

# **CDC Z2T371**

## **Vehicle Management Craftsman**

### **Volume 2. Base Construction Vehicles, Material Handling Equipment, Flightline Service Vehicles, and Flightline Support Vehicles**



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**Air Force Career Development Academy**

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WELCOME to the 7-level career development course (CDC) for the 2T371 career field. This course is designed to accommodate all vehicle maintenance career field shred-outs that merge at the 7-level. With this in mind, be aware that although some information contained in this course may have been taught at the 5-level in your shred-out, it has not been taught in others. In short, the nature of our career field has made it necessary to incorporate 5-level CDC material into this course.

Your first volume covers vehicle management procedures, responsibilities, and fundamentals of M-series vehicles. In volume two, we cover base construction, aircraft and flightline servicing, and specialized vehicles and equipment.

There are seven units in this volume. Unit one covers base construction vehicles and material handling equipment (e.g., the crane crawler tractor 10K standard forklift and 10K adverse terrain forklift). In unit two, we look at flightline servicing vehicles with the snow sweeper and snow blower. In unit three, we continue with flightline vehicles by discussing the regenerative sweeper, aircraft towing tractor, and the aircraft deicer. The fourth unit introduces you to the crash fire truck. In the fifth unit, we cover the rapid intervention vehicle (RIV) and structural fire truck. In unit six, we learn about aircraft-fueling equipment, specifically fuels support equipment and operational readiness equipment. Finally, in unit seven, we discuss the aircraft refueler truck, fuel hose maintenance, and refueling maintenance safety.

A glossary is included for your use.

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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 provided in this volume.

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For Guard and Reserve personnel, this volume is valued at 28 hours and 7 points.

**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.



	<i>Page</i>
<b>Unit 1. Base Construction Vehicles and Material Handling Equipment.....</b>	<b>1-1</b>
1-1. Crane .....	1-1
1-2. Crawler Tractor .....	1-19
1-3. Hyster 10K Standard .....	1-31
1-4. Adverse Terrain Forklift .....	1-43
<b>Unit 2. Flightline Servicing Vehicles and Equipment.....</b>	<b>2-1</b>
2-1. Windrow Sweeper .....	2-1
2-2. Snow Blower .....	2-9
<b>Unit 3. Flightline Support Vehicles .....</b>	<b>3-1</b>
3-1. Regenerative Sweeper .....	3-1
3-2. Aircraft Towing Tractor .....	3-11
3-3. Aircraft Deicer .....	3-19
<b>Unit 4. P-23 Fire-fighting Truck.....</b>	<b>4-1</b>
4-1. P-23 Fire-fighting Truck Systems .....	4-1
<b>Unit 5. P-34 Rapid Intervention Vehicle and P-19 Fire-fighting Truck.....</b>	<b>5-1</b>
5-1. Rapid Intervention Vehicle Fundamentals .....	5-1
5-2. P-34 Rapid Intervention Vehicle Maintenance .....	5-17
5-3. P-19 Fire-fighting Truck Systems.....	5-19
5-4. P-19 Fire-fighting Truck Maintenance .....	5-41
<b>Unit 6. Expeditionary Fuels Equipment .....</b>	<b>6-1</b>
6-1. Fuels Mobility Support Equipment .....	6-1
6-2. Fuels Operational Readiness Capability Equipment .....	6-19
<b>Unit 7. Kovatch R-11 Chassis Systems .....</b>	<b>7-1</b>
7-1. Air System .....	7-1
7-2. Electrical and Winterization System .....	7-3
7-3. Power Takeoff .....	7-6
7-4. Power Takeoff and Throttle Interlock.....	7-7
7-5. Bottom-loading System.....	7-10
7-6. Bypass System .....	7-15
7-7. Mainline System.....	7-21
7-8. Defuel System .....	7-26
7-9. Fuel Flow Meter Testing and Calibration .....	7-29
7-10. Fuel Hose Maintenance.....	7-32
7-11. Refueling Maintenance Safety .....	7-34

<i>Glossary.....</i>	<i>G-1</i>
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# Unit 1. Base Construction Vehicles and Material Handling Equipment

<b>1-1. Crane .....</b>	<b>1-1</b>
201. Carrier assembly .....	1-2
202. Crane functions.....	1-5
<b>1-2. Crawler Tractor .....</b>	<b>1-19</b>
203. Cab controls.....	1-20
204. Powertrain and final drive assembly.....	1-22
<b>1-2. Hyster 10K Standard .....</b>	<b>1-33</b>
205. Hyster 10K fundamentals .....	1-33
<b>1-3. Adverse Terrain Forklift .....</b>	<b>1-45</b>
206. Caterpillar adverse terrain forklift .....	1-45

**M**AINTENANCE ON AN AIR FORCE INSTALLATION is similar to that of a major corporation. Someone must repair and maintain structures, utilities (electricity and gas), roads, flight lines, and parking lots. Equipment and materiel must also be transported as part of mission operations. In order to accomplish these tasks, the employment of several types of specialized vehicles is required. For the base infrastructure, construction vehicles are used. For moving materiel in an efficient manner, materiel-handling equipment is used. This unit covers four of these vehicles: the crane, the crawler tractor, the Hyster® 10K forklift, and the Caterpillar® adverse terrain forklift.

## 1-1. Crane

In today's Air Force, cranes are used for a variety of purposes from construction applications to aircraft maintenance to crash recovery missions. As maintenance personnel, it is our responsibility to ensure that this equipment is safe to use and can perform the tasks it was designed to perform. Cranes come in a variety of shapes and sizes. Some cranes are designed to be driven to the job site while others have to be hauled to the job site.

The crane covered is the Arva® crane, AT3035 military model (fig. 1-1). The main purpose of the Arva crane is to lift objects and move them safely from one site to another. The crane can also be equipped with an optional swing away 15-foot jib (extension). The Arva crane is capable of lifting a load up to 7 ½ tons. In this section, you will learn the various systems that make up the Arva crane, beginning with the carrier assembly.



Figure 1-1. Arva 7.5 ton crane.

## 201. Carrier assembly

The carrier assembly is a welded box-type frame with two axles and is specially configured for military applications. You can think of the carrier assembly as the truck part of the crane. It includes the engine, transmission, drive axles, and other associated parts. The carrier, along with the turntable and upper structure, make up the crane. The carrier measures 19½ feet long and 8 feet wide; the whole crane is 26 feet long and 8 feet high. The Arva crane's dimensions were designed to make it transportable by the C-130 aircraft.

### Engine

The engine is a computer-controlled 5.9-liter, in-line six-cylinder turbo diesel. It is mounted facing rearward, in the rear of the vehicle. The engine is capable of running on standard diesel, biodiesel and North Atlantic Treaty Organization (NATO) single battlefield fuel (jet propulsion [JP] 8). The engine also features a two-speed remote throttle control. A rocker switch located on the left side of the dash control panel controls the remote throttle. Push the rocker switch up one position for the medium throttle preset, which maintains engine speed at approximately 1,600 revolutions per minute (rpm). Push the switch all the way up for the high preset throttle (approximately 2,400 rpm).

**NOTE:** You should run the engine at the recommended 1,600 rpm (minimum) in work mode.

### Digital engine monitor

The engine monitor is located on the right side of the dash control console. A multifunction tool enables the equipment operator to view many of the different engine parameters. The operator can view either one or four engine parameters at a time and retrieve diagnostic trouble (fault) codes. The module has a key pad for navigating the various menus. The monitor also displays "wait to start preheating" during the engine preheating cycle. Wait until the display message clears before attempting to start engine.

The monitor communicates with the engine electronic control module (ECM) using the Society of Automotive Engineers J1939 Controller Area Network. The Controller Area Network uses a two-wire, high-speed network system to communicate with the crane's ECM. The monitor is capable of communicating with the ECM using four different J1939 versions (i.e., 1, 2, 3, or 4). Different manufacturers that communicate trouble codes to the module use the different versions. The unit defaults to version 4, which is the most used version. The monitor must be set to the same version as the ECM or it will not be able to communicate. If a *noncritical fault* is detected, the monitor will display WARNING followed by the alphanumeric fault code and the code description. If a *critical fault* is detected, the monitor will display SHUTDOWN followed by the code and its description. Stored fault codes can be retrieved through the "stored codes" menu on the monitor.

### Transmission

The engine drives the torque converter and transmission. This automatic transmission has three forward and three reverse gears. Shifting the transmission is accomplished using a direction and transmission control lever. The direction and transmission control lever controls the travel direction and speed of the crane. The operator must rotate the end of the lever for a speed change. In order to move out of the neutral position, the operator must lift the lever. The direction and transmission control lever is located to the left of the steering wheel on the steering column. Incorporated into the lever is a neutral safety lock. The operator must turn the lever clockwise with shifter in neutral to lock the lever.

### Drive axle range

The transmission incorporates a drive axle range, which provides the functions of a transfer case within the transmission assembly. It provides two-wheel drive high range or four-wheel drive low range. These two drive axle ranges are selected manually by an electric rocker switch located on the control console (right of operator armrest). The rocker switch energizes the four-wheel drive solenoid

located in front of the transmission. When the solenoid is energized, the magnetic field moves a spool within the four-wheel drive solenoid valve assembly. Transmission fluid then flows through the passageways within the spool and is directed to the hydraulic range (hi-lo) and axle disc (two wheel/four wheel) actuators to change ranges. The hydraulic range and axle disc actuators are located on the transmission. If the four-wheel drive solenoid malfunctions, the transmission will default to four-wheel drive low.

**CAUTION:** To prevent transmission damage, the vehicle *must* be stopped when shifting ranges.

### Drive axles

The crane uses two heavy-duty full-floating axles. The front axle utilizes a limited-slip differential while the rear axle uses a locking differential for maximum traction. Both axles can be used for steering and each hub contains a final drive assembly. The final drive assemblies consist of planetary gears incorporated into each axle hub, which provides an increase in torque to the wheels. The planetary gears are splash lubricated with 90-weight oil. The fill plug in each axle hub allows the technician to check and service the oil level.

### Suspension

The Arva crane has no suspension. The front axle (fig. 1-2) is bolted directly to the main frame of the carrier and the rear axle (fig. 1-3) is an oscillating axle. There is a pivot point located between the rear axle and the carrier frame, which allows the axle to pivot like a teeter-totter. This oscillating movement allows the rear wheels to maintain contact with the ground, even in rough or uneven terrain. The rear axle pivots along the longitudinal centerline of the crane when maneuvering. The rear axle pivots four inches in either direction for a total of eight inches of total travel.

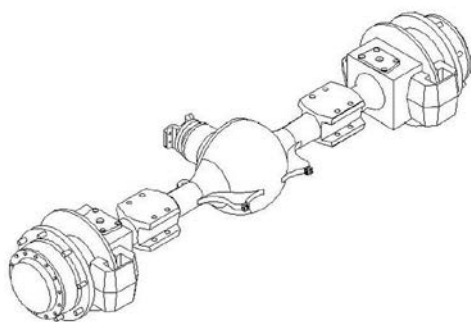


Figure 1-2. Front axle assembly.

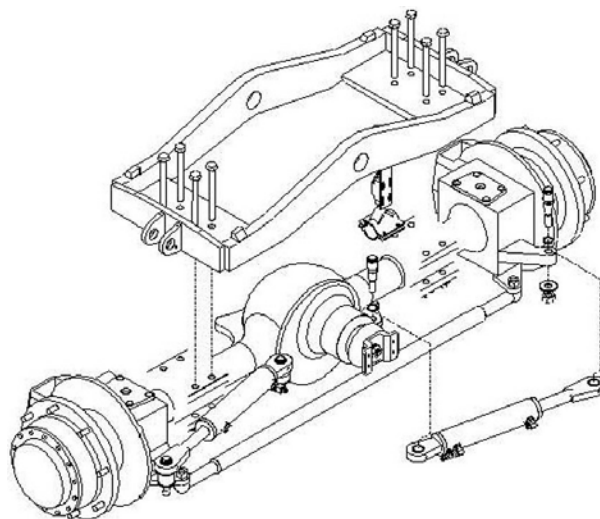


Figure 1-3. Rear axle assembly.

Axle lock cylinders (fig. 1-4) may be used for additional stability in lieu of outriggers when doing an “on-rubber” lift or when the load being lifted must be transported to another site. The axle locks provide more stability when lifting on tires alone. The axle locks are two double-acting hydraulic cylinders mounted between the frame and the rear axle. Axle lock cylinders are connected to the transmission hydraulic system and are *not* part of the main hydraulic system. The cylinders lock the rear axle to the frame and prevent the rear axle from oscillating. The axle locks are actuated by a three-position electric rocker switch located on the right side console next to the outrigger controls. Caution must be observed when lifting objects without outriggers.

**CAUTION:** Do *not* exceed tire sidewall rating when accomplishing an on-rubber lift.



Figure 1-4. Axle locks.

### Brakes

The hydraulically operated service brake system receives fluid from the main hydraulic system. The main hydraulic pump is a tandem-gear-type pump that incorporates two pumps in one housing. The pump has two different fluid output ratings, 31 and 15 gallons per minute (gpm). The 15-gpm hydraulic pump supplies fluid for the service brakes. The service brake system components consist of an accumulator charging valve, two accumulators, a modulating brake pedal valve, and four disc brake assemblies. One disc brake assembly is located at each axle end.

Fluid from the hydraulic pump is directed to the accumulator-charging valve. The accumulator-charging valve charges the two accumulators, which supply pressurized fluid to apply the service brakes. It is important to note, the accumulators supply the brake fluid pressure required for proper brake operation, not the hydraulic pump. The hydraulic pump and the charging valve charge the accumulators. The pressure stored in the accumulators allow the operator to stop the crane safely in the event of a hydraulic system failure. A modulating brake pedal valve directs pressurized fluid from the accumulators to the disc brakes during application.

A push/pull-type button located on the right side of the dash control panel manually actuates the parking brake. The parking brake button glows red when the parking brake is applied. The parking brake is a spring-applied/hydraulically released disc-type brake that is mounted to the output of the transmission. The parking brake must be applied for the engine to start. The transmission and parking brake are interlocked for safety. The transmission disengages when the parking brake is applied and will not engage until the brake is released.

### Steering

The steering system on the Arva crane is part of the main hydraulic system and receives fluid from the 15-gpm pump. The system incorporates a steering control valve, which directs fluid to either side of the steering cylinders depending on the direction of the turn. The steering control valve is located at the end of the steering column inside the cab. The steering control valve also acts as a pump for the steering system during an engine or main hydraulic pump failure. Four double-acting cylinders (two per axle) are used to steer the crane, depending on the selected mode of steering.

There are three modes of steering the crane fig. (1-5):

1. Two-wheel conventional steering.
2. Four-wheel coordinated steering.
3. Four-wheel crab steering.

Two-wheel conventional steering is when the front wheels steer only. Four-wheel coordinated steering is when the front and rear wheels turn in opposite directions. Four-wheel coordinated steering provides for the sharpest turns. Four-wheel crab steering is when the front and rear wheels turn in the same direction. This mode of steering is also known as four-wheel oblique steering. A three-position electric rocker switch located to the left side of the dash control panel controls the three modes of steering.

**CAUTION:** Do *not* change modes of steering while crane is in motion.

Additionally, the crane utilizes a “rear-wheel steer not centered” indicator light that will illuminate when the rear wheels are not in the centered position. This light is located at the top of the left side dash control console. The indicator light is controlled by a microswitch (normally closed) and is mounted on the left side of the rear axle.

