unobstructed and allows the tank to breathe properly. The vent pipe normally extends above the ground level to a height of at least 12 feet.

Fill line

The fill line is a pipe that extends to within 3 inches of the tank bottom. The bottom end of the fill line is equipped with a splash deflector, which helps prevent the fuel entering the tank from stirring up the sediment and water at the bottom of the tank.

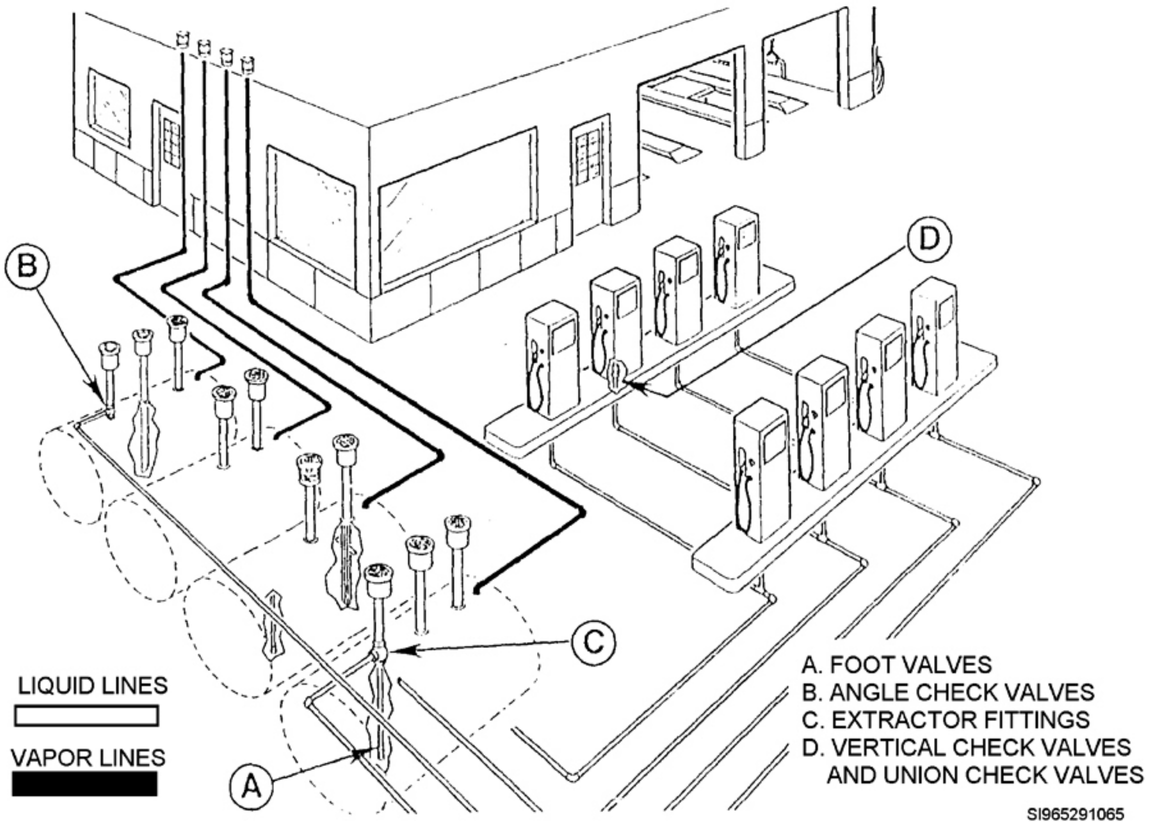


Figure 5–1. Vehicle service station.

Gauging hatch

Some service station tanks have separate lines for gauging, while others use the fill line for gauging. We covered how to use a tape and bob to gauge larger tanks in an earlier lesson. Normally, small tanks used for service stations are checked with a gauging stick. The stick gauge can be made out of wood or metal and must be marked in 1/8-inch increments of measurement. If the tank has a separate gauging hatch, it will have a striker plate, which is a ¼-inch piece of uncoated stainless steel or aluminum, directly beneath the hatch. This will give added strength to the tank bottom where the gauging stick will be hitting. As with all AF fuel tanks, it will be fitted with a weather-tight locking gauging cap.

Cleanout connections

Again, large tanks should always have cleanout connections; small tanks may or may not have them. If the service station tank does have a cleanout line, it will be 3/4 inch in diameter and should extend 12 inches above the grade. Cleanout lines are used to remove water and sediment from the bottom of the tank.

Tank entrance

The tank may also have an access used for physical entry. Ground product tanks are cleaned only at the request of the fuels management officer. There is no regular frequency for physical entry inspection of ground product tanks. The suction line is connected to the dispensing unit. On self-contained units, the suction line is equipped with a foot valve that prevents reverse flow in this line. There is also a screen over the end of the suction line to keep dirt and scale out of the line. The suction line should extend to within 4 inches of the tank bottom. However, some systems may have a submerged or submersible pump installed on the tank piping that eliminates the requirement for a foot valve. Since the pump unit will be located in the tank, this type of dispensing unit is classified as a remote unit.

235. Different designs of automotive dispensing units

Automotive dispensing units are purchased separately for each base; therefore, you will see the dispensing units of several different manufacturers represented in the system. Some dispensing units are plain in appearance and record only the number of gal. delivered. Other units show the price as well as the number of gal. As a maintenance specialist, you will have to maintain and repair these different dispensers, so you must have a good idea of how they operate. Once again, the only sources of detailed information you will have on various dispensers are the manufacturers' maintenance manuals. AF directives provide very limited coverage. When you learn about the general design and operating principles of one typical dispensing unit, you should not have much trouble understanding the design and operating principles of any type of dispenser you encounter.

Self-contained dispensing units

These are either single- or dual-dispensing units. Both single and dual units are illustrated in figure 5–2. Figure 5–2, A, illustrates a single unit, and figure 5–2, B, a dual unit. Both units pump only one fuel grade or product. The major differences between the two units are the number of meters and the hose. The single-dispensing unit has one meter and a register. The dual-dispensing unit has two meters and two registers. As you can see, there are also two hose reels on the dual unit and only one on the single unit. Both units use only one pump, which is belt driven by a constant-speed electric motor. In the dual-dispensing unit, the single pump can deliver fuel through both hoses at the same time. These units are called *self-contained* because the meter, pump, and motor are located in the unit housing.

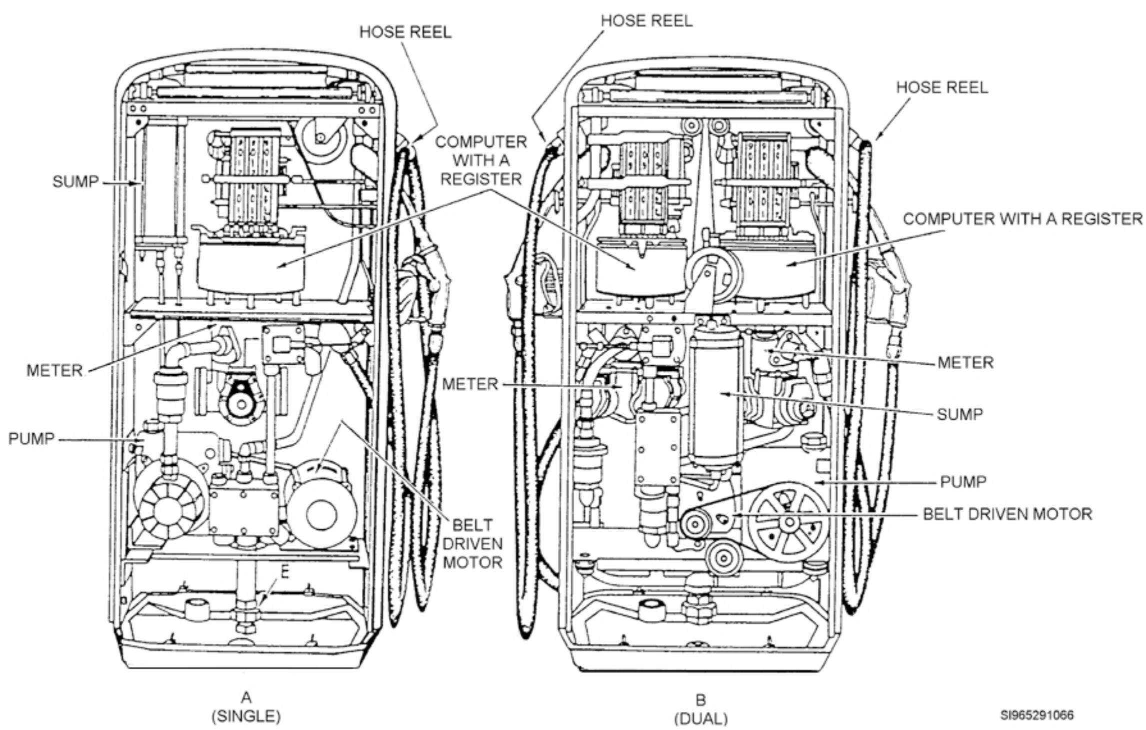


Figure 5–2. Single and dual dispensers.

The motor for the dual-dispensing unit normally has a higher horsepower rating to handle the increased load. You may find a unit with two pumps that is designed to dispense two different products. These units are known as *dual-dispensing, dual-product*. As fuel passes through the pump assembly, trapped air is separated and routed to the float chamber where it is vented. Some units include an air eliminator as part of the pump assembly. The electrical components of dispensers are explosion-proof.

Figure 5–3 illustrates a simple single-dispensing, single-product unit. Look at figure 5–3 as you read about the flow of fuel through the unit. As fuel is drawn from the storage tank by suction, it passes through a strainer, which is usually located in the pump inlet. The pump is started by first resetting the register using the reset crank (newer models have a spring-loaded lever). When the control lever is set for operation, the control rod linkage energizes the motor switch, starting the motor. The pump now moves the fuel to the meter. Any air in the fuel is directed to the float chamber through the meter discharge tube, where it is dispensed. After the fuel leaves the meter, it goes to the hose and nozzle. The meter is equipped with a check valve to prevent reverse flow through the unit. Other units may have a check valve on the suction side of the pump. When the float chamber is full of fuel, the float raises and opens the suction tube connected to the suction side of the pump. Then the fuel is dispensed through the hose.

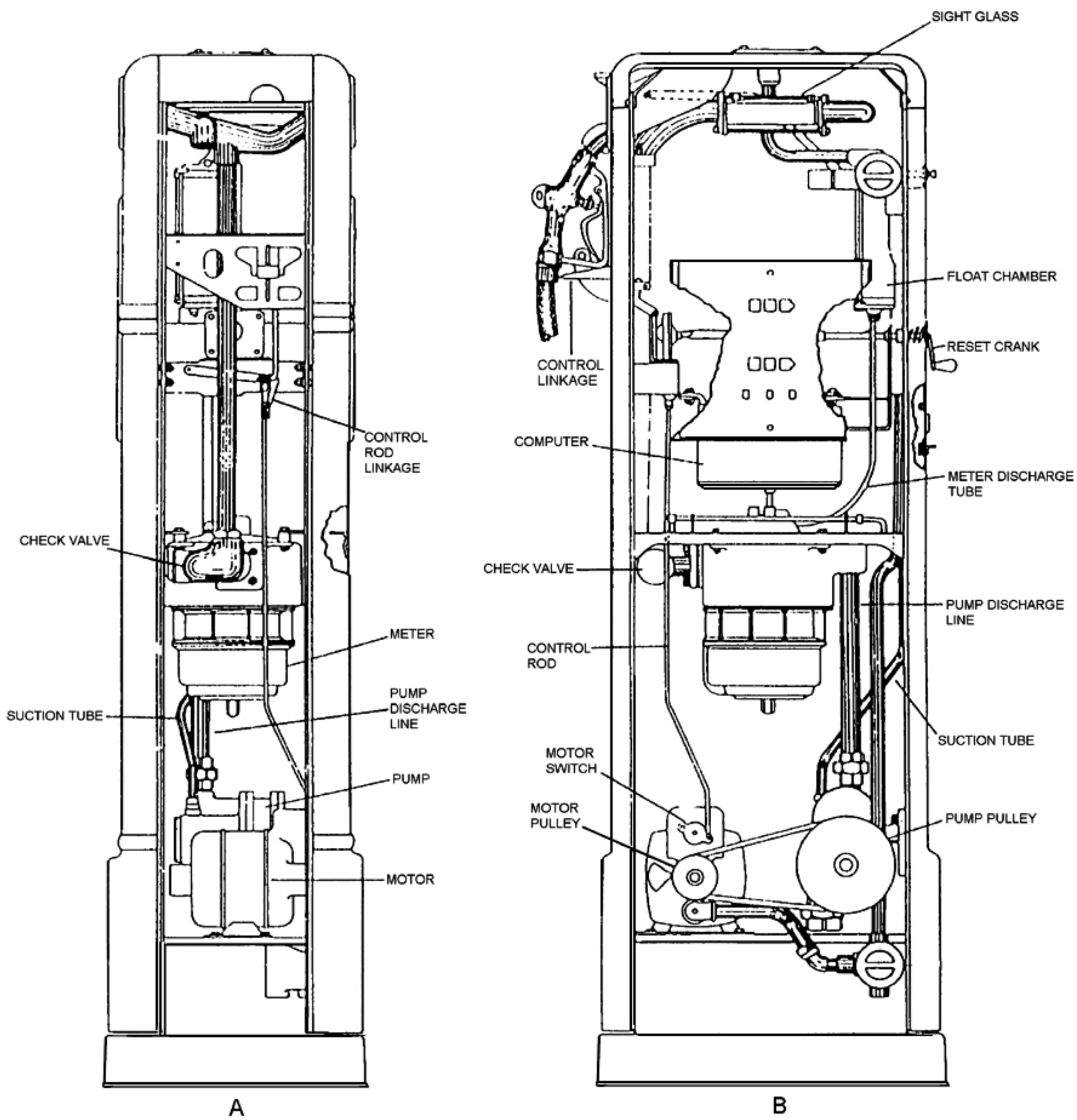


Figure 5–3. Single-product dispensing unit.

Remote submerged pump and motor units

Proven reliability and cost savings are just a couple of the features the submerged pump affords a service station. In this improved system of ground-product handling, the submerged pump and motor unit is completely submerged in the storage tank, where it is tamperproof, weatherproof, and foolproof (fig. 5–4). From this central source of supply, fuel is pushed to island dispensers at speeds actually exceeding the rate of delivery of standard suction pumps. A flow of about 10 gal. per minute can be achieved with one dispensing unit in operation, decreasing only slightly as additional units serviced by the same pump are put into operation.

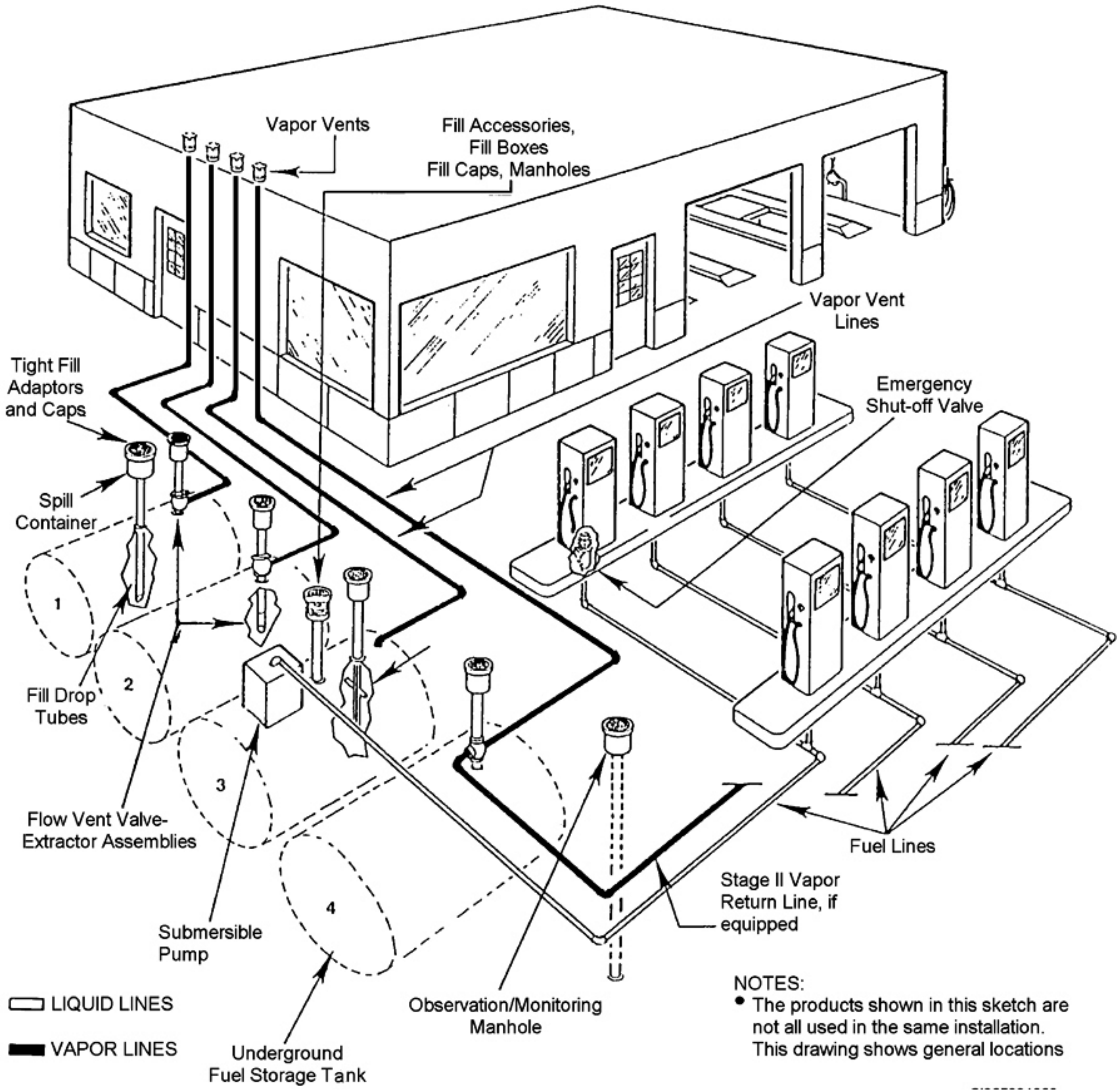


Figure 5–4. Submersible pump application.

Because one pump and motor unit is sufficient to supply fuel to as many as eight dispensing pedestals, a substantial savings in equipment cost, elimination of individual suction lines, check valves, excavation, and maintenance can be realized. In addition, operational difficulties, such as vapor locking, encountered with suction pumps while handling highly volatile fuels in extremely hot weather, are completely overcome.

Emergency shutoff valve

The NFPA–30 requires that an approved emergency shutoff valve (fig. 5–5), incorporating a fusible link or other thermally actuated device designed to close automatically in the event of severe impact or fire exposure, be properly installed in the supply line at the base of each individual dispensing device. NFPA further requires that, upon completion of the installation, the section of the pressure piping system between the pump discharge and the connection for the dispensing facility must be tested for at least 30 minutes at the maximum operating pressure of the system. NFPA also requires the use of a dry break swivel between the hose and the nozzle. This eliminates fuel spills when people accidentally drive off with the fuel nozzle still in their vehicle.

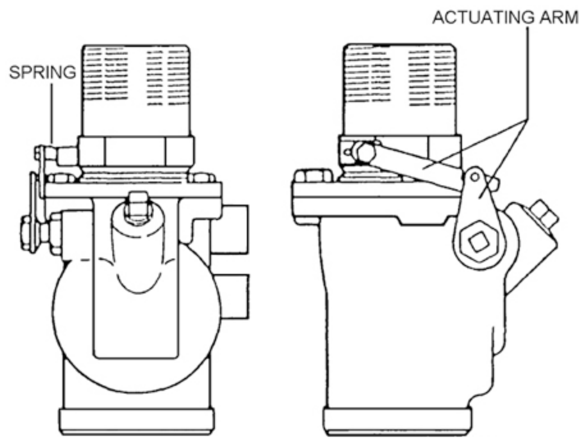


Figure 5–5. Emergency shutoff valve.

Hydraulic control valve

The purpose of the hydraulic control valve (a.k.a the solenoid control valve) is to regulate the flow of gasoline through the dispenser. Operation of the valve is purely hydraulic. The pilot valve must be fully open before fuel can flow through the dispenser. The opening of the pilot valve allows the operator of the nozzle lever to lower the pressure on the top side of the operating piston that opens the main valve, thus allowing the gasoline to flow through the dispenser.

The main valve opens only enough to allow the amount of gasoline required by the nozzle to pass through the dispenser. This is due to the differential pressure created on the operating piston by the dispensing nozzle. When the pilot valve is closed, the pressure on both sides of the operating piston is equal. This allows the spring on the main valve to close, preventing the flow of fuel in dispensers not being used.

A check valve keeps the system full of product above this valve. The pressure-relief valve is incorporated in the poppet stem located in the strainer body directly below the meter.

236. Performing maintenance on automotive dispensing units

There are many different automotive dispensing unit manufacturers. Each assignment you have may present new equipment, and the only way you can be sure of the maintenance requirements is by studying the manufacturer’s manual and following the instructions completely.

In this lesson you will learn about self-contained station dispensing systems—not because they are the most popular or best, but because they are more complex than a submersible pump dispenser. A submersible pump dispenser has a solenoid-operated valve instead of a pumping unit, motor, and air eliminator.

Electrical wiring

When properly cared for, the motors furnished with self-contained pump dispensers will give excellent service. Pumps are shipped from the factory with motors wired according to the specifications given on the order regarding current, frequency, and voltage. Often it becomes necessary to change the original hook-up to suit the current supply. Many motor failures result from improper settings on motor changeover plates (fig. 5–6). If you receive a motor set for 110 volts and your system is 220 volts, simply reset the changeover plate.

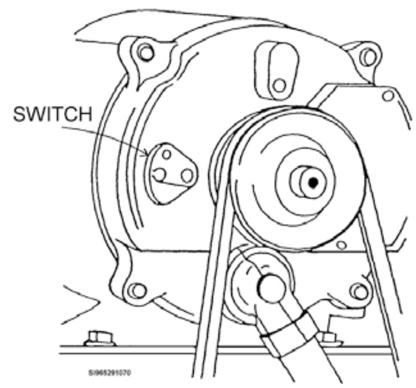


Figure 5–6. Motor changeover plate.

If the motor is set for 110 volts and a 220-volt current is used, the motor will burn out after running only a short time. If the motor is set for 220 volts and a 110-volt current is used, the motor will run very slowly and the starting field will soon burn out. Incorrect wiring of a motor is due to carelessness on the part of the individual making the electrical connection. All motors are properly tagged at the factory, and with ordinary precaution, any competent individual will find it easy to wire them correctly.

Internal gear pump

Most suction-type, self-contained pump dispensers are equipped with an internal gear-type pumps that are very simple in design and efficient in operation. There are only two moving parts—the rotor and idler, both machined to a very close tolerance.

The purpose of the internal gear pump is to create a vacuum in the suction line that pulls the fuel up from the storage tank to the dispensing unit. Fuel entering through the suction inlet fills the spaces between the gear teeth in the idler, and it is carried through the pump body, transforming it into power. Because there is only a small clearance between the gear teeth on the rotor and the pump body, and because gear pumps are usually rotated at high speeds, the rotary unit will pump air and vapor as well as liquid. Thus the pumping action of gear-type unit is positive displacement.

Because gear pumps are positive placement in operation, some means must be provided to limit the pressure they build up when the discharge from the pump is closed. Otherwise, excessive pressure would create strains within the pump or connecting pipe and might cause leaks or blow fuses by overloading the motor. A bypass valve is used to prevent excessive pressure by routing surplus fuel back to the suction side of the pumping unit. When the nozzle is open and the motor is turned on, the bypass valve closes and allows the liquid to discharge from the nozzle outlet of the pump.

Priming

A new internal gear pump will prime itself, unless it is connected to an extremely long suction line with an excessive vertical lift (over 12 feet), provided that the suction line is otherwise correctly installed. Refer to figure 5–7 for the following discussion.

If the pump will not prime itself, remove the strainer cap (20). Then, while turning the pump pulley by hand in the reverse direction, squirt a small amount of heavy lubricating oil into the strainer cavity. Replace the strainer cap and start the pump. In practically all cases, this will provide a tight seal long enough for the pump to prime. This procedure may be necessary when a considerably worn pump is moved to a different location.

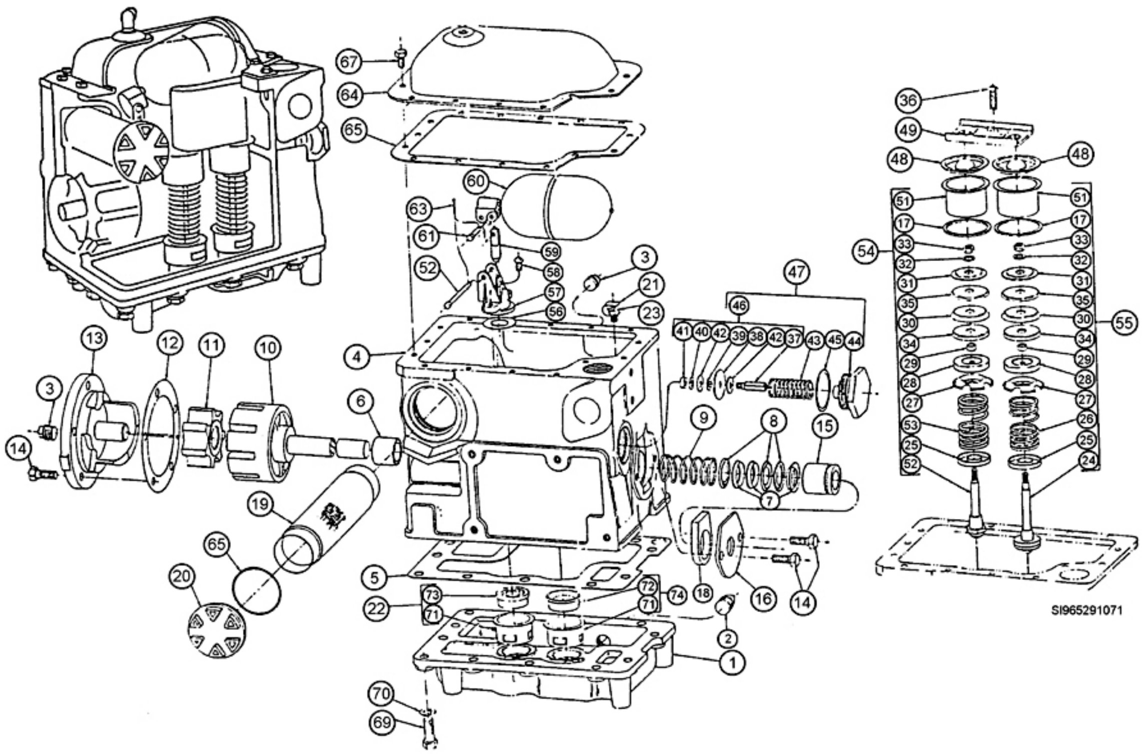


Figure 5–7. Internal gear pump and air eliminator.
(Courtesy of the Gasboy® Corporation.)

End play

Overhauling the pump is necessary only when the pump has lost efficiency due to end play. Excessive end play can be caused by wear over a period of years, or by damage resulting from the pumping of foreign matter or water. Ordinary end play can be taken up by removing the internal gear pump head (13) and using a thinner gasket (12).

Causes of sticking

If a pump should stick while in operation, remember that it can be caused by three things: (1) foreign matter in the working parts, (2) working parts badly rusted by water, or (3) ice formed from moisture that may have gathered in the pump.

If foreign matter is causing the trouble, it can be remedied easily by removing the pump head and cleaning out the accumulated foreign matter. In case of ice, the pump can be thawed out by applying some safe form of heat. The safest method is application of rags that have been saturated with hot water. **NEVER** use a flame or a glowing electric heater!