**CAUTION:** Change steering modes *only* when rear tires are in the *centered* position.

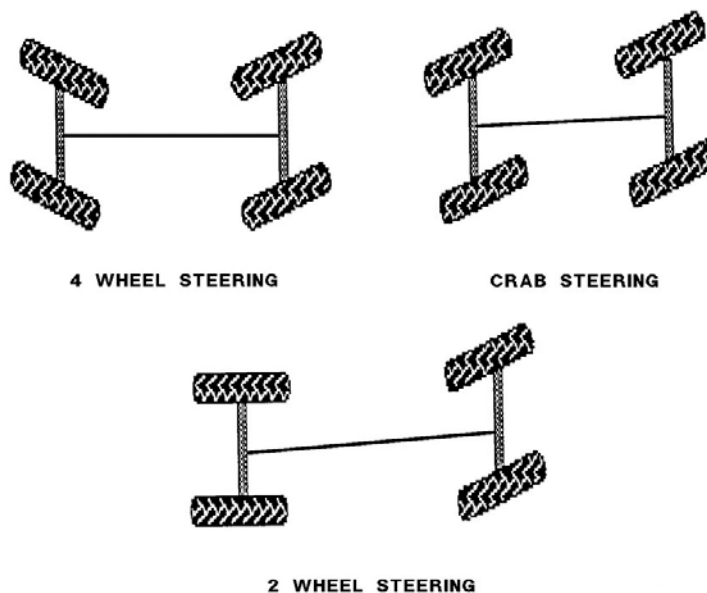


Figure 1-5. Steering modes.

## 202. Crane functions

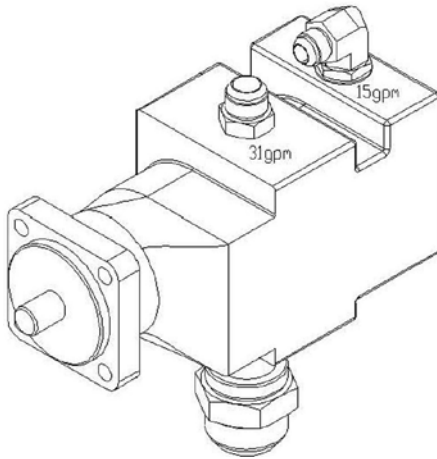
The crane functions consist of the parts and systems associated with lifting and positioning loads. This lesson covers hydraulics, outriggers, the turntable, the boom winch, boom functions, and the two-block system. These components work together to enable the crane to lift and position loads safely under varying conditions.

### Hydraulic system

The hydraulic reservoir on the crane has a 60-gallon capacity and is located next to the turntable on the right side of the crane. The main hydraulic pump (fig. 1-6) is a tandem gear-type pump and is gear driven off the torque converter. The tandem gear pump has two fluid output ratings: 31 gpm and



15 gpm. The 31-gpm pump supplies fluid for main control valve functions and the 15-gpm pump supplies fluid for winch boost, outriggers, steering, and the service/park brake.



**Figure 1-6. Hydraulic pump.**



**Figure 1-7. Joystick manipulator.**

Two joystick manipulators (fig. 1-7) used to control boom hydraulic functions are located next to each armrest in the operator's compartment. The joystick manipulators control pilot pressure to the main control valve assembly and manipulate the main control valve spools. The left joystick controls boom extend/retract and boom swing and the right joystick controls winch and boom lift/down. The joysticks are disabled by the joystick lockout rocker switch located on the bottom left of the dash control panel. Always disable joysticks before exiting equipment.

### **Main control valve**

The main control valve assembly (fig. 1-8) is mounted under the vehicle on the inside right side frame rail. There are four closed center-type spools within the main control valve assembly. The spool valves are closed by spring pressure and are opened by pilot pressure. The valves control winch, boom lift/down, boom extend/retract, and boom swing functions. Pressure relief valves are incorporated in the control valve assemblies.



**Figure 1-8. Main control valve.**



### Rotary manifold

The crane is equipped with a rotary manifold, also known as the hydraulic swivel (fig. 1-9). This allows the boom to rotate 360 degrees continuously without twisting or breaking the hydraulic lines and hoses to the turntable assembly or upper structure. The rotary manifold directs hydraulic fluid to all upper structure hydraulic actuators. It consists of an inner spool, outer casing, and O-ring seals. Fluid lines from the carrier are connected to the inner spool that remains stationary with the carrier. The outer casing rotates around the outside of the inner spool with the turntable and upper structure. The inner spool has multiple grooves around its body O-rings to seal fluid from leaking into other sections of the spool. A port and a line from the carrier connect each groove. The outer casing fits over the inner spool and rotates with the boom. Each groove on the inner spool matches a port in the outer casing. The lines connected to the outer casing are directed to the upper structure actuators. The hydraulic functions that require the fluid to be directed through the rotary manifold are the winch, boom lift/lower and boom extend/retract.

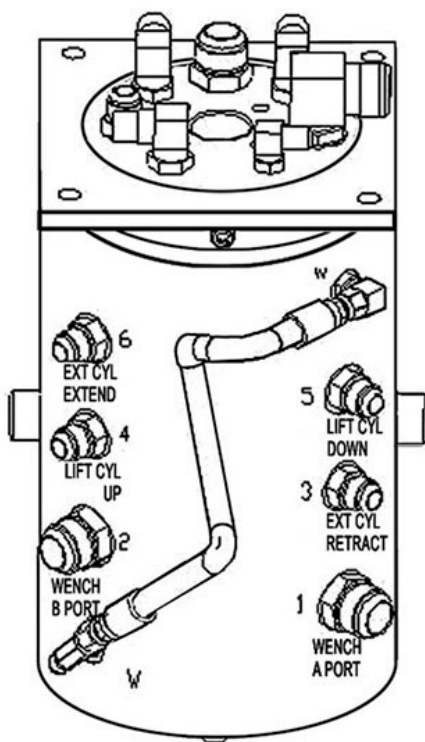


Figure 1-9. Rotary manifold.

### Outriggers

Hydraulic outriggers (fig. 1-10) provide stability during lifting operations. The Arva crane utilizes four independently controlled outriggers, one for each corner of the vehicle. Each outrigger uses a one double-acting cylinder with a hold valve to lock it in position. The outriggers must be fully extended to provide support for the crane when lifting heavy loads. The carrier must be leveled prior to extending the boom or lifting heavy loads. Each outrigger is actuated independently by a three-position rocker switch located to the right of the operator on the outrigger control console.

Operators must know if the crane is level *before* lifting a load. The Arva crane has bubble indicators (fig. 1-11) mounted just behind the operator's seat on the right side. The bubble indicators indicate when the platform is level. The crane *must* be leveled during the positioning of the outriggers. Failure to ensure the crane is level could cause an accident or equipment failure during lifting operations.



Figure 1-10. Outriggers.

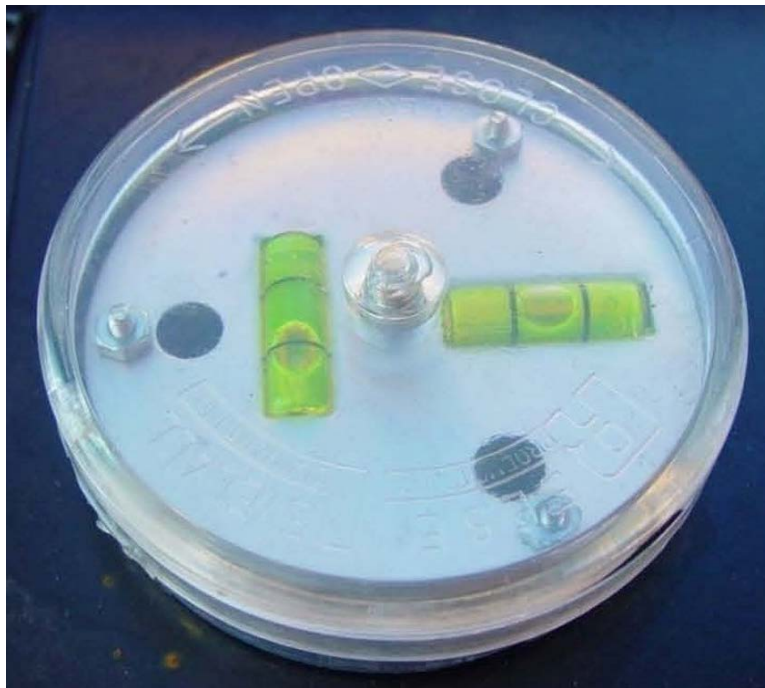


Figure 1-11. Bubble indicator

### **Turntable assembly**

A crane that is only capable of lifting and lowering cargo is not very useful. A device called a turntable assembly (fig. 1-12) allows the boom to swing in a complete circle so the cargo can be placed anywhere the crane's boom can reach. The turntable assembly attaches the boom assembly to the carrier assembly. The turntable utilizes a swing bearing and a hydraulically driven gear reducer to accomplish the boom swing function. A counter weight mounted to the rear of the turntable assembly offsets the weight of the load being lifted.



Figure 1-12. Turntable assembly.

### *Swing bearing assembly*

The component that carries the weight of the upper structure and allows the boom to rotate 360 degrees continuously in either direction is the swing bearing assembly (fig. 1-13). It is composed of two races: an outer race and an inner race. The outer race is part of the bull gear and is bolted to the turntable assembly. The inner race is bolted to the carrier assembly and between the races are ball bearings.

### *Boom swing*

A high torque gerotor-style motor that drives a self-locking worm gear drive in a gear reducer (fig. 1-13) accomplishes boom swing. A worm gear drive is said to be self-locking when the output cannot drive the input. This means that if the boom were to try to turn without the reducer or against it, it would be unable to do so. This is especially useful so if the hydraulic motor stops, so does the boom. The gear reducer also incorporates a fail-safe brake located between the drive motor and the gear reduction. The brake is a spring-applied and hydraulically released disc-type brake. The gear reducer is mounted to the carrier assembly. The worm gear drives a pinion (output) gear within the gearbox. The pinion gear meshes with the bull gear that is mounted to the turntable. The bull gear is actually the outer race of the swing bearing assembly. When the pinion gear rotates, the bull gear is forced to move. This action causes the turntable and boom assembly to rotate 360 degrees in either direction depending on the rotation of the pinion gear. The maximum rotational speed of the turntable assembly is two revolutions per minute.

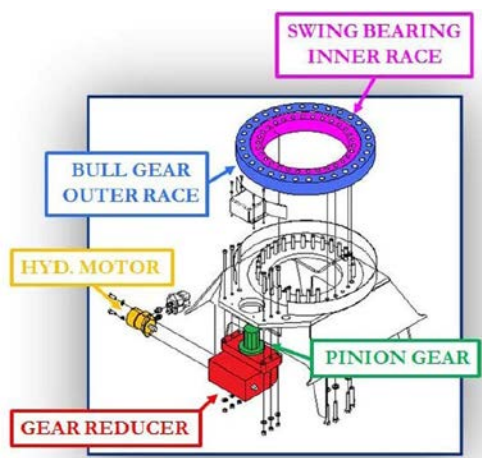


Figure 1-13. Swing bearing and boom swing components.



### Collector ring

A collector ring (fig. 1-14) allows all upper structure wiring to continuously rotate 360 degrees without twisting and breaking. It utilizes slip rings (commutator rings) and brushes similar to an alternator's slip rings and brushes. It is located in the middle of the turntable assembly, just under the hydraulic swivel (rotary manifold). The contact brushes are self-cleaning. If the operator experiences any electrical malfunctions in the turntable or upper structure, the operator should rotate the boom several times to clean the contacts between the brushes and commutator rings within the collector ring assembly. This procedure can eliminate most turntable or upper structure electrical malfunctions.



Figure 1-14. Collector ring.

### Upper structure

The upper structure (fig. 1-15) provides a high point from which to lift objects. It is mounted to the turntable assembly by one large pin. The upper structure consists of two segments: a base and a fly tip section. The fly tip section slides in and out of the base section. The boom is extended by the use of one double-acting cylinder. The ram is mounted to the fly tip segment and the cylinder is mounted to the base section of the upper structure. The boom sections are held in alignment by pads. These pads also provide a replaceable wear surface and help to reduce the slap that occurs when a swing movement is performed. The pads on the bottom are called slide pads. These pads are the wear surface of the boom sections and must be lubricated with grease. The pads on the side sections of the boom are called side pads. These pads are also used to maintain alignment of the boom sections. The side pads do not require

lubrication. A single double-acting cylinder lifts the upper structure and utilizes a counterbalance valve to lock the cylinder in place for safety.

**CAUTION:** Crane booms are *not* intended to withstand side pulling of a load. This may cause the boom sections to collapse.

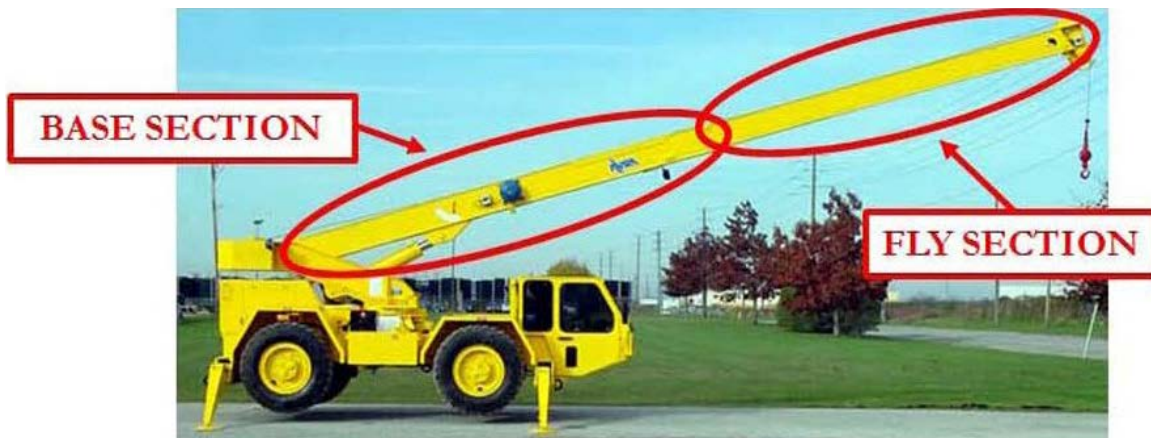


Figure 1-15. Upper structure.

One of the simplest safety devices is the boom angle indicator (fig. 1-16). It informs the operator of the angle of the boom in relation to a horizontal plane. It consists of a pendulum and a numbered scale located on the left side of the boom (base section). As the boom rises, the pendulum will remain pointing down at the numbered scale indicating boom angle. The pendulum must swing freely without binding. The operator must be able to read the boom angle accurately in order to decide if a load may be lifted safely.

### Winch and load hoist cable

The winch performs the lifting function for the crane.

It is slow in movement and allows for maximum operator control.

The winch is mounted at the rear of the turntable in front of the counter weight. During normal operation, the 31-gpm pump supplies fluid for the winch. The operator can speed the rotation of the winch by using the winch boost function. The winch boost function is selected by a push button on top of the right joystick manipulator. When the operator presses the winch boost button, 12-volt direct current (VDC) is supplied to the winch boost solenoid. The solenoid energizes and moves a hydraulic spool valve. The spool valve diverts fluid from the 15-gpm pump to the winch circuit. Forty-six gpm of hydraulic fluid will flow to the winch hydraulic motor during winch boost. The winch in the Arva crane incorporates a load hoist brake. The job of the load hoist brake is to hold the suspended load. The load hoist brake is a wet multiple-disc-type brake. It is spring-applied and hydraulically released by pilot pressure. The load hoist brake is located within the winch cable drum assembly.

The load hoist cable runs from the winch over the top of the boom to the hook block. The tip of the boom is equipped with pulleys that provide a smooth rotating surface for the load hoist cable to ride on.