If the working parts are rusted, it will be necessary to remove the head (13) and the idler (11) as well as the rotor (10). After the head and the idler have been removed, remove the pump pulley and file off the pulley set screw burr on the shaft so that it will not damage the bearings or the packing when the shaft is removed. Loosen the tension on the packing by removing cap screws (14), the retainer plate (16), the oil well felt (18), and the bearing (15). Clean all parts thoroughly with fine sandpaper and rinse them in a cleaning solvent before reassembling the pump.

Ordinary cleaning will not correct the problem if the working parts are badly scarred by large abrasives, such as sand, or are badly pitted by rust. You will have to replace the complete pumping unit.

Replacing pump head

When replacing the internal gear pump head, first relieve all tension on the packing bearing. Next, position the pump pulley so that the shaft can be turned easily by hand. Then place a sufficient number of thin head gaskets (12) on the head. Finally, tighten the head securely and turn the pump pulley.

If the pump binds, remove the head and add one gasket at a time (retightening the head each time) until the pump is free. When the pump is free, remove the head again and coat the top gasket with shellac or other fuel-resisting compound. Replace the head on the pumping unit and tighten all cap screws.

Should the pump turn too freely, remove one gasket at a time (retightening the head each time) until it binds. Then remove the head, add one gasket, replace the head on the internal gear pump, and tighten all cap screws.

This procedure permits the end clearance to be adjusted very closely, and it is important because the gasket material is only $^{3}/_{1,000}$ of an inch thick.

Repacking pump shaft

The internal gear pump is packed with special “V” packing. Be sure that the proper size and kind of packing are used whenever you repack the stuffing box. The packing is shown as item 7 in figure 5–7. You can easily replace them by removing the pump pulley and removing cap screw (14). This allows the removal of the retainer plate (16), the bearing (15), and the oil well felt (18). The packing glands of this unit are spring-loaded (9) to keep the proper tension on the packing at all times. For this reason, when the bearing (15) is removed, the packing will be forced forward by the spring (9), provided the unit has been properly lubricated as recommended by the manufacturer. When old packing rings are removed, be sure to replace them with the same number of new ones. This is important in order to prevent leaks in the stuffing box.

Air eliminator

The purpose of the air eliminator is to remove the air and vapors from the fuel before they reach the measuring unit. This device consists of two chambers—the supply chamber and the float chamber. Refer back to figure 5–7 for numbered items and figure 5–8 for system operation as you read the following material.

Float chamber

The float chamber, with its float (60) and needle valve (59) assembly, regulates the liquid level. The needle valve (59) controls the passage of liquid to the suction side of the internal gear pump. When the float rises, it opens the needle valve and allows the pump to draw off liquid until the float is lowered enough to close the needle valve. All fuel entering the float chamber must pass through a small hole in the plug (23) opposite the needle valve, at the rate of 1 gpm.

Supply chamber

The supply chamber contains two valve assemblies—bypass (54) and regulating (55). It is easy to distinguish one from the other because the bypass valve poppet is all metal, while the regulating valve poppet has a cork disc. The bypass valve spring is heavier than that of the regulating valve. The purpose of the bypass valve is to relieve the pressure and allow fuel to circulate while the pump is running with the nozzle closed.

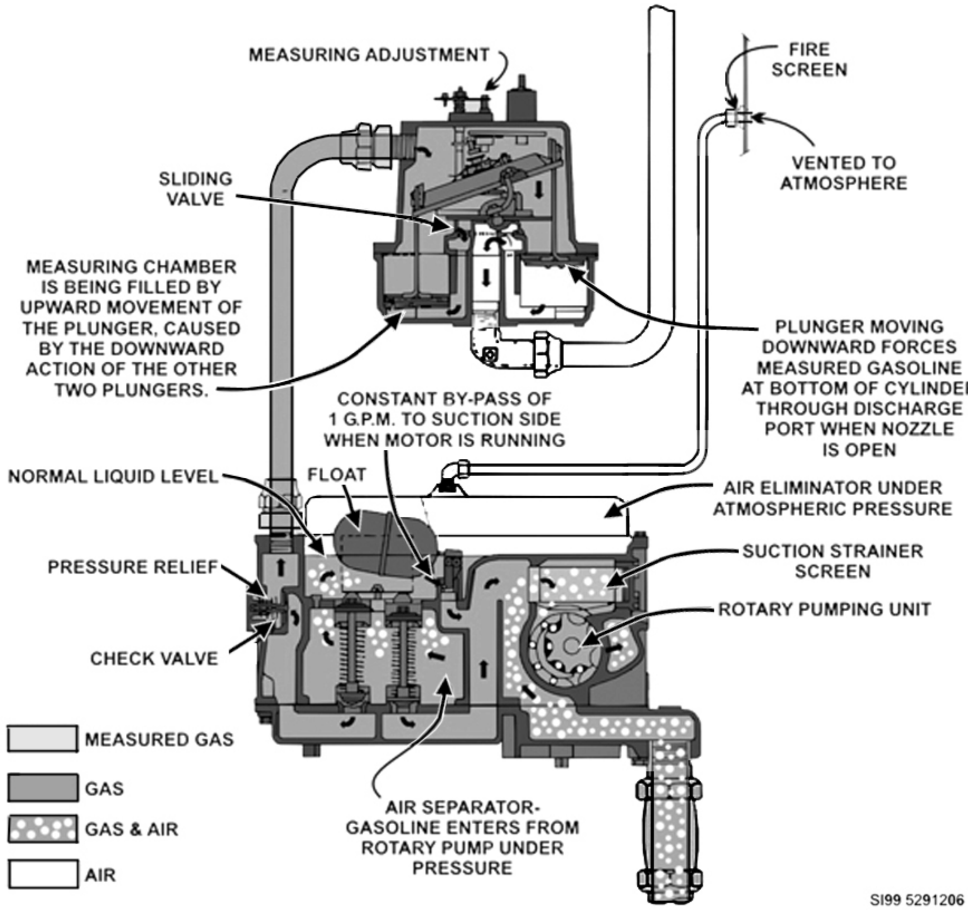


Figure 5–8. Self-contained pump dispenser fuel flow.
(Courtesy of the Gasboy® Corporation.)

The regulating valve has three functions: (1) it regulates the flow of gasoline from the pump to the meter, (2) stops the flow of gasoline to the meter in the event the pressure drops in the chamber, and (3) acts as a check valve to keep the entire system full of fuel to the hose nozzle.

When the pump is started, both the bypass and regulating valves are opened by the buildup of pressure in the supply chamber. This acts against the small piston and cylinder assemblies located at the tops of the valve assemblies. The cylinder caps have small holes in their tops that release any fuel that might leak past the cup disc of the valve pistons and allow the valves to open against atmospheric pressure. The cup disc prevents an excessive amount of fuel leakage from flowing into the float chamber. The spring tensions of the regulating and bypass valves are self-adjusting and compensate for all suction installations.

Surge check valve

Since the regulating and bypass valves are hydraulically controlled, they cushion the shock resulting from the functioning of the internal gear pump. Since the regulating valve is open through the entire operation of the pump, a pressure surge check valve (46) is used in connection with the regulating valve. This added valve prevents gasoline from surging through the open regulating valve when the nozzle is closed and the motor is running. This safeguard eliminates the possibility of the air separator overflowing and fuel passing into the pump. The surge valve closes the instant the fuel flow is shutoff.

Excessive pressure developed by the nozzle closing suddenly is allowed to escape through a relief valve built in the stem of the surge check valve. This valve equalizes the pressure in the system when the motor is turned off and the internal gear pump and air eliminator assembly is at atmospheric pressure (fig. 5–9).

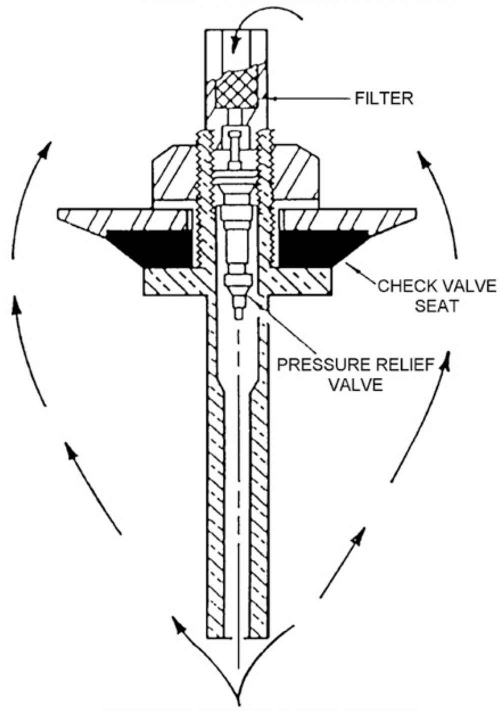


Figure 5–9. Pumping unit surge check valve.
(Courtesy of the Gasboy® Corporation.)

Possible troubles and remedies

The following paragraphs discuss the possible troubles of and remedies for the air separator and its parts if they fail to function properly.

Pump stalls completely

If the pump functions properly when dispensing fuel but stalls when the nozzle is closed, the probable cause is the bypass valve failing to open. The presence of foreign material in a pump may cause the bypass valve to become stuck in its seat or piston assembly. This condition tends to develop when a pump has been idle for some time, when water is present, or when ice has formed. To correct this condition, remove the valve, clean all parts, and replace the valve in the pump.

Fuel not flowing to measuring unit

If the regulating valve does not open, fuel will not flow to the measuring unit. This condition is caused by several factors, one of which is foreign matter lodging in the valve piston and cylinder assembly. If this should happen, clean and replace all parts. Insufficient pressure in the supply chamber also stops the flow of the fuel. This can be caused by a break in the suction line, an empty tank, a clogged strainer screen (19), ice formation, or a stuck foot valve. In addition, the needle valve in the float chamber can be held open by foreign matter, and anything that decreases efficiency of the pump, such as extreme wear of parts or excessive end play in the internal gear pump head, can also cause insufficient pressure.

Regulating valve fails to close

Sometimes the regulating valve will fail to close. This does not happen very often. If the regulating valve is held off its seat by small particles, the effect on the pump operation is not noticeable. However, when the pump is standing idle, even a slight leak will permit fuel to drop down in the system. For this reason the valve should always be tight. The solution to this condition is to remove the valve and clean the dirt from the poppet and seat and then replace it in the pump. If the cork disc of the regulating valve (55) is badly pitted or worn, replace it with a new one. (**NOTE:** When replacing the cork disc, do not tighten the retaining screw too much, as it is very easy to make the poppet out-of-round or distorted.)

Fuel discharge from vent pipe

Fuel will be discharged from the vent pipe at the top of the pump if the float and needle valve fails to open. To correct the trouble, remove the float and needle valve assembly and determine whether the trouble is caused by the float's being logged with fuel or by corrosion of the small shafts of the needle valve mechanism. Replace a damaged float with a new one. Corroded parts may be cleaned or replaced if in very bad condition.

Gasoline discharge from the vent line

Typically this occurs during extremely hot weather. This is not an air separator mechanical failure; it occurs because the suction line from the tank to the pump is too near the surface of the ground, causing the fuel to expand. The suction line should be at least 18 inches underground at the pump island. At this depth the line will not be affected by the sun's heat.

Stuck valve

With a stuck valve, the pump delivers the first gal. at full speed and then slows down for the rest of the delivery cycle. This occurs because the float needle valve fails to close, breaking the vacuum of the internal gear pump. This happens when the underground storage tank runs out of product, allowing air to enter through the vent tube and completely stopping operation of the pump. This is usually caused by foreign matter getting under the needle valve and holding it open. To correct this, remove the float and needle valve assemblies, clean the needle valve parts, and remove sediment and foreign matter from the float chamber. If any parts of the air separator are in very bad condition due to rust, corrosion, and so forth, it is best to replace them with new ones. All parts except the regulating and bypass valve seats can be replaced without removing the separator from the pump. These seats are pressed into the internal gear pump base (1). To remove these seats, first remove the entire pump unit from the chassis. Then remove the hex head cap screws that secure the lower pump base to the pump body. (**NOTE:** Under no circumstances should an air separator be plugged on a normal suction installation. This action will block off the air separator vent, causing the meter to be inaccurate.)

Pumps installed where the fuel level is higher than the dispenser (such as aboveground tanks) must have a model 52 pressure regulator valve, or its equivalent, installed directly under each suction-type pump. This valve is designed so that it will not open until at least 1 inch of vacuum is developed by the pumping unit, which unbalances the pressure in the valve. This valve is also designed with a safety shear section so that if, for any reason, there is a break between the suction inlet of the pump and the pressure regulator valve, or the pump is so worn it cannot develop the 1 inch of vacuum required to unbalance the pressure, the valve will remain closed until the break has been corrected.

237. Calibration devices—maintenance and adjustments

In practice, calibration also includes repair of the device if it is out of calibration. In this lesson, we will cover meter construction and operation, some troubles you may experience with meters, and how to adjust registers.

Meter construction and operation

There are various meter designs in the pump industry. A common model is a three-piston vertical positive displacement unit. Little change has taken place other than material and the methods of attaching the plunger assemblies to the eccentric plate of the meter.

The pressure developed by the pump forces the fuel into the top of the chamber. As the pistons move on the upstroke, fuel enters the cylinders. When the filling cycle is complete, the piston begins the downward stroke, dispensing a measured quantity of liquid to the discharge port located in the center of the body casting. As the first piston finishes a complete cycle, the discharge valve rotates in position for the second and third pistons.

As the pistons move up and down; they create the power to revolve the eccentric plate, which, in turn, rotates the discharge valve from one port to the other. As the eccentric plate revolves on the bracket, the slack roller-post on top of the plate drives the counter gear, which, in turn, actuates the register. For each gal. of fuel delivered, the drive shaft makes four revolutions. After the liquid is measured and the amount displayed on the register, the fuel passes through the discharge tube into the hose and nozzle to the customer’s tank.

Removing the meter

You can remove the complete meter (fig. 5–10) from the dispenser by breaking the seal wire and removing the coupling drive assembly, which is attached to the register unit. Disconnect the inlet and the outlet connections. Then remove the four hex head cap screws and nuts that secure the measuring unit to the support frames.