### Sheaves, reeving, and parts

You will notice on many cranes, the cable is fed over pulleys (called sheaves) on the boom tip. The cable is then sent down to another sheave on the hook-block, directed back up and around another sheave on the boom tip before its finally secured to the hook-block. This is known as *reeving*. Specifically, reeving is the process of running cable through sheaves. It is done to increase the lifting strength of the winch. If you were to look at a hook-block system being suspended this way, it would appear to be held by three cables. The number of times reeving is accomplished is known as parts. The previous example refers to a three-part reeve. The disadvantage of reeving with several parts is that it slows the action of the hook-block. A three-part reeve would provide the winch stronger lifting capability, but the winch must spool in three feet of cable to achieve one foot of lift.

### Rated capacity indicator and anti-two-block system

A digital load indicator is installed on the Arva crane. This device allows the operator to slowly lift a load and see a digital readout of the weight being lifted. This helps prevent operators from lifting loads that exceed the weight limitations for their current crane configuration. The Arva crane is specifically equipped with the Wylie® W3350R Radio Rated Capacity Indicator® (RCI) system (fig. 1-17). This system provides continuous information relating to crane loading and warns the operator of approaching or exceeding crane limitations. The RCI display unit is located on the right side of the dash control panel. The RCI system incorporates an anti-two-block (A2B) system. The A2B system prevents the operator from raising the hook-block into the boom tip or lowering the boom tip onto objects.



Figure 1-16. Boom angle indicator.

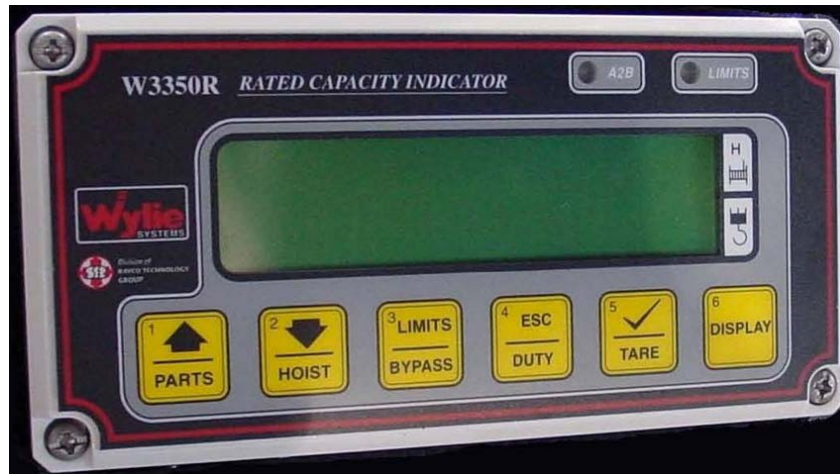


Figure 1-17. Rated capacity indicator and anti-two-block display.

### ***Rated capacity indicator***

The RCI system is a length, load, angle, radius, lifting capacity and two-block indicator. This system automatically monitors the load applied to the crane and continuously compares the current load with the maximum permitted load for each crane position. The RCI computer only detects three boom positions: over-front, over-side, or over-rear.

**CAUTION:** The Wylie Radio RCI system is to be regarded *only* as an aid to the operator. The indicator equipment will not necessarily prevent crane damage due to overloading.

### ***Display unit***

The display unit (refer to fig. 1-17) contains a microprocessor based computer inside with operating software. The software has four operating modes programmed: normal, limits setting, diagnostic, and calibration modes. The liquid crystal display (LCD) screen provides the crane operator with critical information necessary to operate the crane safely and within the maximum permitted load specified by the crane manufacturer. The display unit operates off the crane's 12 VDC power supply. Supply voltage must be a minimum of 11 VDC and not exceeded 30 VDC.

Two warning lights (A2B and limits) and an internal buzzer warn the equipment operator when the crane is approaching or has exceeded the limit of the crane capacity. The limit warning light blinks when the load on hook is between 85 and 99.9 percent of the rated capacity, accompanied by the operation of an audible warning device that is fitted inside the display unit.

When the load on the hook is above 100 percent of the rated capacity of the crane, or the operator has reached a predetermined set limit (set in the limits setting mode), the limit warning light and audible alarm are on continuously. The A2B condition light appears when such a condition is detected by the system.

The display unit has six buttons used to navigate and set up the operating modes. Consult the operator's manual for procedures to set up the operating modes.

### ***Transmitters***

There are two transmitters found on the Arva crane. One is mounted on the fly tip (A2B transmitter) and the other is mounted on the base section (reeling drum transmitter). These transmitters send radio signals to the RCI system's computer. They are powered by the crane's 12 VDC power supply (11 volt minimum/30 volt maximum). Each transmitter's identification number is stored in the computer's memory during the calibration process. The RCI computer will only respond to signal

outputs from stored transmitters. This prevents interference from other cranes operating within the same vicinity.

**CAUTION:** The RCI system should *not* be used in explosive atmospheres. Transmitter radio signals can trigger detonation.

#### *Load pin sensor*

The load pin sensor is mounted on the left of the fly tip section in the head sheave. The load pin sensor provides an electrical signal to the A2B transmitter. The transmitter sends a radio signal to the RCI system's computer that is proportional to the actual load in the crane's load hoist rope system.

#### *Reeling drum*

The reeling drum (fig.1-18) cable has an extension capacity of 110 feet. Cable guides are bolted in front of the reeling drum and in front of every boom section to keep the cable in a straight line. Sagging of the reeling drum cable wire would cause nonlinearity of the length measurement. All cable guides must be in perfect alignment both vertically and horizontally and parallel to the boom. Cable guides allow easy flowing of wire and help keep the boom length measurement linear. The reeling drum cable is made of three insulated wires. Two wires deliver power and ground to the radio load pin and A2B transmitter. The third wire transmits the output signal from the boom length sensor.



Figure 1-18. Reeling drum.

#### *Boom length sensor*

The boom length sensor (fig. 1-19) is a gear-driven potentiometer. The boom length sensor is mounted in the reeling drum housing. As the boom extends, the reeling drum unwinds, and the potentiometer is driven. The output signal of the potentiometer is sent to the transmitter, which is proportional to the extension of the boom.



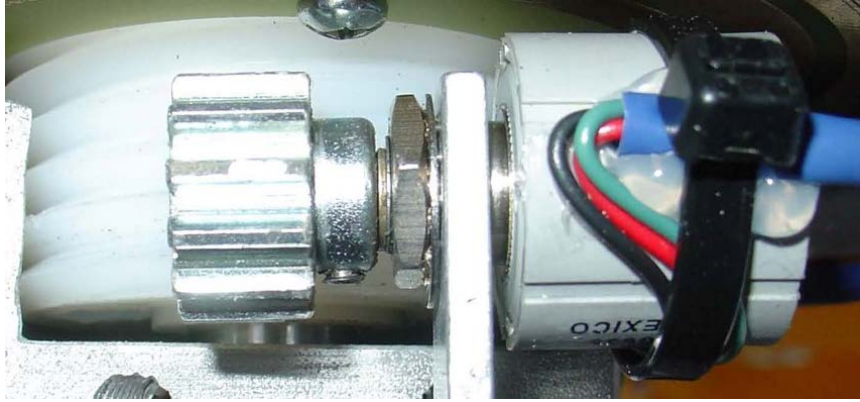


Figure 1-19. Boom length sensor.

#### *Boom angle sensor*

The boom angle sensor is an inclinometer that provides a signal to the reeling drum transmitter. The transmitter sends a radio signal to the RCI system's computer that is proportional to the boom angle. The boom angle sensor is located in the reeling drum.

#### *Slew detection kit*

The slew detection kit consists of two proximity switches and a junction box. The two proximity switches (fig. 1-20) monitor the turntable position by sending an ON or OFF signal to the RCI computer. The two proximity switches are wired into a junction box mounted to the left of the turntable assembly.



Figure 1-20. Proximity switches.

#### *Anti-two-block system components*

The Arva crane utilizes an A2B safety system incorporated into the RCI system. The purpose of this safety system is to prevent the operator from raising the hook-block into the boom fly tip or lowering the boom fly tip onto objects. A two-block condition is when the hook-block or other obstruction touches the fly tip section. Without the Arva crane safety system, damage to the crane or death to personnel could occur.

**CAUTION:** Keep in mind, the A2B system is *only* an aid to operator. The operator *must* ensure that crane motions occur smoothly and at a safe speed.





**Figure 1-21. A2B microswitch.**

#### *A2B microswitch*

The A2B microswitch (fig. 1-21) is a spring-loaded, normally open, held-closed-type switch mounted on the tip of the fly section (bottom right). The contacts of the switch are held closed by the A2B switch hoop. The A2B microswitch provides an electrical signal to an RCI system transmitter. The A2B transmitter sends a signal to the display unit in the event a two-block situation occurs.

#### *Pilot cut-out solenoid valve*

The pilot cut-out solenoid (fig. 1-22) is energized during normal operation. The pilot cut-out solenoid disables three hydraulic functions when the solenoid is deenergized during a two-block condition:

1. Winch up.
2. Boom down.
3. Boom extend.

The pilot cut-out solenoid and hydraulic valve is mounted under the vehicle inside the front right frame rail.



**Figure 1-22. Pilot cut-out solenoid valve.**

#### *Swing cut-out solenoid valves*

The left and right swing cut-out solenoids (fig. 1-23) are energized during normal operation. The solenoids disable two hydraulic functions when deenergized: (1) swing left and (2) swing right.

The left and right swing cut-out solenoids and their hydraulic valves are mounted to the swing hydraulic motor located to the right side of the crane.



Figure 1-23. Swing cut-out solenoid valves.

#### *Overload/A2B relay*

The overload/A2B relay controls 12 VDC power to the pilot and both swing cut-out solenoids. If there were to be a problem with this relay, the crane would *lose* five functions:

1. Winch up.
2. Boom down.
3. Boom extend.
4. Swing left.
5. Swing right.

The overload/A2B relay is located on the electrical fuse panel, under the outrigger control panel.

#### *Anti-two-block system operation*

When the operator accidentally lifts the hook-block too high, the hook-block touches the hoop (boom tip). The hoop lifts and the A2B microswitch contacts open. The A2B transmitter monitoring the A2B microswitch senses an open circuit. The A2B transmitter then sends a radio signal to the RCI computer, signaling a two-block condition. The RCI computer removes 12 VDC from the overload/A2B relay. The overload/A2B relay then removes power from the pilot and swing cut-out solenoids. When the pilot and swing cut-out solenoids deenergize, the five functions mentioned above are disabled. When the pilot cut-out solenoid deenergizes, the pilot cut-out hydraulic valve opens and vents three joystick pilot pressure lines to the hydraulic reservoir. Winch up, boom down, and boom extend function are disabled. When the swing cut-out solenoids (left hand and right hand) deenergize, the check balls in the swing cut-out hydraulic valves block the fluid flow to the swing hydraulic motor. Swing left and swing right functions are disabled. The RCI display unit's A2B condition light appears and the audible alarm sounds, identifying a two-block condition has occurred.

#### *A2B override (bypass) function*

The RCI display unit's BYPASS key is used to override an A2B condition and briefly enables all A2B cut-out functions. While in an A2B condition, the operator must press the BYPASS key while performing the desired function.

**WARNING:** Misuse of override functions can result in *injury or death* to personnel or damage to equipment. Take extreme caution.

## Self-Test Questions

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

### 201. Carrier assembly

1. What were the Arva crane's dimensions designed to allow for?
2. What types of fuel may be used in the Arva crane?
3. What information can be viewed on the digital engine monitor?
4. What does the digital engine monitor use to communicate with the ECM?
5. How many forward and reverse gears does the Arva crane have?
6. What two drive ranges does the Arva crane have?
7. What type of differentials does the Arva crane use?
8. What kind of suspension does the Arva crane have?
9. What are the axle locks used for?
10. Which hydraulic pump provides fluid for the brake system?
11. What provides the fluid pressure for proper brake operation?
12. List and describe the three modes of steering utilized by the crane.

**202. Crane functions**

1. What kind of hydraulic pump does the Arva crane use and what drives it?
2. What is used to control boom hydraulic functions?
3. How are the main control valve's spool valves actuated?
4. What component allows 360-degree movement of the boom without damage to hydraulic lines or hoses?
5. What type of hydraulic cylinder is used to actuate the outriggers?
6. What tells the operator if the crane is level?
7. What component allows the boom to rotate 360 degrees in either direction?
8. When does the boom swing worm gear drive become self-locking?
9. The bull gear is part of what component?
10. What component allows the upper structure wiring to rotate 360 degrees without twisting or breaking?
11. What hydraulic component is responsible for extending the boom?
12. What is the purpose of the load hoist brake?

13. Define reeving.
14. Under what conditions does the limit warning light blink?
15. What RCI sensor sends a signal proportional to the load being lifted by the load hoist?
16. What RCI sensors are located in the reeling drum?
17. What is the purpose of the anti-two-block system?
18. What hydraulic functions does the pilot cut-out solenoid disable?
19. Where are the swing cut-out solenoids located?
20. The overload/A2B relay affects what five crane functions?

## 1-2. Crawler Tractor

The crawler tractor is heavy and powerful. Most weigh nearly 22 tons and utilize a heavy-duty diesel engine and planetary gearing to provide the pulling or pushing power. An optional ripper attachment can be mounted on the rear of the machine for breaking up dirt or other materials. This lesson covers the Fiat Allis ® crawler tractor (fig. 1-24) with a bucket attachment. Many of the fundamentals can be applied to almost all models of crawler tractors. The section on the operating controls is just to familiarize you with tractor operation. It is vital that you know how to operate a piece of equipment before you attempt to isolate or repair various systems.

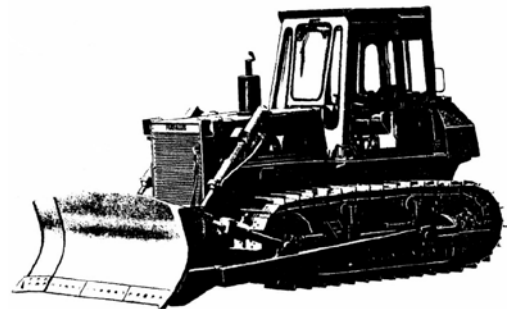


Figure 1-24. Fiat Allis crawler tractor.

## 203. Cab controls

Operating the tractor is greatly simplified through extensive use of hydraulics in the cab. This section covers the operator's compartment, electronic data monitor, and various operating controls and attachments.

### Operator's compartment

Most of the control cables used on older model earth moving tractors have been replaced with hydraulic controls, resulting in much smoother and precise tractor operation. The operator's compartment is the reference point as you study the tractor. Directions on the tractor are given as if you are viewing the compartment from the operator's seat. Figure 1-25 shows the layout of the operator's compartment.

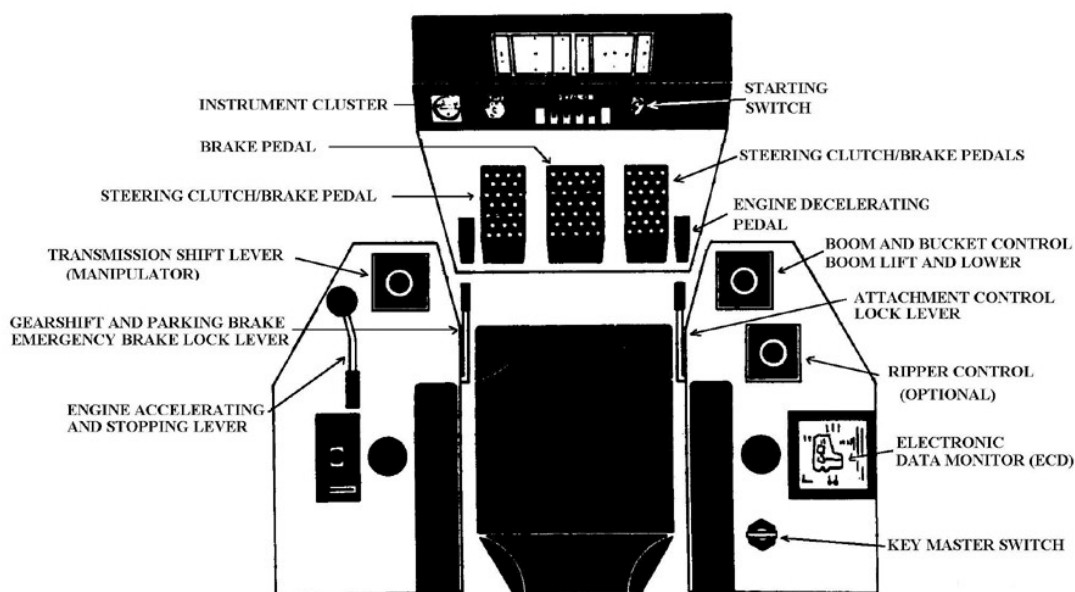


Figure 1-25. Operator's compartment.

### Steering clutch/brake pedals

Steering this tractor is an experience in itself, particularly if you have never operated any type of track vehicle. You steer the tractor with the pedals on the floorboard. If you want the tractor to go left, push the left brake pedal down and the left track will slow down or stop. Pushing the brake harder increases the degree of the turn. The same is true for right turns; press the right brake pedal and the right track slows or stops.

In technical terms, steering is accomplished using two multidisc steering clutch packs, which are manipulated by the operator's foot pedals. Depressing one of these pedals disengages the corresponding steering clutch, allowing the affected track to slow down. By further depressing the pedal, the corresponding track brake is applied allowing the machine to turn in tight spaces. Depressing the large center pedal slows or stops both tracks simultaneously.

### Electronic data monitor

Most tractors are equipped with the typical vehicle malfunction warning systems in addition to a unique operator warning system called the electronic data monitor. This system, located to the right of the operator, sounds a buzzer and illuminates an indicator if a fluid level or a fluid pressure problem occurs in the engine, transmission, or torque converter.

### **Transmission shift lever**

Use the transmission shift lever (referred to as the manipulator) located on the console to the left of the operator, to select the range and travel direction of the machine. This can be done either with the tractor sitting idle or in motion. There are three forward and three reverse positions of the transmission. When you move this lever, you are hydraulically moving the spools in the transmission control valve, which are located on the lower left side of transmission. This changes the direction or path of the hydraulic fluid. This action in turn controls the transmission clutches. The shift lever is locked into its position by oil pressure at the bottom side of the spool valve. Anytime the transmission oil supply is lost, the shift lever automatically returns to the neutral position. When the shift lever is placed in neutral, the external contracting-type parking brake is automatically applied by springs. This design eliminates the need for a separate parking brake switch or lever.

### **Gearshift and parking/emergency brake lock lever**

You can prevent the operation of the transmission shift lever by pulling the brake lock lever up. When this lever is in the raised position, fluid flow from the main supply pump to the gearshift manipulator is blocked, preventing you from shifting the transmission or releasing the parking brake. Normal transmission function and release of the parking brake resumes with the lever in the down position.

### **Throttle lever**

The throttle lever on the operator's left console panel controls engine speed and engine shutdown. Pulling the lever closer to the operator increases the engine's rpm; pushing the lever away from the operator lowers the rpm. Push the lever to the extreme left to shut down the engine. You will also find two deceleration pedals on the floorboard. These levers are used to slow the engine during turns or going down a hill. The throttle lever and deceleration pedals are connected by linkage to the fuel injection pump located on the right side of the engine.

**NOTE:** You must remember to disconnect this throttle linkage in accordance with the technical order before attempting to tilt the operator's cab. Failure to do this can seriously damage the throttle linkage and/or the injection pump.

### **Attachment control lever**

The boom control lever is located on the operator's right. Moving this control lever backward or forward lifts or lowers the boom. This control lever returns to neutral once the boom is lifted fully. Moving the lever to the right or left positions operates the bucket dump.

A button on the top of the control lever controls a bucket "float" position. A two-spool main control valve controls the hydraulic system attachments; one for boom raise/lower and one for bucket dump/retract. This vehicle has two hydraulic boom cylinders, which lift the bucket arms, and two hydraulic bucket cylinders that allow you to change bucket configurations.

### **Multipurpose bucket**

Before you learn about the bucket, it is important that you understand the difference between a bulldozer and the crawler tractor being discussed. This crawler tractor has a multipurpose bucket to perform several functions without changing attachments. A bulldozer typically has a straight blade used for pushing and leveling materials only.

### **Clamshell attachment**

This hydraulic attachment gives the operator the option of changing bucket configurations by simply opening or closing the bucket clamshell using one double-acting hydraulic cylinder on each side of the bucket. The clamshell can be used in the closed position for a conventional bucket or opened to expose the dozer blade or a grapple.



### **Winch**

A hydraulically driven winch located on the rear of the tractor is available for pulling objects behind the tractor. A manual lever on top of the winch engages and disengages the winch clutch. Leaving this lever in the disengaged position allows the winch to free wheel, if needed. The winch has an internal spring applied and hydraulically released brake. Fluid flow from the cab control valve releases the brake, allowing winch operation. A hydraulic relief valve is incorporated to protect the hydraulic circuit in the event of a winch overload.

### **Attachment control lock lever**

This safety device prevents operation of the bucket or ripper attachment. Pulling the lever up blocks fluid from the attachment operations. Normal operation of the attachments resumes when you place the lever in the down position.

### **Safety**

We cannot stress safety enough, specifically around the hydraulic system. A hydraulic system under pressure can be deadly. If you find it necessary to raise the boom to make repairs, you must make sure holding devices are in place to prevent the boom from falling. On this model, a specially designed safety bar is placed on the right lift arm. Always remember to follow all manufacture's safety procedures that apply to the machine you are working.

## **204. Powertrain and final drive assembly**

By this point, you should have a good understanding of the crawler tractor functions and capabilities. Now, let's find out what actually makes the crawler tractor perform. The systems included are the power train and final drive assembly components.

### **Engine**

Diesel engines are used over gasoline engines in heavy equipment because they have a high torque output at lower engine rpms. One example of a crawler tractor engine is the in-line six-cylinder, four-stroke, turbocharged 8.1 liter diesel engine with a peak torque range of 2,000 rpm and an output of 168 horsepower (hp).

### **Cooling system**

As with most conventional cooling systems, the crawler tractor utilizes the standard belt-driven fan. However, some models are equipped with a unique radiator cooling fan system that can be reversed to meet changing weather conditions. The fan is designed to pull cold air through the radiator to remove the heat (summer time operation) or blow the hot air from the engine out through the radiator to keep the coolant in the radiator warm (wintertime operation). The fan is equipped with spring loaded, rotatable blades mounted to the fan hub. You can change the direction of the airflow by pushing the blades toward the center of the hub against the spring. This releases the roll pin from its slot so the blades can be rotated 180 degrees. Remember all the blades have to be rotated in the same direction. Keep the fan blade direction in mind the next time you are trying to fix a tractor that is in the shop for overheating. The fan should pull the air in the summer and push the air out in the winter.

### **Electrical system**

All of the electrical system components on the crawler tractor, including the starting system, operate on a 24 VDC system. This is accomplished by connecting two heavy-duty, 12-volt batteries in a series circuit. A single 24 VDC, internal regulated alternator, driven by two belts, recharges the batteries. To avoid serious personal injury or damage to the equipment, *always* follow the proper isolation and repair procedures in the technical order.

### **Hydraulic operation**

The hydraulic implement system, transmission, steering, and brake systems use the hydraulic pilot operated control system. Fluid flow from the pilot pump actuates the control spool valve(s) to operate



these components, as opposed to using cables or linkage that you might find on other equipment. The gear-type pilot pump (usually found on the right front of the engine) operates the attachments.

### Transmission/converter

As mentioned, the transmission provides three forward and three reverse speeds. These speeds are controlled by a hydraulic power shift mechanism, which acts on five clutches. Torque multiplication takes place using a single-stage torque converter mounted separately from the transmission. A shaft connects the transmission and torque converter. Additionally, the torque converter ring gear drives two, tandem gear-type pumps. One pump is for main hydraulic supply and torque converter charging. The other pump is for vehicle steering and torque converter scavenging. The converter and transmission hydraulic system oil cooling is accomplished using a heat exchanger, which operates on coolant recirculated from the engine.

### Drive gears

Once you select a gear, the transmission output shaft turns the pinion gear to transfer power through the bevel gear at right angles. This sends power via the drive gears (fig 1-26) out to the left and right tracks. After passing through the steering clutch packs, the power goes into the final drive gear case, which is located outside the tractor frame. In figure 1-27, you can see how the term “double reduction” is actually accomplished with the straight spur-type drive gears. This design of the smaller gears (pinion and idler gears) driving the much larger gears (idler and final drive gears) results in a slower speed, but an increase in torque. From there, it goes to the sprocket that drives the tracks.

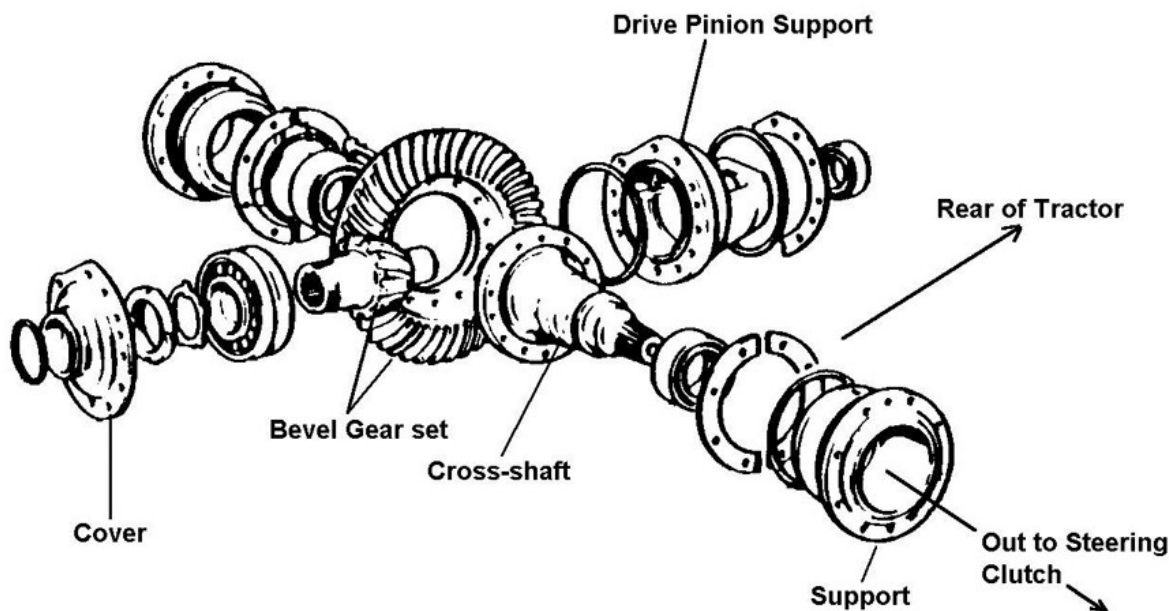


Figure 1-26. Drive gears.

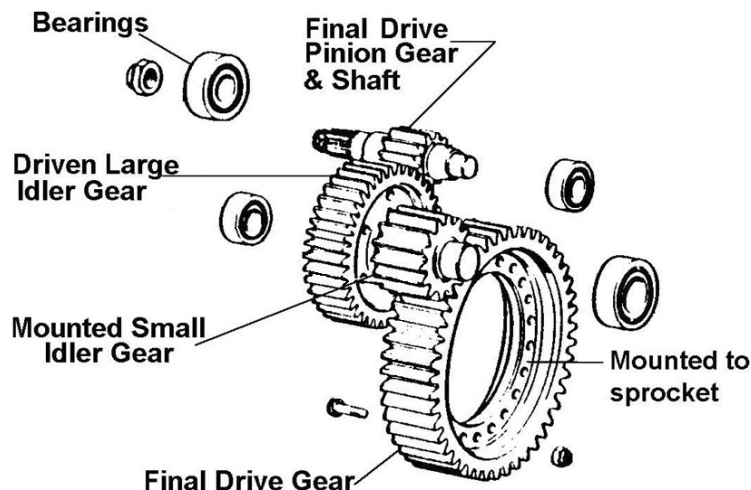


Figure 1-27. Double reduction spur-type gears.

### Steering and braking

Turning the crawler is accomplished by slowing or stopping one track at a time. In order for this to be possible, the steering clutch packs (fig 1-28) must be allowed to slip or be independently disengaged. When you press on the left or right steering pedals, the steering modulating valve opens, causing oil to flow from the transmission to the steering clutch pack. The increased oil pressure in the clutch pack overcomes the spring tension on the pressure plate, causing it to release. The amount of clutch release depends on the amount of pressure applied to the foot pedals. When adjusted properly, three inches of steering/brake pedal movement causes complete release of the clutch pack.

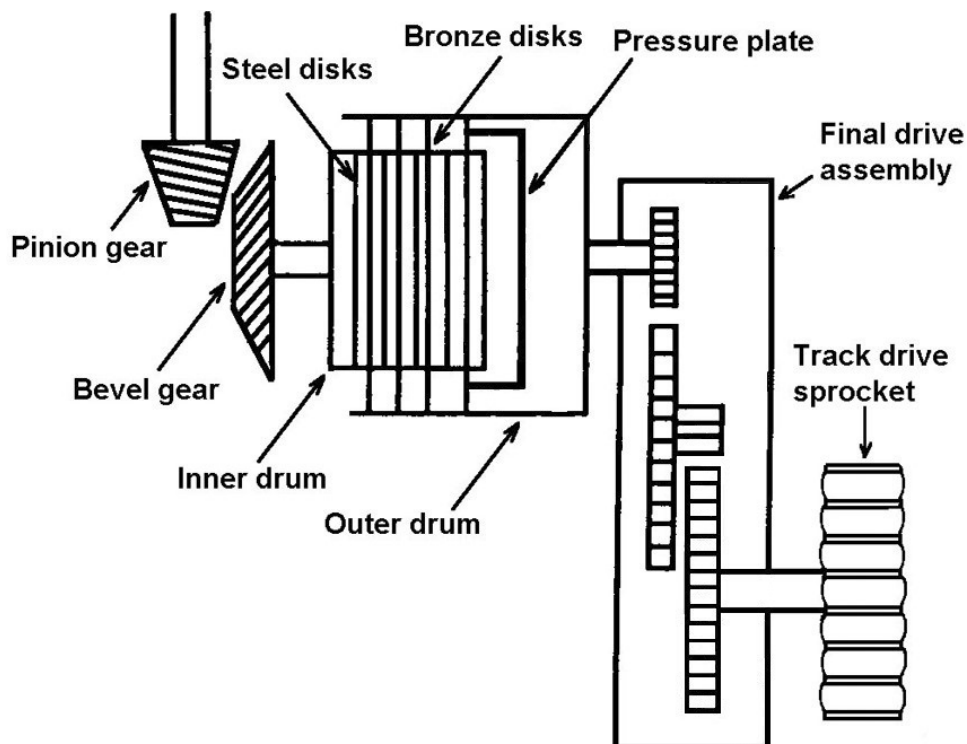


Figure 1-28. Steering clutch.