Repacking the drive shaft

Refer to figure 5–10 as you read. To replace the packing (75) around the drive shaft (39), remove the outer packing (73) and packing gland (51). Insert O-rings, seals, and seal retainers, as shown, into the gland recess. Force packing into place with the upper bearing and the packing gland plate. The packing spring (46) creates tension on the seal and prevents leaking.

Meter troubles

The troubles usually experienced with dispenser meters are caused by binding or failure to operate or measure correctly.

Binding

Binding is usually caused by parts that become rusted or corroded from excessive water that runs through the unit or from large amounts of foreign matter that collects in it. In cold weather, ice formations will stop the operation. Therefore, you must keep the measuring unit as free from water as possible.

Repair work is easier if you remove the meter from the dispenser. When you overhaul a meter (fig. 5–10), first remove the cap screws and lift off the measuring unit cover (38). This exposes the entire working mechanism of the measuring unit. Be careful not to damage the cork gasket (35), and do not shellac it when reassembling. Then loosen the screws (32) and disconnect the plunger assembly (34). Then remove three round-head machine screws (14) and lift off the wobble plate assembly (3). Mark the wobble plate assembly at some point because you must replace it in exactly the same position when you reassemble the measuring unit.

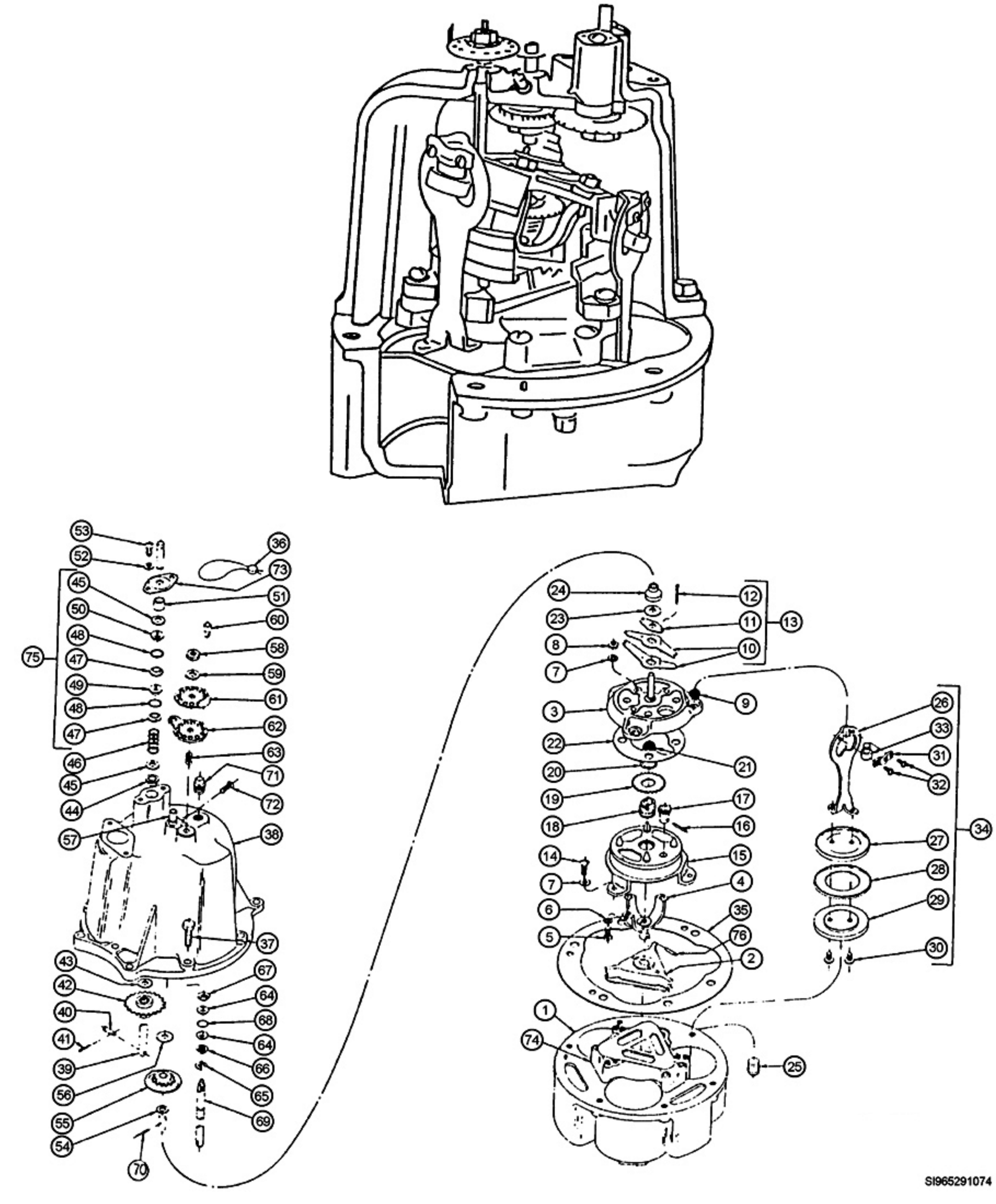


Figure 5–10. Measuring unit.
(Courtesy of the Gasboy® Corporation.)

You can now take the plungers out and do any work that needs to be done without further dismemberment of the measuring unit. You can install new plunger cups (28) if needed. Next, dismember the wobble plate assembly. You do this by removing the three fillister-head machine screws (5) that hold the bracket (4) to the wobble plate (3), permitting the whole assembly to come apart.

The main pivot bearing (21), as well as the compensating cam gear (19), can then be lifted off its location. The adjusting screw (18) and the compensating cam gear (19) are assembled together, requiring no timing—only engagement with compensating pinion (17)—and are mounted onto the main pivot bracket assembly (15).

NOTE: Do not attempt to remove the valve seat (74) from the meter body (1). These two parts are assembled together in the factory before the valve seat surface is ground, and removal may cause the seat to warp.

If you follow these instructions carefully, the meter will be completely disassembled, and any part of it can readily be adjusted. After all parts are cleaned (and any in bad condition replaced with new parts), reassemble the meter and replace the cover. To do so, first turn the meter body (1) and mechanism into position, as shown in the cross-section views on figure 5–10, with the compensating pinion shaft (69) to the right side. Press the wobble plate assembly (3) down on the right side as shown.

The correct position of the cover is determined by a dowel pin in the top flange of the cylinder body and a locating hole in the cover flange. Before attempting to place the cover on the unit, turn the compensating pinion shaft (69) to a position so that it will readily slide into the compensating pinion (17). Turn the gear (55) in the cover so that the driving lug is to the left. Place the cover squarely over the unit with the locating hole in the flange directly over the dowel pin in the cylinder body flange. *Never* use force to bring the flanges together; instead, turn the compensating disc (61) slightly one way or the other in order to bring the coupling into alignment, or remove the cover and readjust the parts as necessary.

Over-measuring

There are three conditions that can cause a positive displacement-type meter to over-measure: (1) Leakage of fuel past the sliding valve; (2) leakage past the plunger cups; and (3) excessive wear of parts. These troubles can usually be remedied easily and inexpensively. The following instructions will aid you in overcoming the trouble.

First, remove the meter and disassemble it as explained above. Then, to locate leaks, test the sliding valve and the plungers as follows:

- Push all the plungers to the bottom of the cylinders.
- Then carefully center the sliding valve so that it closes all the ports at the same time.
- Hold the valve in this position, bearing down on it firmly with one hand.
- With the other hand, pull up on the three plungers, one at a time.

NOTE: If a plunger pulls up easily, either the plunger cup is leaking badly, or the sliding valve is not seating properly. If, however, a plunger does not move when you try to pull it up, the plunger cup and sliding valve are reasonably tight and should not affect the measurement of the meter.

Replace badly worn plunger cups with new ones. When lapping the sliding valve, use only a very fine grinding compound. If the valve seat is so badly damaged so that lapping of low spots is impossible, it is best to install a new meter body.

To adjust the measurement

You can adjust the measurement by breaking the seal wire and removing the seal pin (60). This allows the index disc (61) to be turned either clockwise, which decreases the measurement, or counterclockwise, which increases the measurement. A variation of about 1 cubic inch in measurement is obtained by turning the index disc 5 holes. After measurement is properly adjusted, replace the seal pin and the seal wire.

When calibrating an automotive dispensing unit, you use a 5 gal. prover can. In the neck, at the top of the can, there is a sight glass that indicates exactly 5 gal. of fuel. Increments above and below the

5 gal. mark are in cubic inches. Before calibration, write down the totalizer reading. You must give the start and stop readings to the service station attendant or fuels control center (FCC).

Fill the prover can, ensuring that all air has been expelled. Save this fuel. It will be returned to the fuel tank. Fill the prover can again. This time, pay very close attention to the register and the prover can sight gauge. *Do not overfill.* When the register shows exactly 5 gal., stop. Read the level of fuel on the prover can sight gauge. If the fuel level is above the 5 gal. mark, the meter or register is under-reading and the index disc should be turned to the left to increase the measurement. To move the index disc, you simply move the seal pin from one hole to the next. Each time the seal pin is moved it will move the index disc.

After adjusting, make another test to check the adjustment. Be sure to annotate the totalizer reading. This is the stop reading. Report the start reading and the stop reading to the automotive service station attendant or FCC.

Adjusting the register

The register cannot be adjusted to correct measurement. Measurement can be corrected only by moving the disc on the meter. Adjustments to the register are for setting the price of the product. The sale is computed by the upper set of numeral wheels. The price per gal. is adjustable in tenths of a cent and can be set to compute from $^{1}/_{10}$ of a cent to \$3.99 and $^{9}/_{10}$ of a cent.

To alter the price, first slide the slip cover, which encloses the lower part of the register, thereby exposing the range setting plates and the wheel characters. The wheel character display has three characters—1, 2, or 3—representing the dollar setting. The price range plates are numbered 1, 2, and 3. Plate no. 1 is for $^{1}/_{10}$ of a cent; plate no. 2 is for one to nine cents; and plate no. 3 is for 10 to 90 cents.

For example, to set a price of \$1.28–$^{9}/_{10}$ or \$1.289, (1) set wheel character display to “1”, (2) set sliding gear lever to the hole marked “20” on plate 3, (3) set sliding gear lever to hole marked “8” on plate 2, and (4) set sliding gear lever to hole marked “$^{9}/_{10}$” on plate 1.

Before the register (fig. 5–11) is installed in a unit, you should carefully adjust and lubricate it so that it requires very little attention in actual operation. However, because it is mechanical, it does require cleaning and lubricating at intervals, depending upon the condition of the service, the lack of oil, or the presence of foreign material. Occasionally, you have to replace sheared pins. When you adjust or lubricate, it is easier if you remove the register from the dispenser, take off the covers and variator band, and expose the working parts.

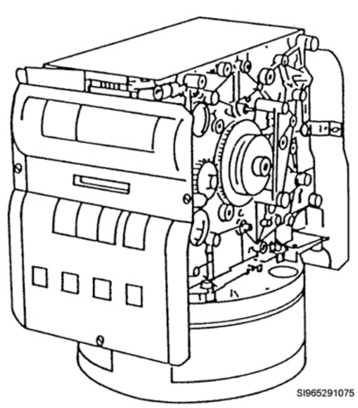


Figure 5–11. Register.
(Courtesy of the Gasboy® Corporation.)

Replacing sheared pins

If the register fails to reset to zero, or if the numeral wheels do not turn during delivery, the trouble can usually be traced to a sheared pin somewhere in the mechanism controlling these particular parts. When removing the broken pieces of the pin, be careful not to drop them into the mechanism. The trouble may continue if parts are caught between the gear teeth. Be sure to look for what caused the sheared pin, which is usually a bind from either lack of oil or the presence of foreign material between the gear teeth. A thorough cleaning and oiling may be necessary.

Cleaning and oiling

Individual cases vary, but under normal conditions you clean and oil the register only once or twice a year—or after each 100,000 gal. have been delivered. Remove the register from the dispenser, as previously explained. Clean with compressed air and wipe all accessible parts (such as figure wheel drums) with a clean cloth. Never use solvents, such as kerosene, because they can become trapped in many of the inaccessible bearings and dissolve the new lubricant when it is applied.

A light, nonacid-type oil of no. 10 Society of Automotive Engineers (SAE) viscosity is recommended. This gives maximum protection in varying temperatures. The oil must also be acid-free so that it will not cause corrosion of the cast metal parts. A long-handled, fine lettering brush is very convenient for applying all the manufacturer's recommended oils to the shafts and the bevel type gears. Do not forget to lubricate the gears in the variator (the lower part of the register) made accessible by removal of the band cover.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

234. Constructional features of automotive dispensing units

1. What is the normal capacity of the automotive dispensing system storage tank?

2. What are the vent requirements for an automotive dispensing system?

3. How far from the bottom of the automotive dispensing system tank should the fill line be?

4. What type of cap will be used on the gauging hatch of an automotive dispensing system?

5. List the dimensions of the service station tank cleanout line and briefly explain its use.

6. Briefly explain when ground product tanks are physically entered for inspection or cleaning.

7. What component on the suction line prevents reverse flow?

8. What type of pump is used when a foot valve is not required?

235. Different designs of automotive dispensing units

1. What source of information should you use to determine the maintenance requirements for an automotive dispensing pump?

2. Explain the difference between a single- and a dual-dispensing self-contained unit.

3. Which self-contained unit normally uses a higher horsepower motor?

4. What is the difference between a dual-dispensing, single-product unit and a dual-dispensing, dual-product unit?

5. What type of electrical components are used inside automotive dispensing units?

6. Where is the fuel in the float chamber dispensed to when the float chamber is full?

7. Explain the fuel flow through the simple single-dispensing unit shown in figure 5–3.

8. Which type of dispensing system has revolutionized service station planning and has demonstrated improved service?

9. The NFPA requires what type of valve to be used with the submersible pump unit?

10. What component in a submerged-pump service station system prevents pressure from entering dispensers that are not being used?