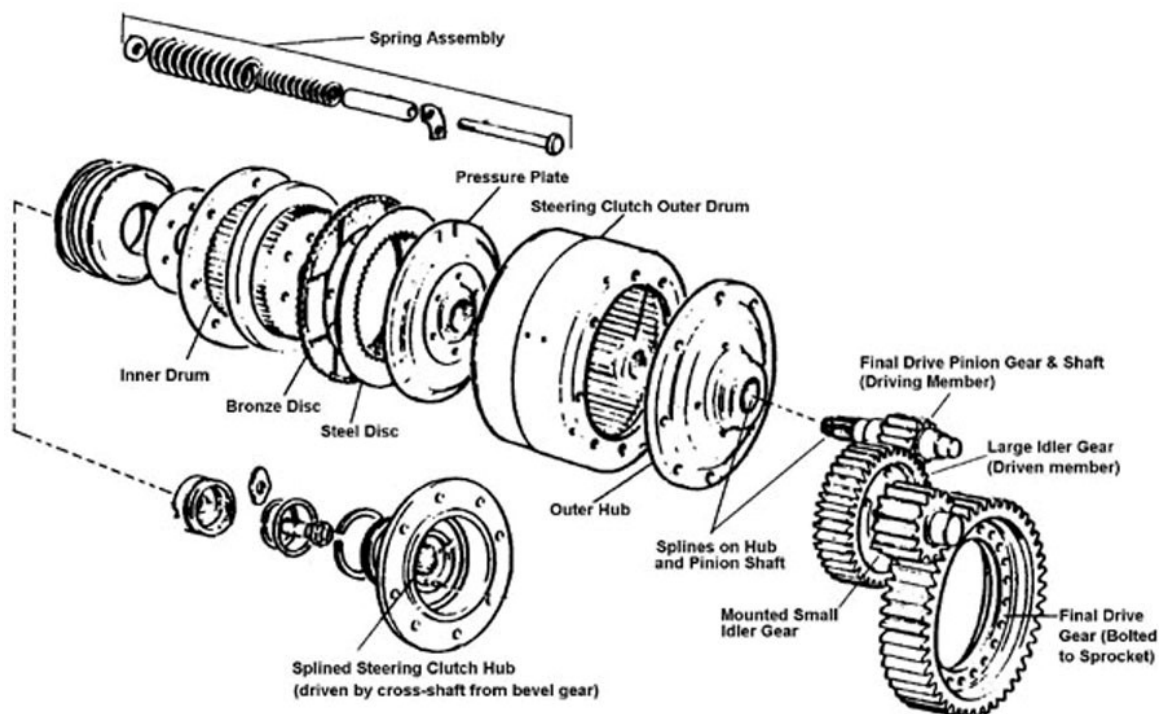


Figure 1-29. Steering clutch with final drive gears.

### *Steering clutch*

The steering clutch pack (fig 1-29) is composed of an inner drum, steel clutch discs (driving member), bronze clutch discs, a pressure plate, springs, and an outer drum. The inner drum is splined and driven by the bevel gear. Splined to the inner drum are a series of steel discs. Between each of the steel discs is a bronze disc. The bronze discs (driven member) push on the clutch discs with enough pressure to prevent any slippage between the discs. The steering clutches are spring applied and hydraulically released by fluid pressure from the transmission. As long as the pressure plate engages the clutch pack, the power flows from the bevel gear to the inner drum, through the clutch pack, to the outer drum that is connected to the final drive gears. In figure 1-28, you can see how the clutch pack drives the final drive pinion gear.

### *Mechanical band brake*

If you press the steering/brake pedal more than three inches, a mechanical band brake is applied (fig. 1-30). This band brake is an external contracting type that is mechanically applied and hydraulically released. The brake band is positioned around the outer steering clutch drum to prevent movement of the outer drum, final drive assembly, and track assembly when applied during turns or when stopping. Even though some hydraulics are used in this brake system, it is still considered a mechanical-type brake system.

### *Automatic brake release*

The tractor brakes are released automatically by hydraulic pressure any time you shift the transmission into forward or reverse. Movement of the steering/brake pedal more than three inches cuts off oil flow to the hydraulic cylinder holding the brake band in the released position. Spring pressure then causes the band brake to contract around the outer drum, preventing it from moving.

### Pivot turn

Application of only one of the brakes allows the tractor to make a pivot turn. The pivot turn is the sharpest turn you can make with a crawler tractor. Pushing the brake pedal closer to the floor increases the degree of the turn by slowing or stopping one of the tracks. The tracks on the crawler cannot be made to rotate in opposite directions. Avoid making sharp turns on asphalt or concrete as such turns can tear up these surfaces.

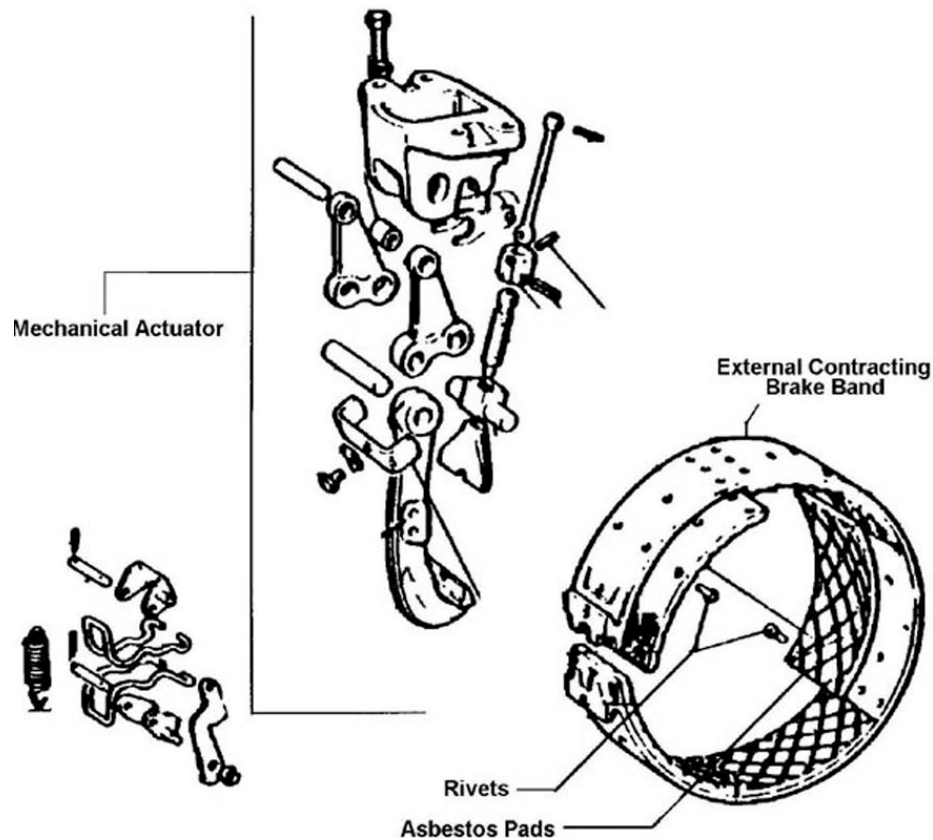


Figure 1-30. Mechanical band brake band.

### Drive sprocket

The drive sprockets are the large-toothed wheels located at the rear of the track frame and are the components that provide the connection between the final drive assembly and the track. Left and right final drive output shafts drive the sprockets. The teeth of the sprocket fit over the pin bushings of the track chain. This is based on the same principle as a bicycle sprocket and chain setup. The teeth of the drive sprocket pull on each of the track chains to move the track in the desired direction.

### Track chain

In order for the power in the final drive sprocket to be transferred to the track shoes, there must be a method of attaching the shoes to the power source. The track chain provides this method, as shown in figure 1-31. The shoes are bolted to the chain with special hardened bolts. The chain is made of hardened steel and held together with machined pins that are about 1½ inches in diameter. One link and one pin are known as the “master link.” This link is the initial disassembly point of the track chain and is used to break the track apart to replace the chain or perform maintenance on any of the track support rollers and guides. Disassembly must be done in accordance with the applicable technical data to avoid damage to the equipment and injury to personnel. As mentioned in the

previous paragraph, the pin bushings between the track links are driven by the teeth on the final drive sprocket (fig. 1-32).

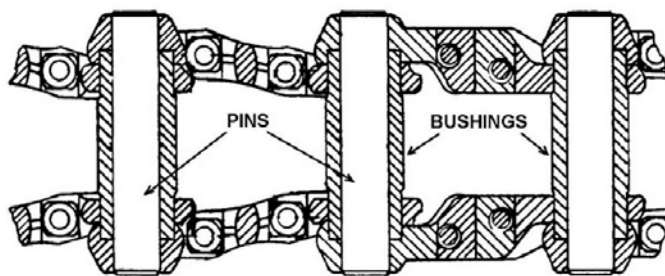


Figure 1-31. Track chain link.

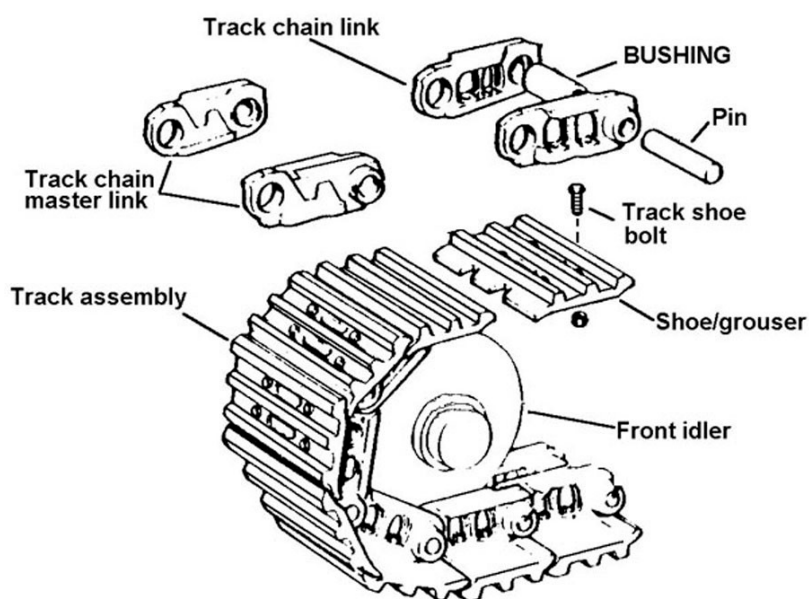


Figure 1-32. Track bushings.

### Track shoes

The shoes are the large, flat metal plates that mount on the track chain on which the crawler tractor rides. The shoes have raised bars, called *grousers*, to grip the ground. Different grousers are used for different surfaces. A vehicle operated on stable, hard ground, such as a gravel yard, may use three short grousers per shoe. Operating in soft terrain may use a shoe with one very tall grouser for maximum traction (fig. 1-33).

### Offset track shoes

Offset track shoes are similar to standard track shoes with the exception of the shoe bolt holes being offset from the center position. The offset shoes are intended for use on larger tractors primarily.

### Track shoe bolts

Track shoe bolts must be kept tight to eliminate a source of damage to the track shoes and links. On a new track, torque the bolts to specifications after each day of operation until they become seated on the shoe.



### **Reconditioning shoes**

Worn track shoes can be reconditioned to regain traction. This consists of welding preformed grouser bars or steel bar stock on the grousers. Recondition grousers in this manner when they are worn to within  $\frac{3}{4}$  of an inch of the shoe. Allowing the grousers to wear any closer may cause the loss of the structural strength and bending of the shoe.

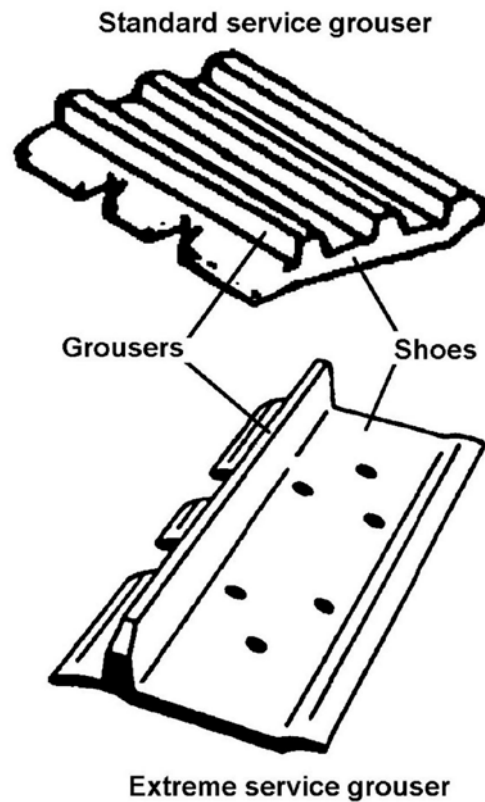


Figure 1-33. Different service grousers.

### **Track frame**

The track frame provides the needed support and rolling capability for the track to rotate. The track frame is a rigid unit, solid mount, which is composed of an idler roller, carrier rollers, track rollers, recoil spring, track tension adjustment mechanism, and assorted shims and bearings.

### **Idler roller**

The front idler provides a freely rotating combination guide and support for the track chain. In conjunction with the recoil spring, the idler protects the track mechanism from damage or shock. When the front idler receives a shock load, the force is transmitted to the track spring by a slide-mounted mechanism to which the idler is attached as shown in figure 1-34.

Keeping the idlers in proper alignment is *very* important. A misaligned idler causes wear on the front idler center flange, the sides of the track links, and the sides of the roller flanges. Typically, these idlers are sealed and do not require lubrication.

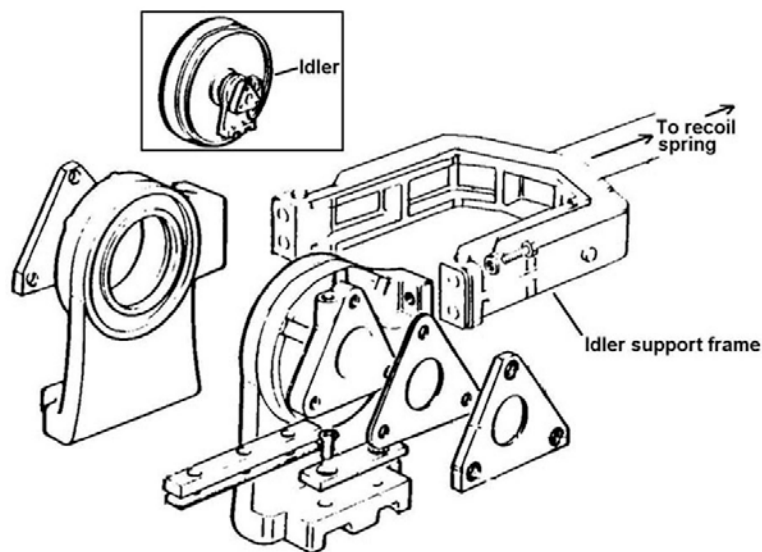


Figure 1-34. Front idler and support frame.

### *Carrier rollers*

The carrier rollers are used to carry the weight of the track over the top of the frame. Without the carrier rollers, the track would have an excessive amount of sag. Operating the crawler in conditions that applies a side thrust to the tracks, such as traversing on an incline, would cause the track to be thrown off the frame.

### *Track rollers*

The track rollers are used to distribute the weight of the vehicle over a large ground area, much the same as a snowshoe allows someone to walk across the snow without sinking. The crawler uses six track rollers. The track rollers may be the single- or double-flanged type as shown in figures 1-35 and 1-36. This model requires the rollers to be lubricated with 30-weight oil. Check this fluid level at the pipe plug on the roller.

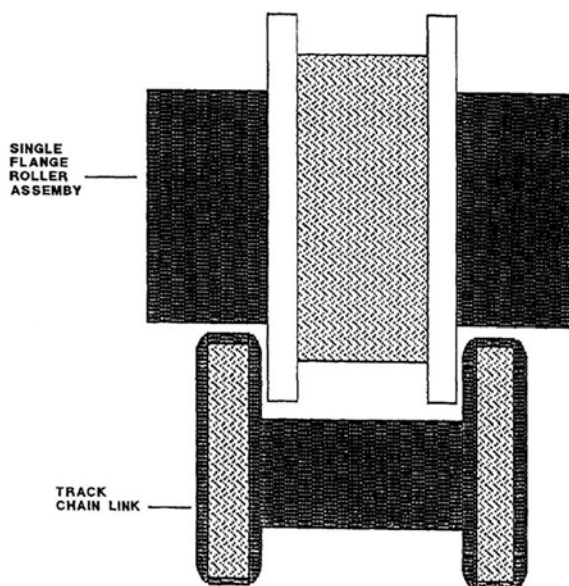


Figure 1-35. Single flange roller.

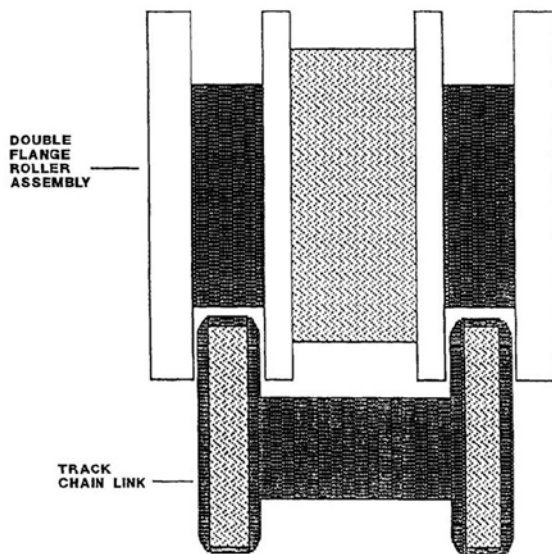


Figure 1-36. Double flange roller.

Check the carrier and track rollers for signs of uneven wear, freedom of rotation, security of mounting brackets, and alignment. If a roller stops turning for any reason, the track moving across it will wear a flat spot on it. Mud freezing around these components may cause this to happen. Typically these rollers are sealed and do not require lubrication.

### *Recoil springs*

The recoil spring and spring seats are located approximately in the center of the track frame group. The length of the recoil spring is controlled by a recoil spring stop and is adjustable. This crawler uses a hydraulic cylinder and relief valve to control this distance. However, you must inject grease instead of using hydraulic fluid to adjust the recoil spring length.

**CAUTION:** Use extreme caution around the recoil springs. The assembled spring force of the spring ranges from 25,000 to 38,000 pounds.

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## Self-Test Questions

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

### 203. Cab controls

1. What is the difference between the modern crawler tractors and the older model earth moving tractors?
2. How do you determine which side of the tractor is left and right?
3. What does an operator use to steer a crawler tractor?



4. What notifies the operator of a tractor system malfunction such as a fluid level or fluid pressure problem in the engine, transmission, or torque converter?
5. What is the purpose of a transmission manipulator?
6. How many speeds does the transmission have?
7. What type of parking brake is used on the crawler tractor and when does this brake automatically applied?
8. What makes the crawler tractor differ from a bulldozer in regards to its capabilities of moving materials?
9. What is the purpose of the clamshell attachment?
10. On the crawler tractor, how is the winch driven and where is the winch located?

#### **204. Powertrain and final drive assembly**

1. Why is a crawler tractor powered by a diesel engine rather than a gasoline engine?
2. What makes the crawler tractor cooling system unique?
3. In which direction do you direct the cooling system fan's airflow for summer operation?
4. What voltage is required for the crawler tractor's starting system?

5. What type of hydraulic control system is used for the tractor components and attachments? List the components and attachments that utilize this system.
6. What type of hydraulic pump is used for the attachments and where is it located?
7. What controls the forward and reverse speeds of the crawler tractor transmission?
8. What gear type is used in the final drive assembly of the crawler tractor?
9. How is turning of a crawler tractor accomplished?
10. How are the steering clutch packs engaged and released?
11. What is the purpose of the master link in the track chain?
12. What are grousers, and what is their purpose on the crawler tractor?
13. What is the purpose of the crawler tractor front idlers?
14. Describe how the front idler is able to absorb the forces of an impact without damaging the tractor?
15. What is the likely result of improper front idler alignment?

16. What are the carrier rollers used for on the crawler tractor?

17. What are the track rollers used for on the crawler tractor?

## 1-2. Hyster 10K Standard

This section covers one of the most common forklifts in the Air Force inventory—the Hyster H155XL 10K forklift. This piece of equipment is designed for use in areas with improved or finished paths of travel, such as warehouses, a cargo yard, or a loading dock. No matter where your Air Force career takes you as a vehicle maintainer, you are likely to find a Hyster 10K forklift.

### 205. Hyster 10K fundamentals

The Hyster H155XL (figs. 1-37 and 1-38) is a “standard” forklift that lifts materials using a three-stage telescoping upright with forks on the front to engage the load. This lift configuration allows the load to rise, making it possible to move and stack a load. The maximum stacking height in which the forks can be raised is 150 inches. Its maximum lifting capacity is 10,000 pounds, hence the name 10K. The forklift utilizes rear-wheel steering and front-wheel drive, enabling the vehicle to operate in small areas.

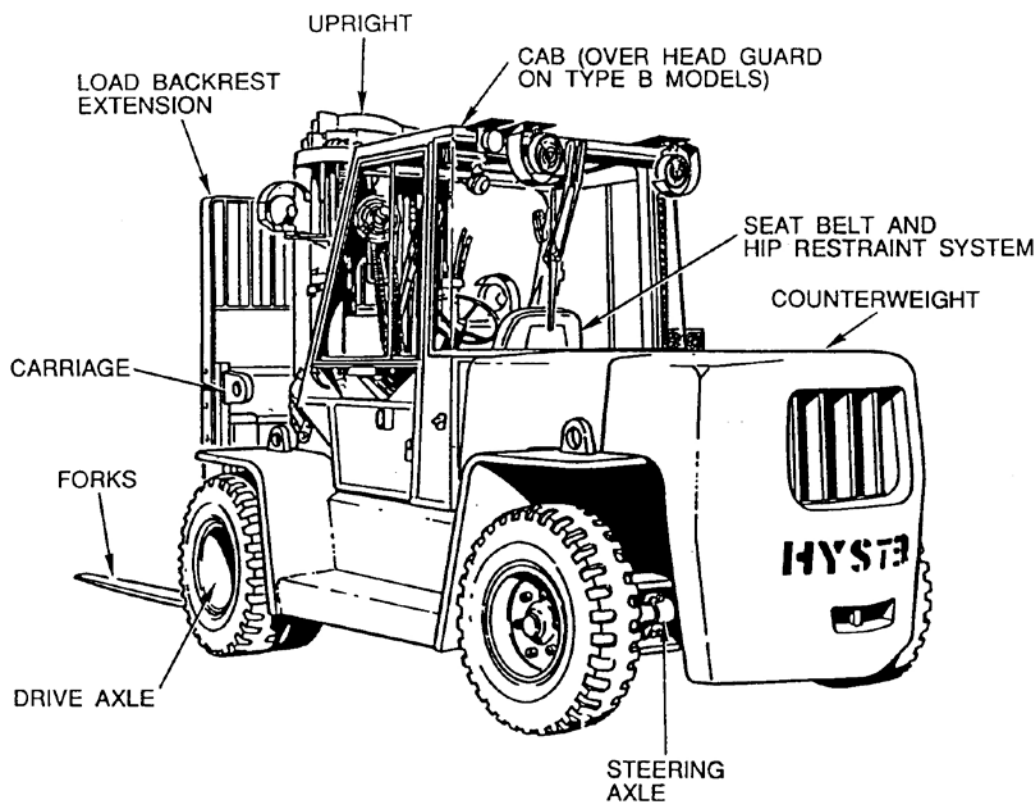


Figure 1-37. Hyster H155XL 10K forklift.

- 1 Chassis Installation
- 2 Engine Installation
- 3 Exhaust System
- 4 Cooling System
- 5 Fuel System
- 6 Air Filter Installation
- 7 Electrical System
- 8 Drive Train Installation
- 9 Brake System
- 10 Steering System
- 11 Hydraulic Pump
- 12 Lift System

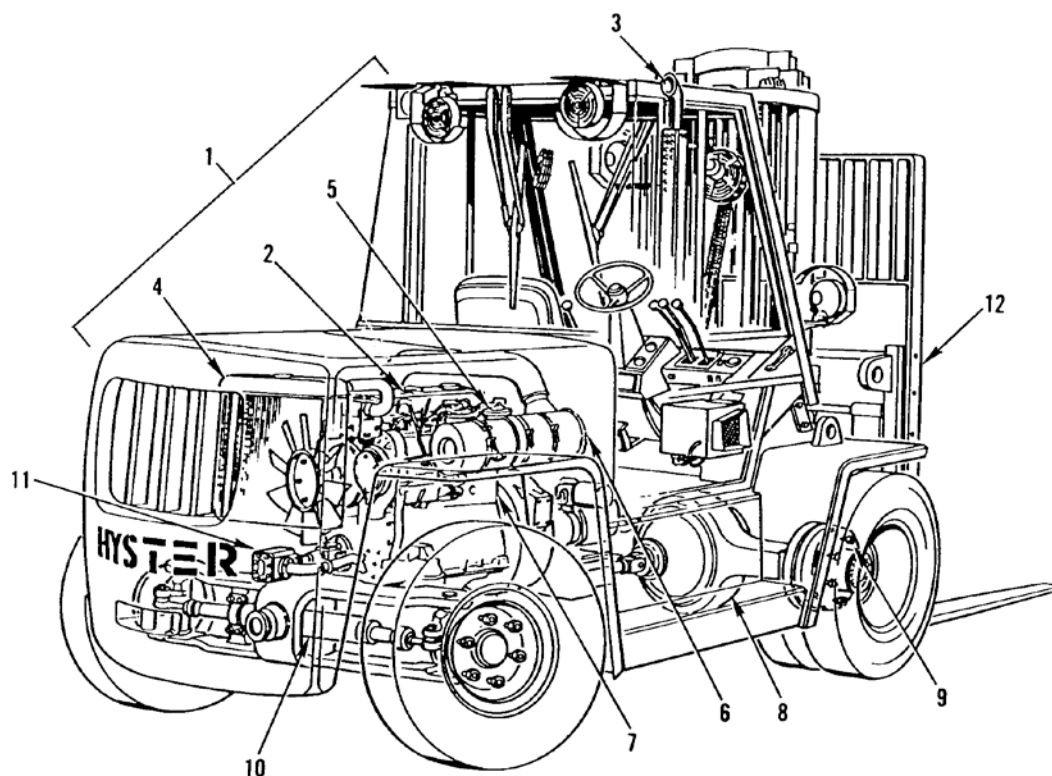


Figure 1-38. Major components.

### Power train

The engine most commonly used in the Air Force version of this particular forklift is the Perkins® model 1004-4 diesel engine. It is a four-stroke, four-cylinder, naturally aspirated engine. Engine generated power is transmitted through the torque converter to a two-speed power shift transmission, two speeds forward, and two speeds in reverse. An inching/brake pedal allows slow travel speed while keeping the engine speed high for efficient operation of the lift mechanism. When you apply the inching/brake pedal, the clutch in the transmission partially disengages; this slows the movement of the lift truck. When you fully apply the inching/brake pedal, the transmission completely disengages and the brakes apply completely. A differential fastened to the axle housing of the lift truck gives a single-speed reduction for an increase in torque to the drive wheels.

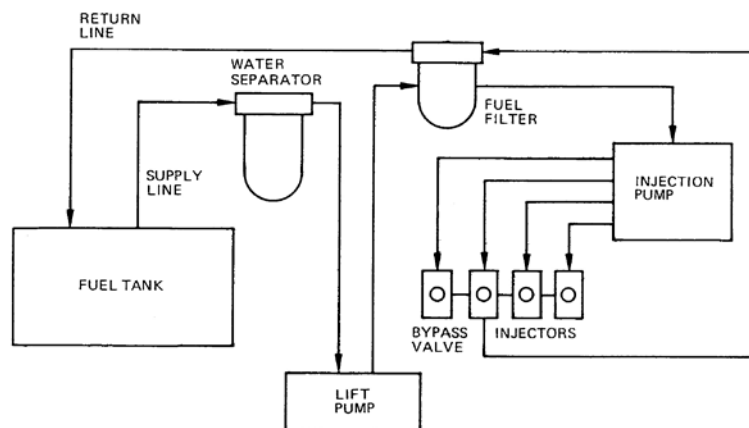


Figure 1-39. Fuel system diagram.

### Fuel system

Refer to figure 1-39 as you cover the fuel system and fuel flow through the system. Fuel flow starts from a 23-gallon fuel tank. The low-pressure lift pump, mounted on the side of the engine block, draws fuel from the tank and forces it through the water separator and fuel filter (fig. 1-40). An eccentric on the camshaft drives the lift pump. Drain plugs located at the bottom of the water separator and fuel filter remove any trapped water. A priming lever on the bottom of the lift pump allows the technician to prime the fuel system by hand (fig. 1-41). One thing to consider is that the priming lever will not work if the camshaft eccentric is pushing against the lift pump's internal rocker lever.

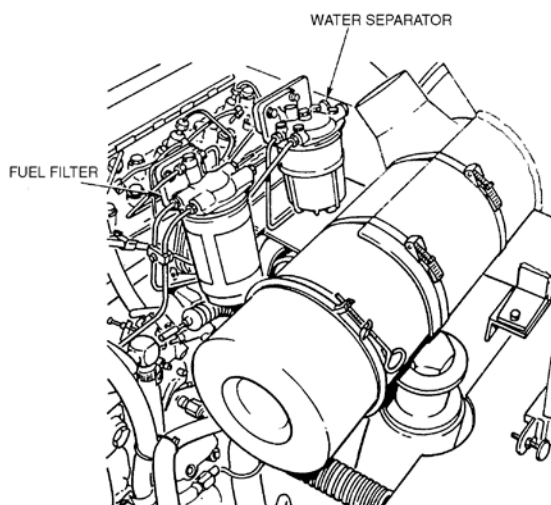


Figure 1-40. Water separator and fuel filter.

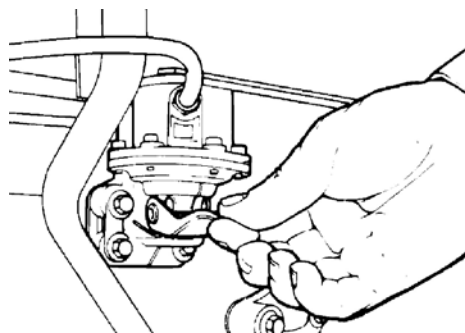


Figure 1-41. Operating the priming lever.

### Electrical system

Refer to the schematic (fig. 1-42), as necessary, to help you understand the electrical components. The forklift has a 12 VDC, negative ground system. Two batteries connected in parallel supply current for starting the engine and operating the controls, lights, and accessories. The positive battery cable connects to the starter solenoid through an emergency disconnect switch. The negative battery cable connects to the vehicle frame.



The emergency disconnect switch is located in the engine compartment (fig. 1–43). Its function is to disconnect the batteries from the rest of the electrical system in the event of an emergency. A mechanical cable that is similar to a choke cable actuates the switch. You can locate the handle end of the cable in the operator compartment. The other end of the cable connects to the switch's lever.



When you pull the cable, the lever on the switch rotates and the internal contacts of the switch disconnect. This causes the main battery power to disconnect from the rest of the electrical system. Additionally, the alternator energize circuit is interrupted.



Figure 1-43. Emergency disconnect switch.

### *Alternator*

The Prestolite® 8E-series internally regulated alternator (fig. 1-44) forms a complete charging system. It is a three-phase, diode-rectified unit, housed between two aluminum end-housings. The rotor, stator, and diode trio function much the same as any other alternator. Two permanently sealed ball bearings support the rotor in the end housings. A plastic cover on the backside of the alternator protects and encompasses the voltage regulator and brush holder assembly. Regulator and brush removal does not require alternator disassembly.