236. Performing maintenance on automotive dispensing units

1. What should you adjust on a dispenser motor if the motor is running very slowly?

2. How do you prime a pump that will not prime itself?

3. How can ordinary end play be taken up on an internal gear pump?

4. Explain a safe method to thaw ice in the pump head.

5. What must you do if, after you replace the pump head, the pump binds?

6. What thickness of gasket material should you use when replacing the pump head?

7. What type packing should you use when repacking the internal gear pump shaft?

8. Which of the two valve assemblies in the supply chamber has a cork disc?

9. What must you remove and inspect if the pump seems to stall when dispensing is stopped?

10. What is the cause of gasoline discharging from the vent line during extremely hot weather? How should it be corrected?

11. What dispensing pump components should you check if fuel is discharged from the vent pipe located at the top of the pump?

237. Calibration devices—maintenance and adjustments

1. What type of meter design does the self-contained pump-dispensing unit use?

2. How many revolutions of the dispenser meter drive shaft will equal one gal. of fuel delivery?

3. Explain how to remove the dispenser meter.

4. What must be done to repack the drive shaft on a dispenser meter?

5. What usually causes a meter to bind? What can you do to help eliminate the problem?

6. What must you do before removing the wobble plate assembly?

7. Why should you not remove the valve seat from the meter body?

8. What determines the correct position of the meter cover?

9. If the flanges of the meter do not come together, instead of forcing them, what component should you turn slightly one way or the other to align the coupling?

10. Explain how to test the dispenser meter's sliding vane and plungers.

11. What would be the probable cause if a plunger pulled up easily during the test mentioned in question 10?

12. If the valve seat in the meter body were damaged beyond the possibility of lapping the low spots, what would be the best course of action?

13. Which way do you turn the index disc to decrease the measurement?

14. In which direction would you turn the index disc if the meter you are calibrating reads 5 gal. but the prover can shows 5 cubic inches less than 5 gal?

15. What would be the trouble with the register if it fails to zero or the numeral wheels do not turn during fuel dispensing?

5–2. Troubleshooting, Hoses, and the Automated Fuels Service Station

Now that you have a pretty good grasp on the components of the service station, it is time to take what you have learned and apply the troubleshooting principles. Hoses and nozzles are the last two components to tie the system together. You will perform more repairing and replacing these items more than any other task at the service station.

238. How to inspect and troubleshoot automotive dispensing units

The automated fuels service station components are an integrated part of the dispensers, so understanding how they work will help you inspect and troubleshoot these devices.

Friction losses in self-contained pump installations

Remember that we depend on nature to assist us in lifting liquid from underground tanks. The conventional service station pump does not actually pump the fuel from the storage tank. Rather, it creates a vacuum in the line; atmospheric pressure then pushes the product to the pumping unit. To ensure that pumping equipment operates efficiently and has long life, proper balance must be maintained between the amount of vacuum created by the pump and the atmospheric pressure. Line friction in the suction pipe tends to overload the pump by requiring too great a differential between the pump vacuum and the atmospheric pressure. In effect, the longer the pipe and the more elbows, valves, and so forth, the more friction there is and the harder the pump must work.

For this reason, we have developed a simple chart (fig. 5–12) that shows friction losses for each item. With this information, you can easily figure the amount of resistance in a given installation and determine whether you are within safe ranges for efficient pump operation.

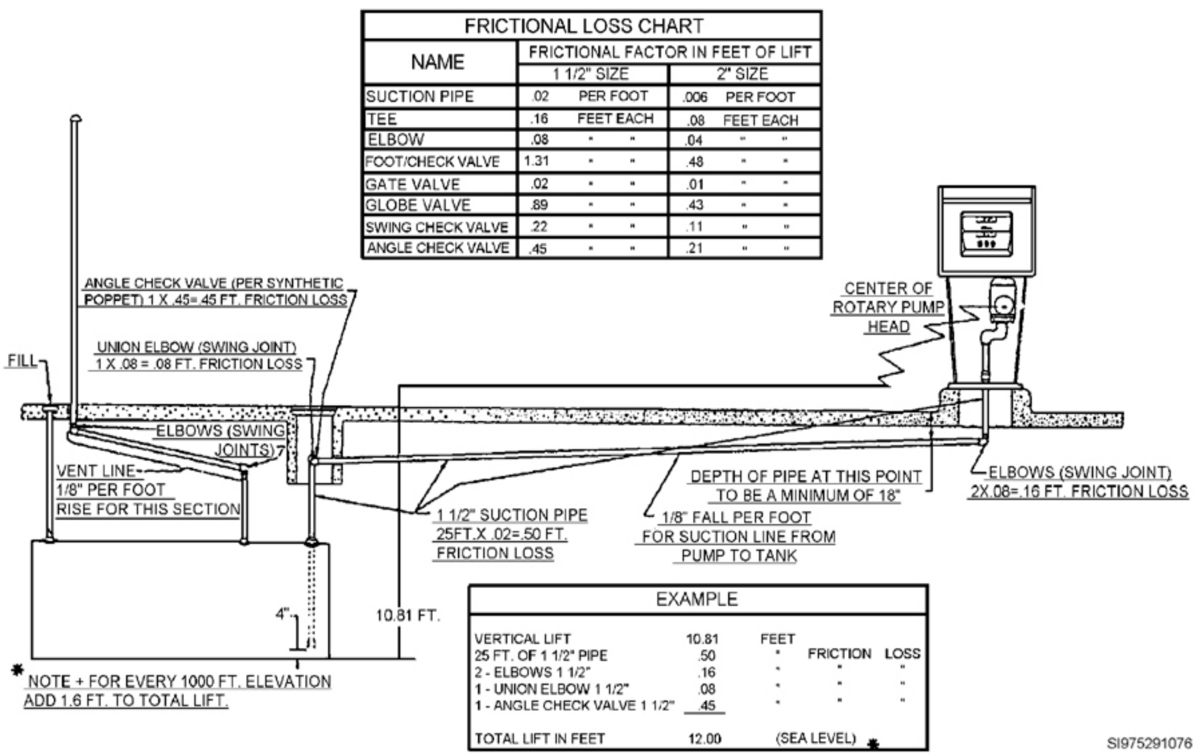


Figure 5–12. Pump installations and friction loss.

Vacuum and pressure gauges

In analyzing fuel pump difficulties, vacuum and pressure gauges are extremely helpful. Their use removes guesswork from determining the cause of improper functioning of equipment. Vacuum and pressure gauges are either separate or combination gauges. Combination gauges measure both vacuum and pressure; separate gauges measure only one quantity, either vacuum or pressure. The separate gauge is recommended because it permits the attachment of a vacuum gauge to the suction of the internal gear pumping unit and a pressure gauge to the discharge side of the pumping unit. In this way, both vacuum and pressure readings may be obtained at the same time.

Use of a vacuum gauge

For the best results and consistent vacuum readings, the suction strainer cap is drilled and tapped for a $^{1}/_{4}$-inch pipe thread size and an elbow added to hold the vacuum gauge (fig. 5–13). With the pump running and the internal gear pumping unit primed, the vacuum gauge should show from 4 to 6 inches of vacuum on a normal installation. Refer to the friction loss chart in figure 5–12 for correct vacuum reading in any particular installation. To determine the maximum vacuum efficiency of the pumping unit, make sure the unit is wet and the suction line completely blocked off. A good pump should create at least $22^{1}/_{2}$ inches of vacuum.

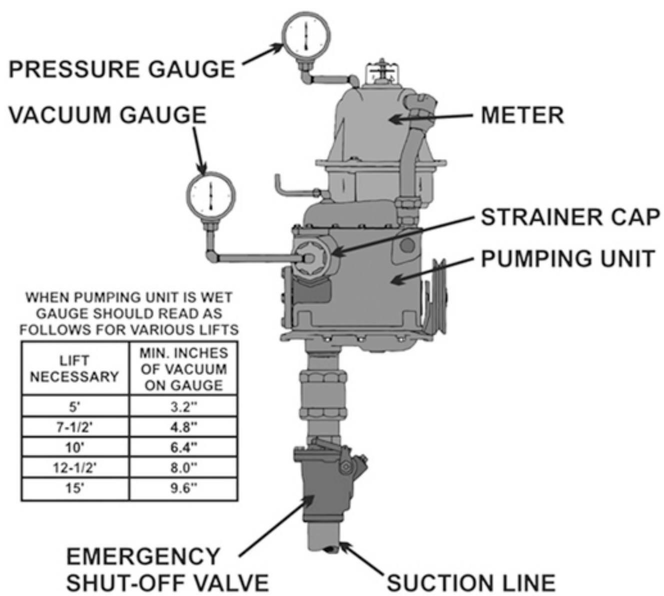


Figure 5–13. Vacuum and pressure test.
(Courtesy of the Gasboy® Corporation.)

A vacuum gauge reading in excess of that indicated on the chart means a possible problem. Vacuum readings above chart level suggest problems in several areas: (1) the suction lift—too high; (2) the suction line—diameter too small (at least $1^{1}/_{2}$ inches required) on the bottom of the tank or restricted with too many elbow fittings; (3) the suction screen—contaminated with foreign material; (4) the foot or angle check valve—poppet spring too heavy, valve poppet is partially or completely stuck shut, or valve strainer clogged at bottom of tank; or (5) insufficient storage tank venting.

Vacuum readings below the figures shown on the chart signify problems such as an empty storage tank, a broken suction line, a loose connection at the base of the internal gear pumping unit, excessive wear in the pumping unit, the suction strainer cap is not airtight, bypass valve is not seating properly or is stuck open, or the needle valve in the air separator is not closing.

Use of a pressure gauge

The pressure gauge is used to check for sufficient pump pressure. Install the gauge at the pipe plug on the top of the meter cover as shown in figure 5–13. With the pump running and the nozzle closed, the bypass pressure should read about 24 psi. (The bypass valve is self-adjusting for all vacuum lifts. This assures a proper delivery rate.)

The pressure gauge can also be used to determine whether the regulating valve is seating properly. Failure of the regulating valve to seat is indicated by fuel emptying from the system when the pump is standing idle or by the register's advancing when the pump is turned on and the nozzle is closed. To make this test, operate the pump with the nozzle open to ensure that the system is fully primed. As the nozzle closes, the pressure gauge should read about 24 psi. After the pump is turned off, the pressure should not drop immediately to zero but should level off to about 18 psi after about 1 hour. This indicates that the regulating valve is functioning properly.

However, if the pressure drops rapidly to zero, and there is no visible leak, you can assume that the fuel is leaking back through the regulating valve. If this is the case, remove and clean the regulating valve assembly, or replace it, if necessary. Other reasons for pressure drop in the internal gear pumping unit include the bypass valve stuck in the open position, worn plunger cups on the regulating and the bypass valve assembly, cracked valve cylinders, faulty gaskets under the valve cylinders, excessive wear in the internal gear pump unit, or too much clearance on the head of the pumping unit.

Excessive pressure showing on the pressure gauge indicates that the bypass valve is stuck closed.

Problems with submerged pumping units

The motors and controls used in a submerged pumping system are precision-designed instruments and should be handled with care. Manufacturer recommendations must be followed in every detail; otherwise, damage may occur to the units. Submersible pumps must not be put into operation without product in the storage tank. This is because the pump uses the fuel to cool the motor. If product is exhausted after initial startup, the submerged motor will heat up and the thermal overload protector in the motor will cut out, preventing damage to the motor windings. A cooling period of at least 60 minutes (1 hour) is required after the storage tank has been filled with product before the thermal overload protector will close and allow the motor to operate.

WARNING: All master switches should be turned off before breaking any electrical connections.

Slow delivery

Slow delivery by a pedestal may be due to improper wiring of the motor or low voltage. The pilot valve in the hydraulic valve does not open sufficiently to allow full flow of fuel through the unit. The installation of automatic nozzles may also result in slow delivery. They lower the delivery about 30 percent. A clogged pedestal strainer screen can also cause slow delivery.

Register creeping

In a remote control system, register creeping is caused by pressure loss above the hydraulic valve. To check the pressure, attach a pressure gauge at the pipe plug located on the side of the hydraulic valve casting just above operating piston. The minimum pressure should be 25 psi. The pressure loss may be caused by (1) pilot valve in the hydraulic valve being improperly adjusted or stuck partially open; (2) external leaks beyond the hydraulic valve assembly-unions at the discharge tube, connections, or hose; (3) foreign matter under the pressure-relief poppet in the hydraulic valve assembly; (4) a broken or leaky discharge line between the pump and the pedestal; or (5) the system not completely purged of air.

Pedestal discharging with the switch turned off

This condition can be caused by either the pilot valve in the hydraulic control valve being stuck wide open or improper adjustment of the control rod to the pilot valve.

Other troubles and their causes and remedies are listed in the table below:

Problem	Cause	Remedy
Pump fails to deliver fuel.	Check underground tank to make sure fuel is not below the end of the suction line.	Fill tank with fuel as necessary.
	V-belt may be slipping.	Tighten belt.
	Strainer may be dirty.	Remove and clean if necessary.
	Check valve in hose nozzle may be stuck closed.	Remove the spout and investigate.
	Voltage of power line to motor may below.	Test with multimeter.
	Bypass valve on pump may be held open by dirt on seat.	Remove and clean thoroughly. Before reassembling, the valve should be checked to be sure it moves freely in valve guide.
	Meter may be stuck.	Check by manually rotating meter at calibrating discs.
	Pump has lost prime.	Squirt oil into the strainer cavity while turning the pulley in a reverse direction. Check for leak in pipe upstream of pump.
Pump makes excessive noise.	Pump anchor bolts not tight.	Tighten as necessary.
	Low voltage to motor.	Check voltage.
	Strainer dirty.	Clean strainer.
	Bypass valve sticking.	Remove and check.
	Pump or motor pulley loose or out of alignment.	Tighten or align pulley.
	Suction piping or conduit vibrating.	Fill hole under the dispenser with sand and pack down.
	V-belt not adjusted properly.	Adjust.
Pump hesitates.	Suction stub may be too close to tank bottom.	Remove and correct pipe distance.
	Check valve in suction line too heavily spring-loaded.	Remove and replace.
	Leak in suction line.	Pressure test.
Pump delivers product without registration.	Meter may not be connected to register coupling.	Ensure meter is coupled to the register.
	Register not shifting to the mesh position.	Reset and examine for meshing.
	Control handle operating shaft not engaging register.	Operate handle and ensure register is engaged.
Motor will not run.	Fuse blown.	Replace fuse.
	Motor switch inoperative.	Replace switch.
	Motor linkage out of adjustment.	Adjust.