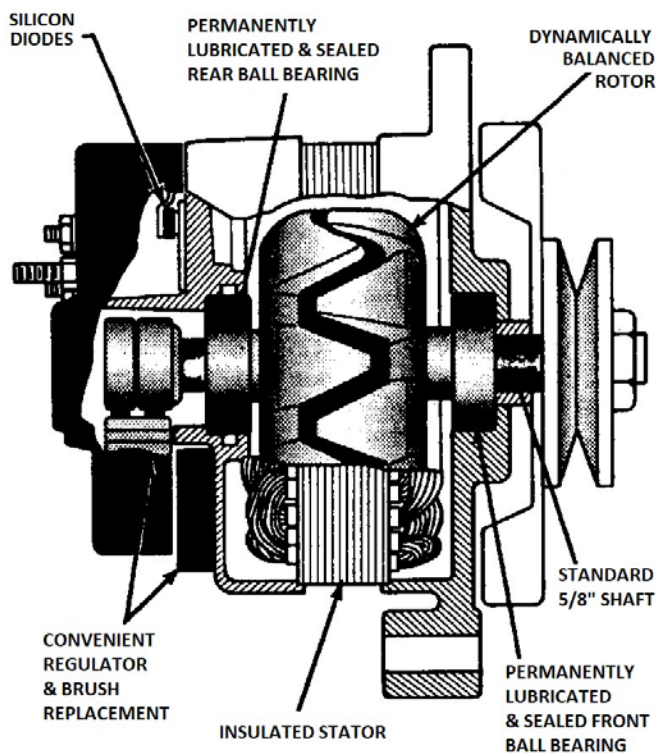


Figure 1-44. Cross-section of Prestolite alternator.

Alternator wiring is incorporated with the emergency electrical disconnect switch; this allows the field circuit to be disconnected in case the switch is tripped by the operator. The alternator electrically links to the switch through two orange wires (fig. 1-45). Notice, in figure 1-45, that the two orange wires from the alternator lead directly to the emergency disconnect switch. A set of contacts in the emergency disconnect switch provide continuity between the orange wires all the time (unless the switch is tripped). One of the orange wires connects to the alternator's D+ terminal, and the other connects to the field terminal. The alternator will not charge unless there is an electrical connection between the D+ terminal and the field terminal. You will notice that the D+ terminal connects to the diode trio.

The diode trio "taps" into the stator's charging current and supplies this current to the field circuit through the orange wires. Refer to figure 1-45. When starting the forklift and the ignition switch is in the RUN position, current from the ignition switch feeds into the voltage regulator. The voltage regulator allows a small amount of this ignition current to flow into the rotor to make the alternator initially start charging. As the alternator begins to charge, the diode trio takes some of the "charging current" and feeds it back into the field winding (through the orange wires). Current into the field winding is supplied fully by the diode trio after the alternator begins to charge. The voltage regulator controls the amount of current flowing through the field circuit by turning the "ground" end on and off (making this an A-circuit alternator).

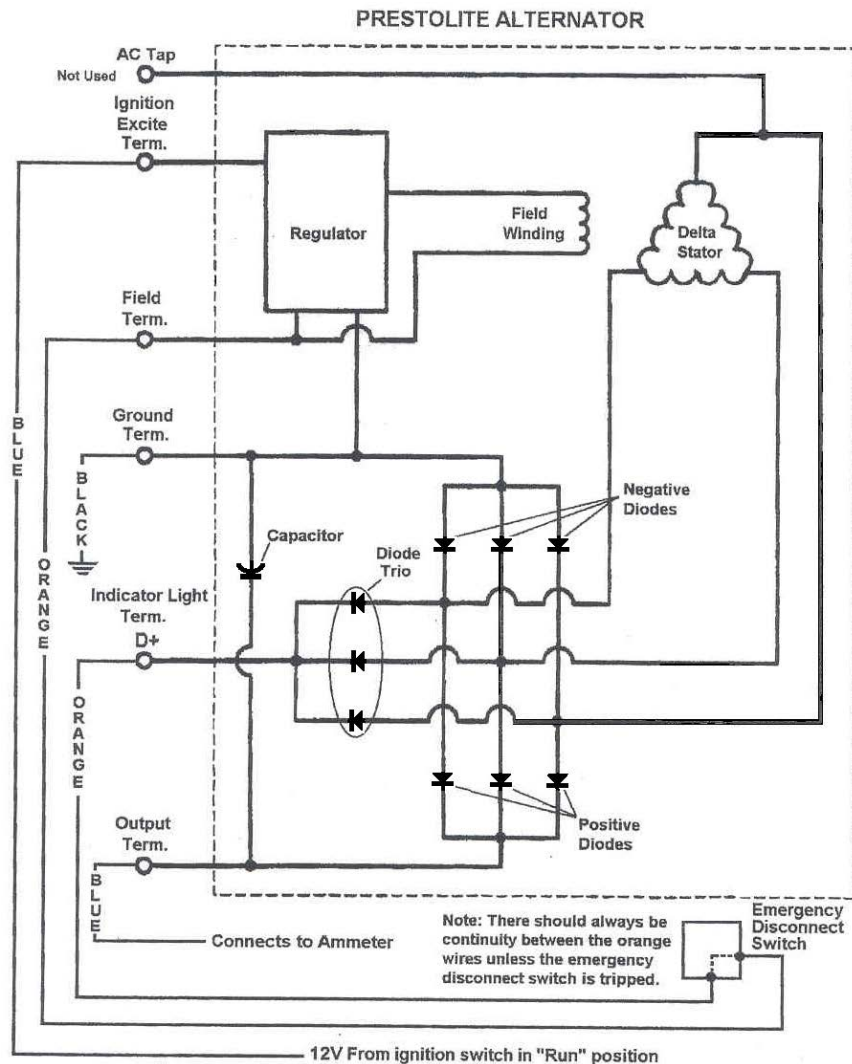


Figure 1-45. Alternator schematic.



## Hydraulic system

The hydraulic system (fig. 1-46) includes the circuits for the upright functions, steering system, and hydraulic brake booster. Two hydraulic pumps supply the flow of oil for the components of the hydraulic system. A small drive shaft connected to the engine crankshaft pulley drives the main hydraulic pump. The engine timing gears drive the hydraulic pump for the steering-and-brake booster.

As with all hydraulic systems, there must be a way to control pressure by relieving excess pressure. The relief valve for the main pump/main hydraulic system is in the main control valve. The relief valve for the steering system is located in the steering pump. Both pumps get their oil supply from the hydraulic tank. Oil that returns to the tank flows through the hydraulic filter located in the hydraulic tank.

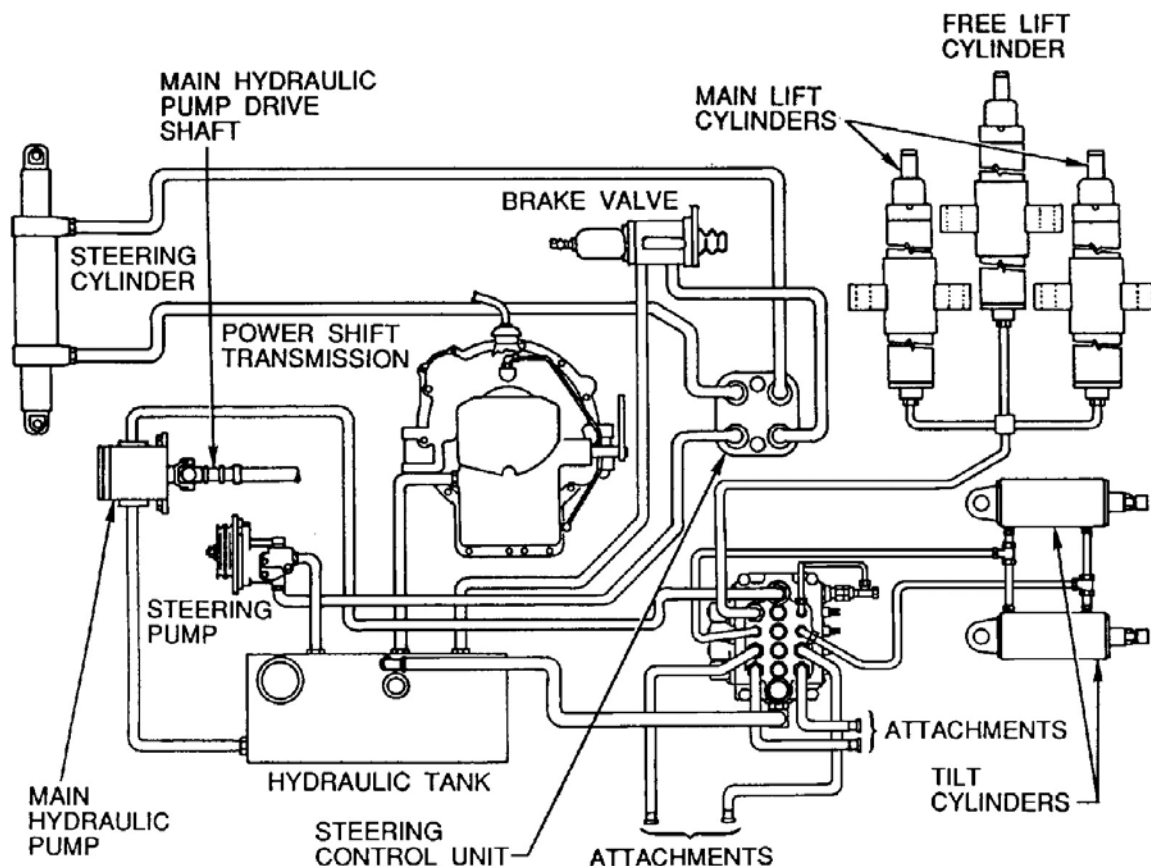


Figure 1-46. Hydraulic system.

## Main hydraulic pump

The main hydraulic pump is a gear-type pump (fig. 1-47). The major components are the gears, gear housing, and end covers. The input shaft and driving gear are one assembly. Seals in the pump prevent leaks between the different components. The front cover contains a lip seal to prevent leakage between the front cover and the drive gear's shaft. The hydraulic oil inlet and outlet ports thread into the gear housing. The pump's inlet port is connected by line to the hydraulic tank. The pump's outlet port is connected by line to the main control valve.

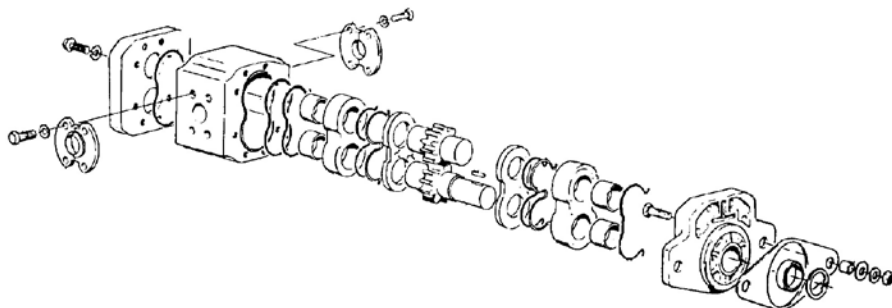


Figure 1-47. Exploded view of hydraulic pump.

### Steering pump

The steering pump is a vane-type pump (fig. 1-48). It mounts to the engine's timing gear case directly underneath the fuel injection pump and supplies oil to the steering control unit and hydraulic brake booster. The pump's main components are the housings, pressure plate, cam ring, rotor with vanes, and shaft. The cam ring, pressure plate, and rotor/vanes fit between the housings. Pump operation is similar to other vane pumps. As the shaft rotates, the rotor and vanes turn within the cam ring. Centrifugal force causes the vanes to follow the inside surface of the cam ring. The vanes pick up hydraulic oil and force it through the pump's outlet port.

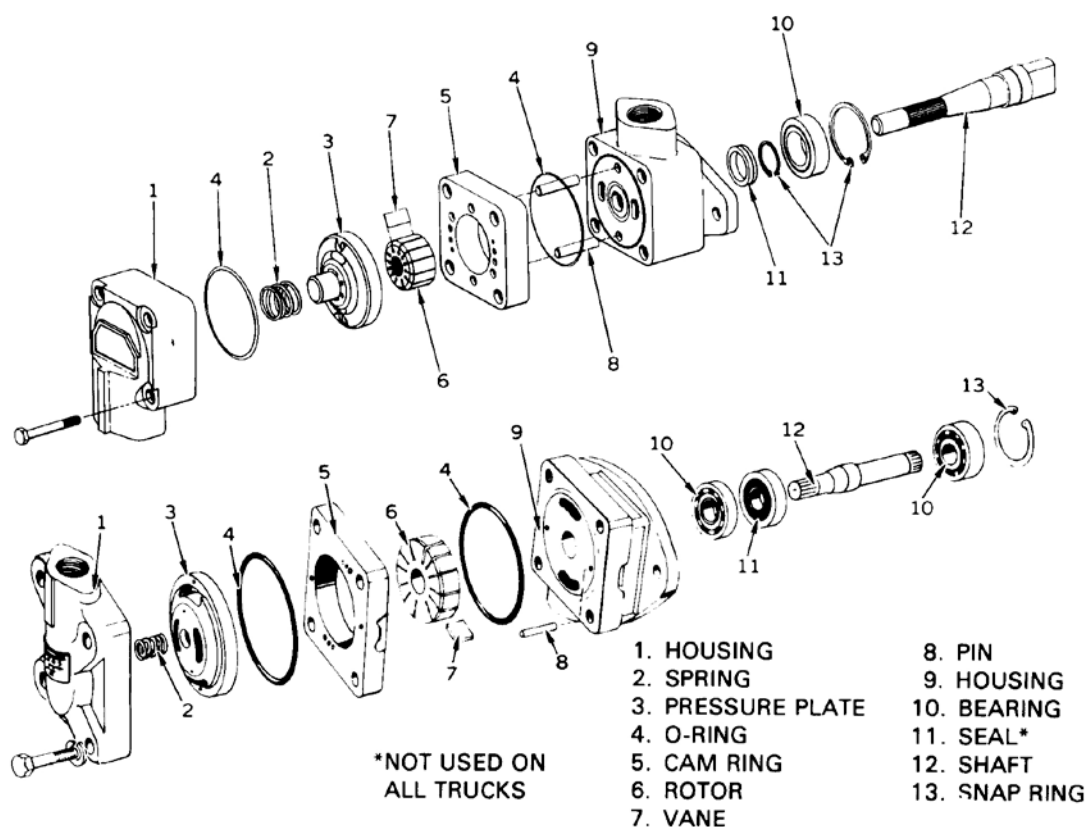


Figure 1-48. Exploded view of steering pump.

### Main control valve

The main control valve (fig. 1-49) is an open center, four-function valve. It controls the operation of the lift cylinders, tilt cylinders, side shift cylinder, and fork spread cylinder (if equipped). The parts of the control valve include the body, four spool valves, a load check valve for each spool, and a two-stage relief valve. Each spool controls a different (separate) hydraulic function. The spools are

connected to external linkages, which are, in turn, connected to each of the control levers. When a control lever is moved, a spool valve moves within the body and allows oil to flow to a hydraulic cylinder(s). A spring inside the control valve, for each spool, returns the spool to the neutral position when the control lever is released. As mentioned earlier, the control valve is an open center valve. When the spools are in the NEUTRAL position, the oil from the pump flows through the valve with minimum restrictions. The oil leaves the valve and returns to the hydraulic tank. All of the spools are in “hydraulic series” with each other.

A two-stage relief valve is attached to the main control valve. This relief valve has an adjustment for the maximum pressure in the lift system and a second adjustment for the pressure in the other hydraulic circuits (tilt, side-shift, fork-spread).