Problem	Cause	Remedy
	Motor burned out.	Replace motor.
Control handle locks up.	Reset trip arm not dropping over the reset lock.	File burrs from reset trip arm so that it locks.
Meter registering before nozzle is opened.	Loose pipe connection, gasket, joint, plug, or cover bolts.	Tighten.
	Check valve not holding.	Remove and replace as necessary.

Pressure test the submerged pump system

You can use either a manual test or an automatic test on the submerged pump system.

Manual test

To test for pressure leaks in the discharge line, attach a pressure gauge (test gauge 2 on the unit) to the pipe plug outlet on the pressure-relief side of the hydraulic valve (fig. 5–14).

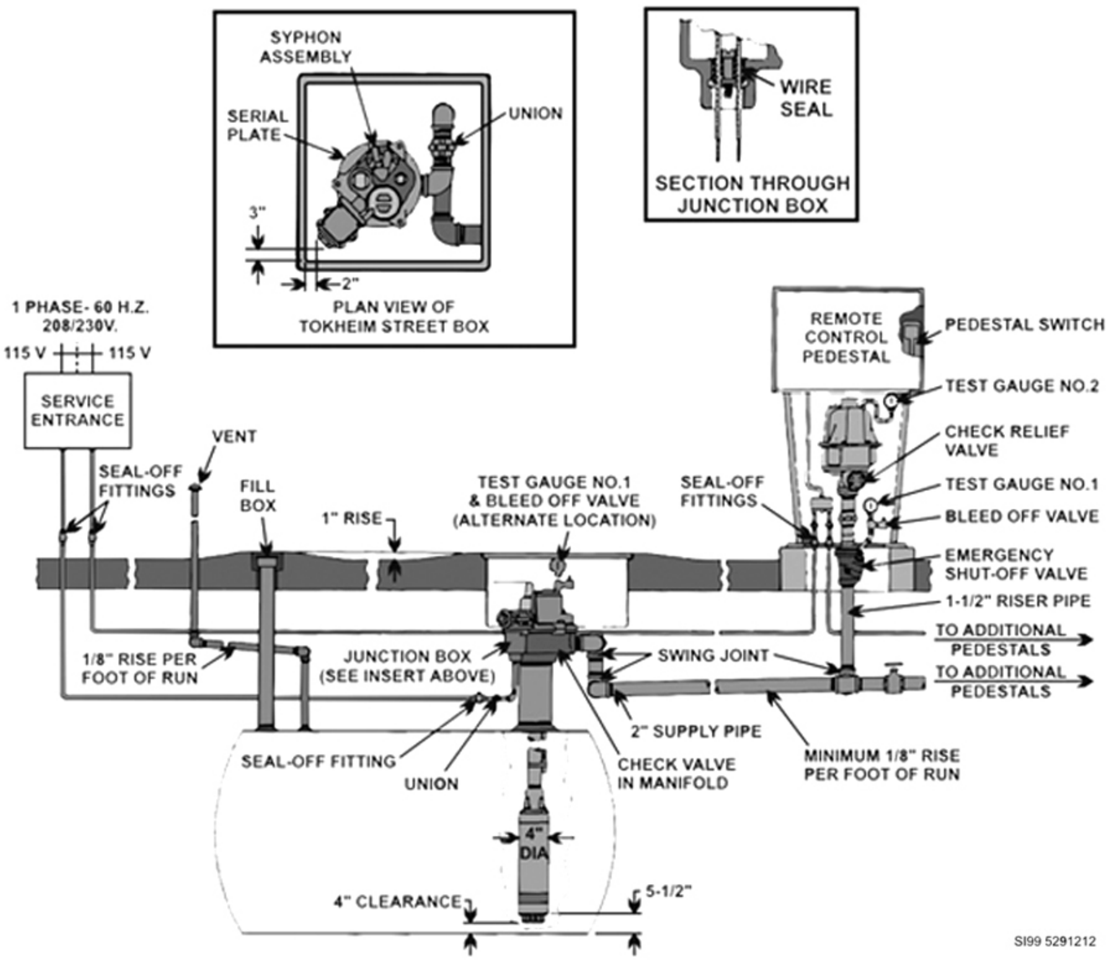


Figure 5–14. Submerged pump pressure test.

Operate the dispenser for about 30 seconds to fully prime the system. The minimum line pressure should be 25 psi. If the pressure drops immediately to zero, there is a leak in the check valves on top of the submerged pump header, a loose fitting, or a broken line underground. Before continuing with testing, block off the expansion valve by tightening the screw located in the siphon assembly. Two pressure tests are recommended.

The first test includes all piping from the submerged pump to the island pedestals. For this test, manually close the emergency shutoff valves at each dispenser and install a 100 psi test gauge (test gauge 1 on the unit) in the tapped opening provided in the valve. In this same opening, provide a fitting for introduction of pressurized fuel (hydrostatic test). Pressurize the line to 75 psi. If the pressure holds at 75 psi for 30 minutes, the piping system is leak-free. A drop in pressure indicates a leak that must be located and corrected. If the system is leak free, release the pressure and back out the screw in the siphon assembly so the expansion valve functions.

The second pressure test includes the piping and the pedestal(s). For this test, the emergency shutoff valve must be open. Block off the expansion valve just as in the previous piping test. Install a 100 psi test gauge (test gauge 2 on unit) in top of the meter and another in the emergency shutoff valve. If the opening in the valve is not readily accessible, the gauge may be installed in a 1-inch tapped opening on top of the submersible pump manifold (test gauge 1 on pump). Depending on the code requirements, the test may be run at the maximum pressure that the submersible pump will develop (25 to 30 psi) or at a higher pressure (not to exceed 50 psi). In the first test, test pressure is developed by auxiliary equipment. In the second test, pressure is developed by the submersible pump. For pressurizing the system with the submersible pump, turn the pump on and take enough product from each pedestal hose to purge the system of air. Note pressure at each of the two gauges. Turn the pump off. If one or both of the valves is faulty or there is a leak in the system, pressure at one or both of the gauges will drop (see the table below).

Pressure in test gauge No. 1	Pressure in test gauge No. 2	Conclusions
No drop	No drop	Entire system from submersible pump manifold to end of nozzle is leak free.
Drops	No drop	System has leaks between submersible pump manifold and pedestal check/relief valve and/or check valve in submersible pump manifold leaks.
Drops	Drops	System has leak between submersible pump manifold and pedestal check/relief valve and/or check valve in submersible pump manifold leaks. Pedestal check/relief valve also leaks and/or pedestal has leak between check/relief valve and end of nozzle.

Automatic test

On some submersible pumps, you will find a mechanical leak detection system (fig. 5–15). It is a pressure-sensing, diaphragm-operated valve designed to indicate a leak between the leak detector and dispenser.

When the submerged pump is energized, a controlled amount of product (three gal. per hour) is metered through the leak detector into the piping system. If a leak is present that equals or exceeds this amount, as much product escapes from the system as is metered in through the leak detector. Under this condition, pressure cannot build up in the piping system. When a nozzle is opened, a poppet in the leak detector moves to a position that restricts the flow to about 1½ to 3 gpm. This is the indication to the operator that the leak is present.

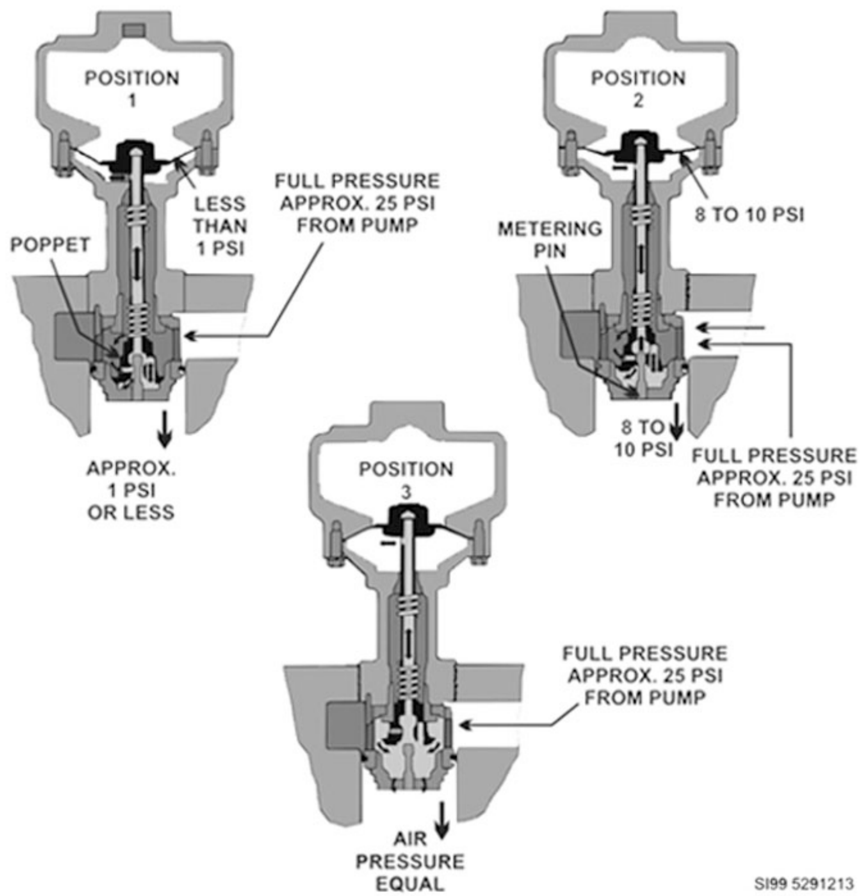


Figure 5–15. Red Jacket XLD diaphragm leak detection.
(Courtesy of the Danaher Corporation.)

If there are no leaks, pressure rapidly builds in the system, forcing the leak detector to open to the full-flow position. In a system with no leaks, it takes about two seconds for the complete test. No further testing takes place until the line pressure drops below 1 psi.

In order to test a mechanical leak detector, you need to induce a leak of 12 cubic inches per minute, or about 3 ½ milliliters per second. To do this, attach tubing to the system with both a ball and needle valve. The ball valve lets you open and close the leak while needle valve controls the leak rate. Adjust the needle valve so that you collect about 35 milliliters of fuel in 10 seconds. This is the equivalent to the mechanical leak detector's three gal. per hour leak sensitivity. Then stop and restart the dispenser with the ball valve open to run your test. If the mechanical leak detector is operating correctly, it will sense the leak, trip, and you will be unable to get more than 3 gpm of fuel out of the dispenser nozzle.

Replacing dispensers

While this may seem a daunting task, there are only 4 types of connections to a service station fuel dispenser—register sensor (pulse counter), electrical, hydraulic (the fuel line), and physical.

Safety first! Close the fire safety valve at the bottom of the dispenser and kill the power to the dispenser. Lock out and tag the switches used to disconnect the power. Then, remove the pulse counter (the device that tells the automated fuels service station system how much fuel was dispensed) from the register. Next, label all the wire connections with their function, not just with numbers from a wire marking kit. Remember, the new dispenser's wires will not be numbered! Then disconnect the wires leading into the junction box, and open the union between the junction box and the explosion-proof seal on the conduit.

Close the fire safety valve located at the bottom of the dispenser. The fuel line coming into the dispenser will have a union directly above the fire safety valve. Use care when uncoupling this union as any torque on the top of the fire safety valve will cause it to shear. Fuel will start to drain from the dispenser, so be ready to catch this to prevent a fuel spill. Finally, remove the nuts where the dispenser is bolted to the concrete. Get several people or a small crane to lift the dispenser. Dispensers are heavy!

To install the new dispenser, reverse the order of the removal sequence. With a new dispenser, the old fuel line, electrical conduit, and even bolt holes may not line up with the old ones. In this case, you will have to re-plumb the fuel line or conduit to meet, or drill, the concrete and install new studs in the proper position. Once everything is lined up and the dispenser is bolted on, reconnect the fuel union, reconnect the conduit union, connect the wiring, and install the pulse counter. Open the fire safety valve and unlock the electrical switches. As the last step of any repair, operationally inspect the dispenser. Check for fuel leaks, proper operation, and meter calibration and pulse counter function.

239. Hose nozzles—maintenance and care

In this lesson, we discuss operation and maintenance for the hose nozzles.

Operation

The fuel going through the dispensing units is dispensed to a vehicle through the hose nozzle. This nozzle is actually an automatic-shutoff valve that cuts off the flow of fuel when the vehicle tank is full. A cutaway illustration of a nozzle is shown in figure 5–16.

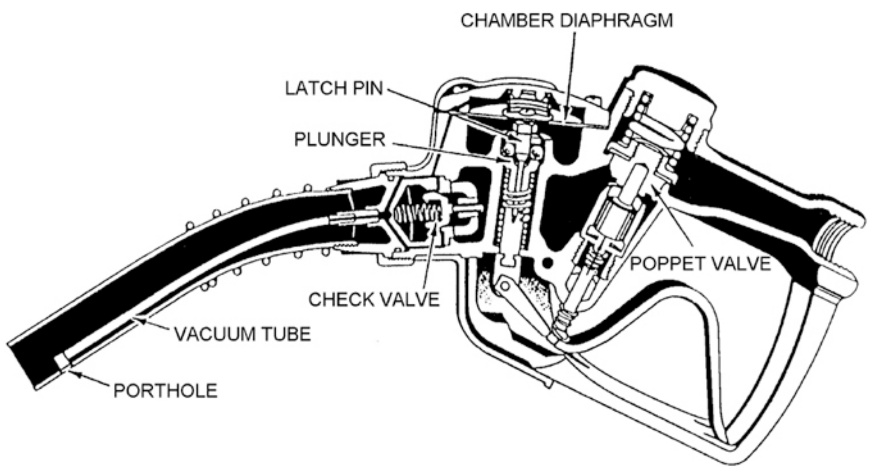


Figure 5–16. Automatic fuel nozzle.

The automatic shutoff uses Bernoulli’s principle to operate on a vacuum. You recall that as the velocity of a liquid increases, pressure decreases. This decrease in pressure (actually a vacuum) is created just before the fuel enters the spout at a check valve (actually a type of pressure-relief valve). This pressure relief creates the vacuum. Looking at figure 5–16, notice the ports located at the check valve. As fuel passes around the check or pressure relief, the velocity of the fuel increases, creating a vacuum in those ports. The ports are connected not only to the vacuum tube, but also to the chamber diaphragm. The vacuum tube offers lower resistance, so air is constantly being drawn through it. When the vehicle tank is full, liquid or fuel will be drawn into the vacuum tube. Now the vacuum tube offers resistance, and the chamber diaphragm senses the vacuum and rises. This diaphragm action also raises a latch pin which, in turn, releases the spring-loaded plunger.

The plunger changes the fulcrum position for the handle. During a normal filling operation, the handle operates as a second-class lever. Pulling on the handle with your fingers is the effort, resistance is offered by the poppet valve spring, and the plunger acts as the fulcrum. Once the vacuum lifts the latch pin, the fulcrum changes and the handle becomes a third-class lever. Your fingers now act as the fulcrum, the poppet valve spring becomes the effort, and the plunger spring provides the resistance. When the vacuum is no longer sensed in the chamber, the plunger spring pulls the plunger up. Releasing the handle resets the latch pin. Now the handle acts as a first-class lever. The poppet valve stem is the fulcrum, your fingers are the resistance, and the plunger spring is the effort.

Maintenance

Hose nozzles are almost maintenance-free. Problems are usually limited to leaks or automatic shutoff failure. Rebuilding kits can be bought, but often it is cheaper to replace a worn nozzle with a new one.

Replacing a nozzle

When removing any component, *first* turn off all the power to the dispensing unit. If the system has an aboveground tank, you must close and lock the tank valves. Also, close the emergency shutoff valve located just below the pedestal. Take the nozzle from its holder and place it over a bucket or drip pan. To keep fuel from spraying, wrap a rag around where the hose and nozzle are threaded together. Then, using two wrenches, loosen the nozzle from the hose. Once the nozzle is loose, you can unthread it with your hands. Apply Teflon tape to the threaded hose end, and screw the new nozzle on. When you are sure the nozzle is tight, turn the power on and open any valves you closed. Dispense some fuel into the prover can to ensure that all air is bled out and that any dirt in the new nozzle is flushed away.

Leaking

The nozzle can leak where it connects to the hose, the poppet valve cover, the poppet valve stem, the chamber diaphragm, and the spout. Always try tightening first, but do not over-tighten. If tightening does not fix the problem, check the manufacturer’s manual. Leaks at the hose connection can usually be taken care of with Teflon tape. Be careful when you remove the poppet valve cover because there is a very stiff spring under it. Some covers are sealed by a gasket and others by O-rings, which may have to be replaced.

The poppet valve is usually sealed by an O-ring; however, some are sealed with packing material. Any leak at the poppet valve stem requires you to remove the cover.

You rarely encounter a leak at the chamber diaphragm. If you do, first tighten the four screws that hold it in place. If this does not stop the leak, replace the diaphragm. Be sure to use the manufacturer’s recommended diaphragm material. A temporary diaphragm can sometimes be fashioned out of a fuel/acid resistant glove. Using the old diaphragm as a pattern, draw a new gasket on the gauntlet of the glove, and cut it out.

The spout is connected to the nozzle in different ways. Some use a union-type joint; others are threaded in. Many nozzles use an O-ring seal to prevent leaking. Remember that no matter how the spout is connected, the vacuum tube is inside; if it breaks or becomes disconnected, the automatic shutoff feature will actuate at all times. Check the manufacturer’s maintenance instructions.

Automatic shutoff

The automatic shutoff is an important safety feature that is required on all vehicle dispensing units. You know how important the automatic shutoff is. Have you ever splashed fuel all over you because it did not work properly? Make sure the automatic shutoff will work. You do this by sticking the end of the spout in the fuel you dispensed into the bucket. As soon as the porthole is covered, the nozzle should close. There are really only two things that can go wrong with the automatic shutoff. One is the nozzle will not shut off; the other is just the opposite, the nozzle always shuts off.

Nozzle won’t shut off

This condition can usually be traced to one of two problems. First, the spout could be loose and the pressure relief is not producing enough vacuum; second, the diaphragm could be ruptured. Tightening the spout is the most logical and easiest thing to check. The spout can take quite a bit of abuse, and the diaphragm is protected.

Shuts off all the time

Here several problems can be involved. The first, and probably easiest to check, is the vacuum tube. If it is blocked or broken, vacuum is continually sensed in the chamber diaphragm that constantly lifts the latch pin to make the nozzle shut off. The second place to look is through the chamber diaphragm to the latch pin and plunger. Here, several things could be wrong. The latch pin could be stuck in the shutoff position (up), or the plunger could be stuck in the shutoff position (down). The plunger spring could be broken or stretched. All of these problems require a rebuilding kit for repair. Follow the manufacturer's instructions for the repair.

Aircraft are not the only machines the AF uses to complete our mission. Keeping the automotive dispensing system in good working order will ensure that we can not only refuel all of our ground vehicles and equipment, but account for the fuel used, as well as prevent environmental damage and fuel loss due to leakage.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

238. How to inspect and troubleshoot automotive dispensing units

1. What two things must have the proper balance so that self-contained pump units will operate efficiently and have a long life?

2. What should the vacuum gauge read on a normal installation?

3. Where should the vacuum and pressure gauges be installed so that both readings can be obtained at the same time?

4. Would the vacuum gauge read high or low if the needle valve in the air separator was not closing?

5. What should the pressure gauge read while the pump is running against a closed nozzle?

6. What pressure gauge reading would indicate that the regulating valve was not seating properly?

7. Would the pressure gauge read high or low if the bypass valve was stuck closed?

8. What three things could cause slow delivery from a pedestal?

9. What causes register creeping? How can you check the cause?

10. What type of problems would cause the pedestal to discharge even though the switch for that pedestal was turned off?

11. Explain how to test a submerged pump system discharge line for leaks using pressure from the submerged pump.

12. When using pneumatic or hydrostatic pressure to test piping from the submerged pump to the island pedestals, how much pressure should you use and how long should you maintain the pressure to indicate a leak-proof system?

13. What is the maximum pressure used to leak test the piping and pedestal(s)?

14. Explain how the Red Jacket XLD (fig. 5–15) leak detection system works.

239. Hose nozzles—maintenance and care

1. What nozzle component creates the vacuum that operates the automatic shutoff?

2. What occurs when the vacuum tube becomes blocked?

3. What must you do before removing a nozzle?

4. Before removing a nozzle from a dispenser with an aboveground tank, what valves should you close?

5. Why should you dispense some fuel through a new nozzle?

6. Where will leaks normally occur on the nozzle? What is your first course of maintenance before rebuilding or replacing it?

7. Why must you be careful when replacing the O-ring on the nozzle poppet valve cover?

8. What can you use to temporarily replace the automatic-shutoff diaphragm?

9. What are some of the reasons an automatic-shutoff nozzle would *not* shut off?

10. What would you check if the automatic-shutoff nozzle continuously shuts off?

Answers to Self-Test Questions

234

1. 10,000 gal.
2. Vent pipe normally extends above the ground level to a height of at least 12 feet.
3. 3 inches.
4. A weather-tight locking gauging cap.
5. $^{3}/_{4}$-inch in diameter and should extend 12 inches above the grade. A tank cleanout line is used to remove water and sediment from the bottom of the tank.
6. Only at the request of the fuels management officer.
7. The foot valve.
8. A submersible or submerged pump.

235

1. The manufacturer's maintenance manuals.
2. The single unit has one meter and one register with a register. The dual unit has two meters and two registers.
3. The dual-dispensing unit.
4. The dual-dispensing, dual-product unit has two pumps.
5. Explosion-proof.
6. To the suction side of the pump.
7. When the motor is energized, fuel moves to the meter. Any air in the fuel is directed to the float chamber through the meter discharge tube where it is dispensed. After the fuel leaves the meter, it goes through the sight glass, then to the hose and nozzle.
8. The submerged pump.
9. An emergency shutoff valve.
10. The hydraulic control valve.

236

1. The changeover plate.
2. Remove the strainer cap, and while turning the pump pulley in reverse, squirt a small amount of heavy lubricating oil into the strainer cavity.
3. By removing the internal gear pump head and using a thinner gasket.
4. Use rags that have been saturated with hot water.
5. Remove the head and add one gasket at a time until the pump is free.
6. $^{3}/_{1,000}$ inch thick.
7. "V" packing.
8. The regulating valve poppet.
9. The bypass valve.
10. The suction line from the tank to the pump is too near the surface of the ground. The suction line must be at least 18 inches underground at the pump island.
11. The float and needle valve assembly.

237

1. It has its own three-piston vertical positive displacement unit.
2. Four.
3. Break the seal wire and remove the coupling drive assembly, disconnect inlet and outlet connections; remove the four hex head cap screws and nuts.
4. Remove outer packing and the packing gland. Insert O-rings, seals, and seal retainers into gland recess. Now force packing into place with upper bearing and packing gland plate.
5. Binding is usually caused by parts becoming rusted or corroded by water or by the presence of foreign matter. Keep the measuring unit free from water as much as possible at all times.
6. Mark the wobble plate assembly.
7. It may cause the seat to warp.
8. A dowel pin in the top flange of the cylinder body and a locating hole in the cover flange.
9. The compensating disc.
10. Push all plungers to the bottom; center the sliding valve so that it closes all ports at the same time. Holding the valve in this position, pull up on all three plungers, one at a time.
11. A plunger cup is leaking badly or the sliding valve is not seated properly.
12. Install a new meter body.
13. To the right.
14. To the right.
15. A sheared pin.

238

1. The amount of vacuum created by the pump and the atmospheric pressure.
2. 4 to 6 inches of vacuum.
3. The vacuum gauge is installed in the suction of the internal gear pumping unit, and the pressure gauge to the discharge side of the pumping unit.
4. Low.
5. 24 psi.
6. Zero.
7. High.
8. (1) Improper wiring or low voltage. (2) Installation of automatic nozzles. (3) Clogged pedestal strainer screen.
9. It is caused by pressure loss above the hydraulic valve. Check pressure loss by installing a pressure gauge at the pipe plug on the side of the control valve. Minimum pressure should be 25 psi.

10. The pilot valve in the hydraulic control valve stuck open or improper adjustment of the control rod to the pilot valve.
11. Attach a pressure gauge to the pipe plug outlet on the pressure-relief side of the hydraulic valve. Operate the dispenser for about 30 seconds until fully primed. Line pressure should be 25 psi.
12. Pressurize to 75 psi for 30 minutes.
13. 50 psi.
14. When the submerged pump is energized, a controlled amount of product (3 gal. per hour) is metered through the leak detector into the piping system. If a leak is present that equals or exceeds this amount, as much product escapes from the system as is metered in through the leak detector. Under this condition, pressure cannot build up in the piping system. When a nozzle is opened, a poppet in the leak detector moves to a position that restricts the flow to about $1^1/_2$ to 3 gpm. This is the indication to the operator that the leak is present.

239

1. Check valve or pressure-relief valve.
2. Vacuum is sensed in the chamber diaphragm, which will raise the latch pin.
3. Turn off all power to the dispensing unit.
4. The tank valves and the emergency shutoff valve.
5. So all air is bled out and dirt can be flushed away. Also you must check the automatic shutoff.
6. Where it is connected to the hose, the poppet valve cover, the poppet valve stem, the chamber diaphragm, and the spout. Always try tightening first.
7. Because of the stiff spring under the poppet valve cover.
8. A piece of a fuel/acid resistant glove.
9. A loose spout or the diaphragm ruptured.
10. A blocked or broken vacuum tube, latch pin or plunger stuck in the shutoff position, or the plunger spring could be broken or stretched.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

83. (234) For safe dispersal of fuel vapors, a storage tank vent pipe *must* extend how high?
    a. 10 feet.
    b. 11 feet.
    c. 12 feet.
    d. 13 feet.

84. (234) What type of gauging device is normally used to gauge small service station tanks, and what is the increments of measurement used on this gauging device?
    a. Stick gauge; $^1/_{16}$ of an inch.
    b. Tape and bob; $^1/_{16}$ of an inch.
    c. Stick gauge; $^1/_8$ of an inch.
    d. Tape and bob; $^1/_8$ of an inch.

85. (235) What is the difference between the motors used in the self-contained single- dispensing and the dual-dispensing units?
    a. Single-dispensing motors have a higher gallons per minute (gpm) rate.
    b. Single-dispensing motors have a higher horsepower rating.
    c. Dual-dispensing motors have a higher gpm rate.
    d. Dual-dispensing motors have a higher horsepower rating.

86. (235) What valve regulates the flow through the service station dispensers?
    a. Bypass.
    b. Pressure-relief.
    c. Hydraulic control.
    d. Emergency shutoff.

87. (236) What *must* you do if you receive a new fuel dispenser with a motor set for 110 volts but the service station island is serviced for 220 volts?
    a. Order a new motor.
    b. Have the island rewired.
    c. Install a step-down transformer.
    d. Reset the motor changeover plate.

88. (236) To prime a self-contained dispenser pump, you squirt
    a. some of the pump’s product in the internal gear pump cavity.
    b. some of the pump’s product in the strainer cavity.
    c. lightweight oil in the internal gear pump cavity.
    d. heavy lubricating oil in the strainer cavity.

89. (236) End play in a self-contained dispenser pump can be taken up by removing the internal gear pump head and
    a. adding larger O-rings.
    b. adding more gasket material.
    c. using a thinner gasket.
    d. replacing large O-rings with smaller ones.

90. (236) When you have replaced the pump head of a dispenser pump but the pump still binds, you
    a. check shaft for burrs and remove if necessary.
    b. remove the head and reduce the amount of gaskets until the pump is free.
    c. remove head and check the rotor and idler gear alignment, correct if necessary.
    d. increase the number of gaskets used under the head, one at a time, until the pump is free.

91. (236) Which valve in a self-contained pumping unit equalizes the pressure in the system when the motor is turned off and the internal gear pump and air eliminator is at atmospheric pressure?
    a. Bypass.
    b. Regulating.
    c. Surge check.
    d. Float chamber needle.

92. (237) The drive shaft on a three-piston vertical positive displacement meter will make how many revolutions for each gallon (gal.) of fuel delivered?
    a. 2.
    b. 4.
    c. 6.
    d. 8.

93. (237) When servicing a dispenser meter, you have to remove the wobble plate. Before removing the wobble plate from the measuring unit, you must mark it at some point because
    a. the manufacturer's instructions require this step.
    b. it serves as a mark for proper placement of the cork gasket.
    c. it serves as a reference point for reinstalling the plunger assembly.
    d. it must be replaced in exactly the same position when reassembling the unit.

94. (238) What should the vacuum reading be on a normal self-contained dispenser pump installation?
    a. 6 to 8 inches.
    b. 4 to 6 inches.
    c. 2 to 4 inches.
    d. 1 to 2 inches.

95. (238) Which problem would cause a rotary pump to have an excessive vacuum reading?
    a. Broken suction line.
    b. Bypass valve stuck open.
    c. Foot valve poppet spring too heavy.
    d. Needle valve not closing in air separator.

96. (238) To check for sufficient pump pressure on a self-contained dispensing unit, where should you install the pressure gauge?
    a. In the bypass valve.
    b. In the float chamber.
    c. On top of the meter cover.
    d. On the pump discharge line.

97. (238) The self-contained dispenser pump regulating valve is functioning properly when a pressure gauge is reading
    a. 18 pounds per square inch (psi) one hour after the pump is turned off.
    b. 18 psi while the pump is running with an open nozzle.
    c. 24 psi one hour after the pump is turned off.
    d. 24 psi while the pump is running with an open nozzle.

98. (238) You suspect register creeping in the remote control system. To confirm your suspicion you take a pressure reading at the hydraulic valve just above the operating piston. What is the *minimum* acceptable pressure reading that would rule out register creeping?
    a. 10 pounds per square inch (psi).
    b. 15 psi.
    c. 20 psi.
    d. 25 psi.

99. (238) Why is the mechanical line leak detector test leak rate set to 3½ milliliters per second?
    a. This is the normal flow rate through a dispenser.
    b. This is the mechanical leak detector’s sensitivity.
    c. This is the minimum safe output of a submersible pump.
    d. A faster rate would allow air to enter the line when the dispenser nozzle is opened.

100. (239) Why should you be careful when removing the automatic shutoff nozzle poppet valve cover?
    a. You can warp the seat.
    b. The stem will bend easily.
    c. Damage can easily occur to the disc.
    d. There is a very stiff spring under the cover.

Student Notes

Glossary of Terms, Abbreviations, and Acronyms

Terms

atmosphere—The mass of air surrounding the earth. The pressure of the air at sea level is used as a unit of measure.

automatic valve—A fuel system component, which operates hydraulically using system or pneumatic pressure.

barrel—A unit measurement of liquid. Petroleum industry uses 42 gal. barrel as the standard barrel.

blind (blank) flange—A piping flange with no passage through the center used to block off an opened flanged pipe. See spectacle flange.

bonding—A term used to describe equalizing the static electrical potential between two different components or pieces of equipment. This is done by connecting both pieces of equipment by a bonding wire.

bottom loading—Method of filling tank trucks or tank cars through a tight connection at the bottom.

bulk storage tank—Storage tank for fuel normally received by pipeline, tank truck, or tank car.

calibration—The act of adjusting a piece of equipment. Calibrate a meter register with a given quantity passing through the meter. Calibrate a pressure gauge with a known specific pressure.

cap—A pipe fitting with female threads used to cap off open pipes.

cathodic protection—A method for preventing corrosion of metals by electrolysis.

centrifugal force—A force that tends to impel a thing or parts of a thing outward from the center of rotation.

centrifugal pump—A rotating device that moves liquids and develops liquid pressure by imparting centrifugal force.

coalescer—A filter designed to cause very small drops of water to form larger drops (coalesce), which will separate from fuel by gravity.

contamination—The addition to a petroleum product of some material not normally present, such as dirt, rust, water, or another petroleum product.

corrosion—The process of metal dissolving due to exposure to electrolytes.

deadhead—The act of pumping against a closed pipeline.

deenergized—A component that has no electrical power applied to it.

deterioration—Any undesirable chemical or physical change that takes place in a item.

differential pressure—The difference between high and low pressure. Pressure created by a venturi or orifice plate. Filter/separators use differential pressure gauges to sense the condition of the filter elements.

downstream—The direction of flow in a pipeline in reference to an object. Downstream is in the direction the fuel is moving. Downstream of the pump would be anywhere after the pump discharge.

energized—A component that has electrical power applied to it.

epoxy coating—A coating of thermosetting resins having strong adhesion to the parent structure, toughness, and high corrosion and chemical resistance.

explosion-proof—Classification of electrical enclosures for use in hazardous areas designed to prevent the passage of internal arcs, sparks, or flames.

filter/separator—A fuel system component used to remove solid particles and water from the fuel.

flash point—The temperature at which a combustible or flammable liquid produces enough vapor to support combustion.

floating roof tank—Petroleum storage tank with a roof that floats on the liquid surface, and rises and falls with the liquid level.

fluid—A substance tending to flow or conform to the shape of a container. Fluid can be in a liquid or gaseous state.

free water—Undissolved water content in fuel.

freeze point—The temperature at which wax crystals form in distillate fuels and jet fuels.

friction—The resistance to motion between two bodies in contact.

fuels control center—POL's control center, which is manned 24 hours a day, 365 days a year.

fuse—An electrical safety device consisting of a piece of metal that will burn or melt and interrupt the circuit when the current exceeds a particular amperage.

galvanizing—Rust resistant zinc coating applied to iron or steel.

gases—A fluid that has no particular shape or volume but tends to expand indefinitely. Will take the shape of the container it is in and can be compressed.

gasoline—A volatile liquid hydrocarbon fuel generally made from petroleum.

gravity—A pulling force generated by a planet, moon, or any other large mass spinning in the universe.

grounding—The equalizing of static electrical potential between a component or piece of equipment and the earth. This is done by connecting the equipment by wire to a ground rod.

ground rod—A rod, normally 3/4" X 8' made of galvanized steel, driven into the earth for the purpose of grounding.

header—A term describing a loading/offloading connection or coupler.

horsepower—A unit of power equal in the US to 746 watts and nearly equivalent to the English gravitational unit of the same name that equals 550 foot pounds of work per second.

hydrant system—Distribution and dispensing system for aviation fuels consisting of a series of fixed flush-type outlets or hydrants connected by piping.

hydrocarbons—Any of the components made up exclusively of hydrogen and carbon in various ratios.

hydrostatic—The science used to study fluids or gases at rest.

hydrostatic test—A test for leaks in a piping system using liquid under pressure as the test medium.

immediate operating storage tank—See operating storage tank.

jet fuel—Fuel used in jet aircraft engines.

JP–4—A grade of jet fuel. Vapor pressure = 2–3 psi; flash point = –20° F; viscosity at 60° F = 1.81 centistrokes (CS); freeze point = –72° F; specific gravity = 0.79.

JP–8—A grade of jet fuel. Vapor pressure=<1, flash point=100° F., freeze point=–58° F, Specific gravity=0.81.

kerosene—A general term covering the class of refined oils boiling between 370° and 515° F used primarily in domestic oil lamps and cooking stoves.

liquid fuels—Any liquid used as fuel that can be poured or pumped.

liquid—A fluid that pours easy and will take the shape of the container it fills. Liquid is almost incompressible where gas is compressible.

loading—A fuel issue connection, where fuel is loaded on refueling units.

lubricants—Material, especially oils, grease, and solids such as graphite, used to decrease friction.

micron—A unit of length equal to one millionth (1/1,000,000) of a meter.

military specification—Guides for determining the quality requirements for materials and equipment used by the military service.

MOGAS—Common expression for motor (automotive) gasoline.

nipple—A short length of pipe.

nonsparking tools—Tools made of metal alloy that, when struck against other objects, will not usually cause sparks of sufficient temperature to ignite flammable vapors.

nozzle—A spout or connection through which fuel is discharged.

offloading—A receiving connection, where fuel can be unloaded by tank truck or tank car.

operating storage tank—Storage tank from which fuel is issued directly to the final-use vehicle, such as aircraft.

orifice plate—A component used to create a differential pressure for automatic valves.

pantograph—A series of pipes, joined by flexible joints, used to connect fueling equipment to aircraft or vehicles.

petroleum—A compound consisting of a mixture of hydrocarbons.

plug—A pipe fitting with male threads used to plug the end of a pipe. Usually used on pipes 2 inches and smaller.

pontoon roof—A type of floating roof for a storage tank having liquid-tight compartments for positive buoyancy.

pounds per square inch—A unit of pressure measurement.

power—A source or means of supplying energy. The time or rate at which work is accomplished or energy is transmitted or emitted.

pressure—The application of force to something by something else in direct contact with it. The force exerted over a surface divided by its area.

pressure drop—The loss in pressure of a liquid flowing through a piping system caused by friction of pipe and fittings, velocity, and change in elevation.

pressure gauge—An instrument used to measure pipeline pressure at the point where it is installed. Some gauges can read differential pressure and some read vacuum.

pressure surge (hydraulic shock)—Sudden increase in fluid pressure caused by a sudden stop of flow.

reciprocate—To move back and forth.

refueler—Tank vehicle used to resupply aircraft with fuel.

resistance—An opposing or retarding force, the opposition offered by a body or substance to its passage.

Society of Automotive Engineers—Used in conjunction with specification for viscosity of lubricating oils.

sludge—Heavy viscous oily mass found in the bottom of storage tanks; often contains rust, scale, or dirt.

spectacle flange—A tool or component used to block off a pipeline. Differs from a blind (blank) flange in that its position can be seen from a distance. See blind flange.

static electricity—An electrical charge produced by objects rubbing together creating negative and positive electrons.

sump—A low area or depression that receives drainage.

tape and bob—A metal measuring tape and plumb bob used to measure the amount of liquid in a tank.

upstream—The direction of flow in a pipeline. Upstream is when the flow is moving toward the pump or component.

valve position indicator—A valve component that indicates the position of the valve (open or closed).

vapor lock—Malfunction of a pumping system caused by vaporization of the fuel.

venturi—A tube that creates differential pressure similar to an orifice plate but much more accurate.

viscosity—Measure of the internal resistance of a fluid to flow or movement.

volatility—Measure of the tendency of a liquid to vaporize; measured as vapor pressure.

voltage—Electrical potential or potential difference.

volume—The amount of space occupied by a three-dimensional figure as measured in cubic units: inches, feet, quarts, gallons, etc. Cubic capacity.

weatherproof—Electrical enclosure used for outdoor service in nonhazardous areas.

weight—The force with which a body is attracted toward the earth or a celestial body by gravitation and its equal to the product of the mass and the local gravitational acceleration.

Abbreviations and Acronyms

°	degrees
a.k.a.	also known as
AF	Air Force
AFB	Air Force base
AFOSH	Air Force Occupational Safety and Health
AFTO	Air Force technical order
AGE	aerospace ground equipment
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AST	aboveground storage tank
ASTM	American Standard of Testing Material
ATG	automatic tank gauging
AVGAS	aviation gasoline
bbl.	barrels
BCE	base civil engineering
BEE	bio-environmental engineer
CE	civil engineer (engineering)
CEF	base fire department
CEV	civil engineer environmental
CFR	Code of Federal Regulations
CH_4	methane
Cl_2	chlorine
Cla-Val	Clayton-Valve
CO	carbon monoxide
CONUS	continental United States
CPR	cardiopulmonary resuscitation
CS	confined space
CSPT	confined-space program team
DBB	double block and bleed
DLA	Defense Logistics Agency
DOD	Department of Defense
DP	differential pressure
EMS	emergency medical service

ESDS	electrostatic discharge sensitive
F	Fahrenheit
F/S	filter/separator
FCC	fuels control center
FDV	fuel discharge valve
FMO	fuels management office
FSC	fuels service center
gal.	gallon
GOV	government-owned vehicle
gpm	gallons per minute
H_2S	hydrogen sulfide
HCN	hydrogen cyanide
HFS	horizontal filter/separator
HHLA	high-high-level alarm
HLA	high-level alarm
HQ USAF	Headquarters, United States Air Force
IDLH	immediately dangerous to life and health
IMT	information management tool
IOST	immediate operating storage tank
IP	ionization potential
LEL	lower explosive limit
LLA	low-level alarm
m	meter
MAJCOM	major command
MEP	master entry plan/mechanical, electrical, and plumbing
MILSPEC	military specification
MIL-STD	military standard
MOGAS	automotive gasoline
mpg	miles per gallon
MSA	Mine Safety Appliances
NATO	North Atlantic Treaty Organization
NCOIC	noncommissioned officer in charge
NFPA	National Fire Protection Association
NH_3	ammonia
NIOSH	National Institute for Occupational Safety and Health
NO	nitric oxide
NO_2	nitrogen dioxide

NSN	national stock number
O_2	oxygen
OE/HDO	oil equivalent/heavy duty oil
OI	operating instruction
oz.	ounce
P/N	part number
PFAS	personal fall-arrest safety
PH_3	phosphine
PID	photoionization detector
PMEL	precision measurement equipment laboratory
POL	petroleum, oil, and lubricants
PPE	personal protective equipment
ppm	parts per million
PRT	product-recovery tank
psi	pounds per square inch
PTFE	polytetrafluoroethylene
QAE	quality assurance evaluator
QC	quality control
RP	recommended practice
RPP	respiratory protection program
SAE	Society of Automotive Engineers
SAR	supplied air respirator
SDS	safety data sheet
SEG	base ground safety
SO_2	sulfur dioxide
SPR	single point receptacle
STANAG	standard agreement
STEL	short-term exposure limit
TCU	tank control unit
TEL	tetraethyl lead
TES	tank-entry supervisor
TO	technical order
TWA	time weighted average
UEL	upper explosive limit
UFC	Unified Facilities Criteria
UL	Underwriters Laboratory
US	United States

UST underground storage tank

UV ultraviolet

VOC volatile organic compounds

WDV water drain valve

WFSM Water and Fuel Systems Maintenance

Student Notes

Student Notes

AFSC 3E451
3E451B 02 1805
Edit Code 04