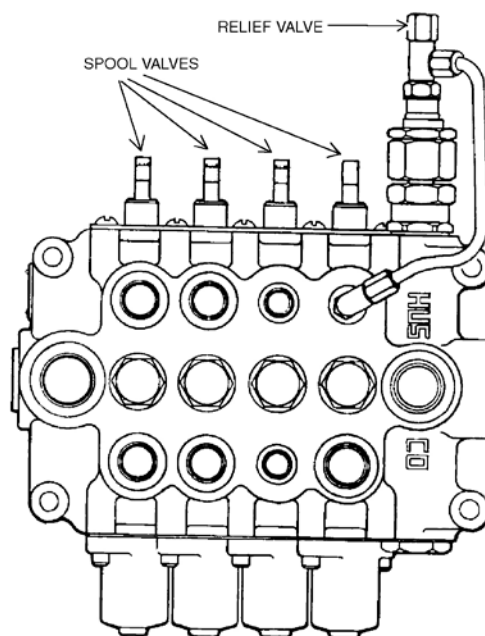


Figure 1-49. Main control valve.

### *Lift system*

Refer to figure 1-50. The forklift has a three-stage upright composed of three hydraulically controlled telescoping vertical frames (weldments):

1. Outer.
2. Intermediate.
3. Inner.

Three single-acting lift cylinders on the upright raise the carriage and extend the telescoping weldments. Load rollers reduce the friction between the channels when the weldments move vertically. In addition to lifting, the complete upright can be tilted forward and backwards by the use of two double-acting tilt cylinders between the frame of the forklift and the outer weldment. The “pivot mounts” at the bottom of the outer weldment connect the upright to the forklift. When the upright is tilted, it rotates on the pivot pins.

The carriage is a separate section that moves within the vertical channels of the inner weldment. The forks are one of the components that attach to the carriage. A double-acting side shift cylinder allows the carriage to move horizontally (from left to right or right to left). A double-acting fork-

spread cylinder allows the forks to spread apart or retract in allowing the operator to change the position of the forks to match varying load widths.

### *Fail-safe relief valve*

In the event of a hydraulic failure (for instance, if a hose to a lift cylinder breaks) while a load is elevated, the lift cylinders are equipped with a fail-safe relief valve, preventing the carriage from quickly dropping. These are check valves operated by hydraulic pilot pressure. During normal operation, the engine must be running to lower the carriage for pilot pressure to open the valves. However, there is a manual override feature built into the valves (fig. 1-51). You can manually lower the upright by using the fail-safe extension tool located under the operator's seat.

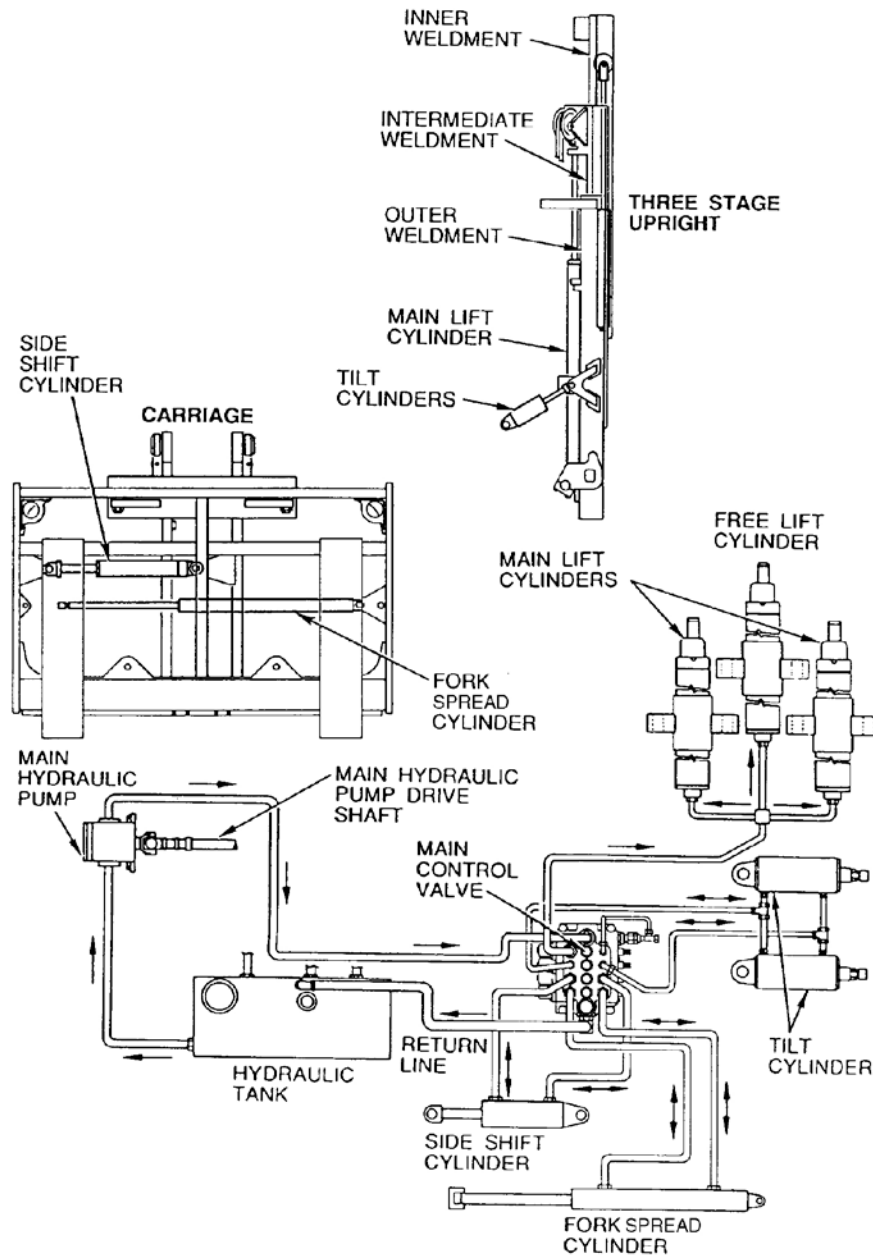


Figure 1-50. Lift system.

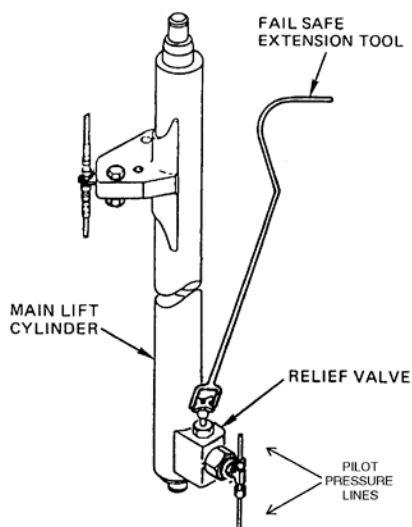


Figure 1-51. Fail-safe relief valve.

### *Steering control valve*

The forklift is equipped with an “all-hydraulic” steering system (fig. 1-52). In other words, there is no mechanical connection between the steering valve and the steering axle/cylinder. The steering valve (also known as the steering control valve), located at the bottom of the steering column, supplies hydraulic oil to the steering cylinder depending on which way you turn the steering wheel. When you turn the steering wheel, oil flows through the steering valve and back to the hydraulic tank freely. If the steering pump fails or the engine quits, steering is still possible. A check valve arrangement in the steering valve allows the steering system to operate without any power assist. However, without power assist, the steering wheel is difficult to turn.

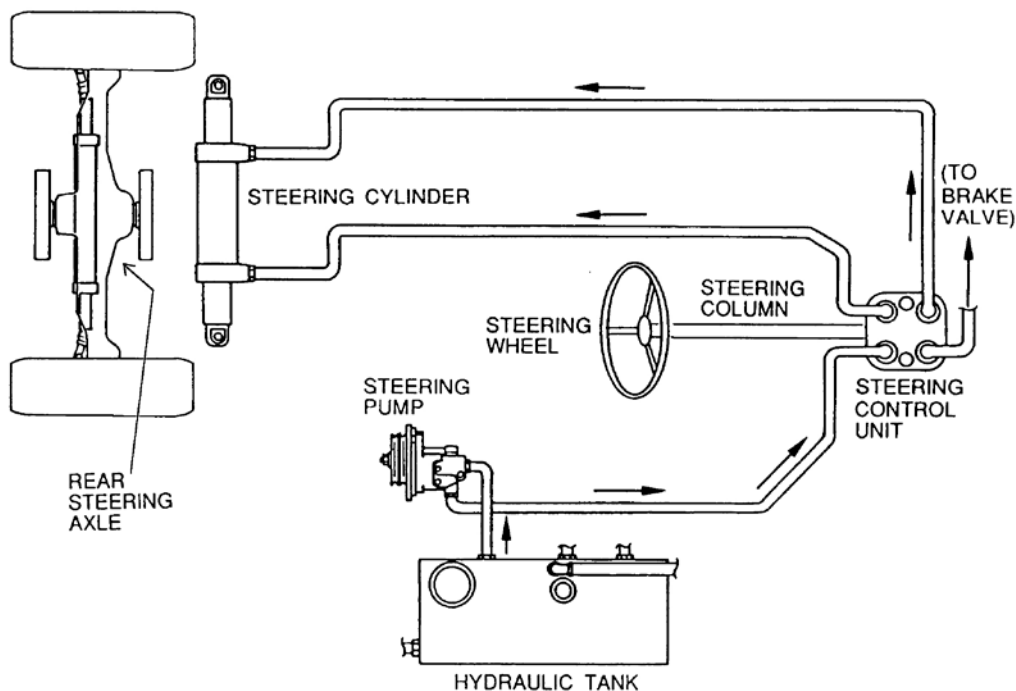


Figure 1-52. Steering system diagram.

## Self-Test Questions

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

### 205. Hyster 10K fundamentals

1. What is the most commonly used type of engine in the Hyster 10K forklift?
2. What component on the bottom of the Perkins 1004-4 engine lift pump allows you to prime the fuel system by hand?
3. What type of electrical system does the Hyster 10K forklift have?
4. How does the operator activate the emergency disconnect switch?
5. What two terminals of the alternator connect together through the orange wires?
6. What component drives the main hydraulic pump?
7. What type of pump is the main hydraulic pump?
8. What type of pump is the steering pump?
9. How many spool valves are contained inside the main control valve?

10. Where is the two-stage relief valve located?
11. How many lift cylinders are used to raise the carriage?
12. What type of hydraulic cylinder is the side-shift cylinder?
13. Where is the fail-safe relief valve's extension tool located?
14. Where is the steering valve located?

### 1-3. Adverse Terrain Forklift

The adverse terrain is another common type of forklift in the Air Force. Its ability to travel over rough ground makes it a vital asset where terrain is a limiting factor.

#### 206. Caterpillar adverse terrain forklift

This lesson covers the basic functions of the Caterpillar (CAT) IT28 adverse terrain forklift (fig. 1-53). This forklift is designed to operate over rough terrain and has the same lifting capacity as the Hyster 10K. This capability is useful in forward operating locations where modern roadways are not accessible. This asset also has electronic controls where other forklifts use mechanical controls.

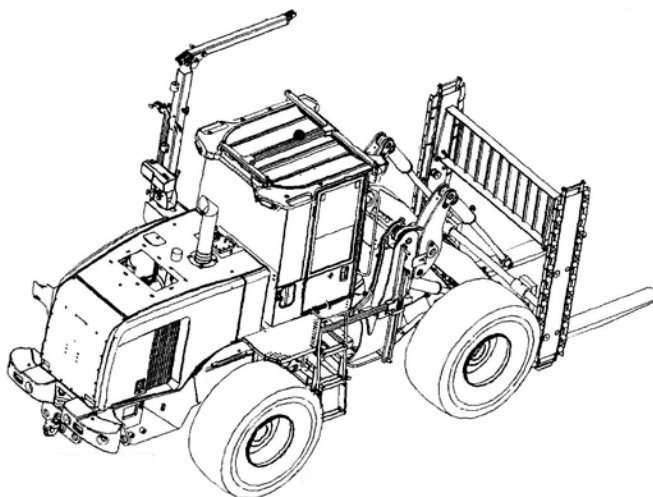
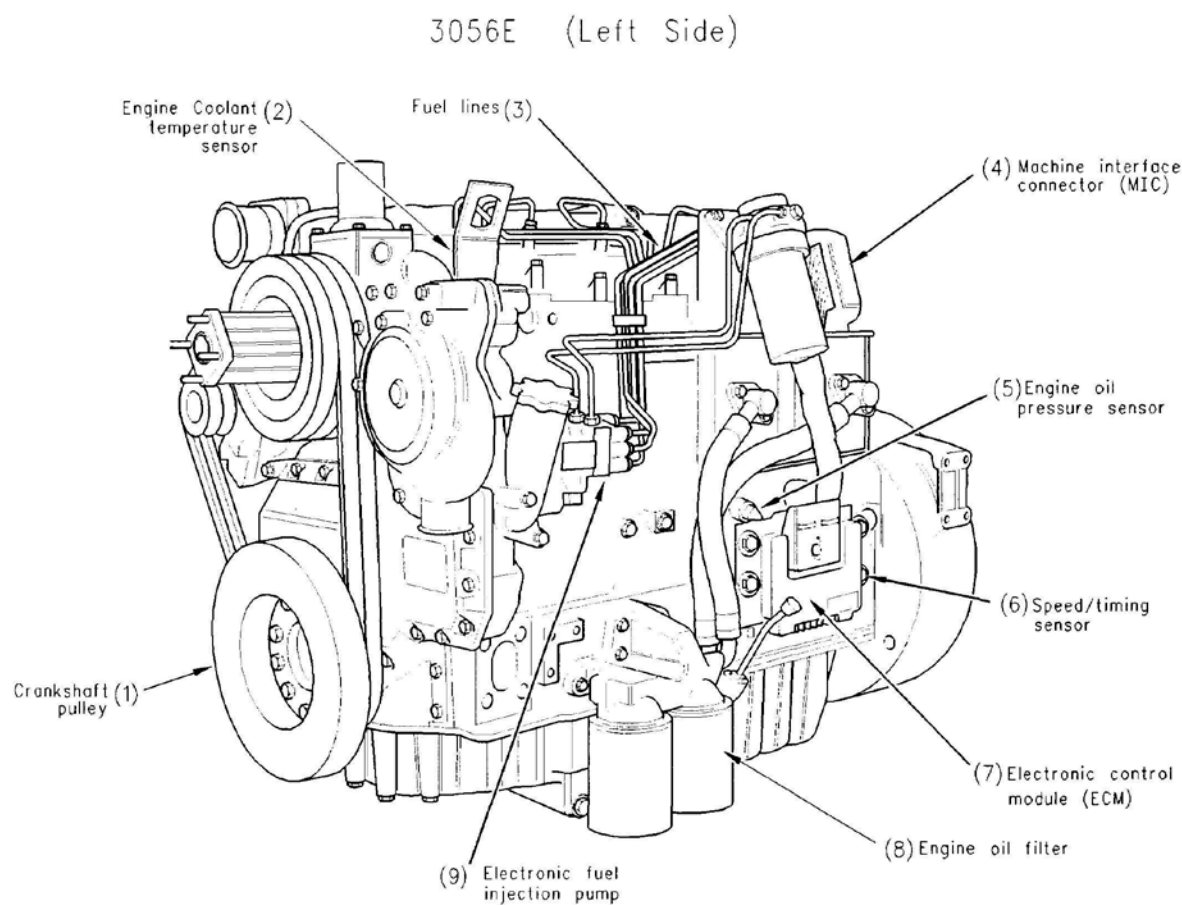


Figure 1-53. Caterpillar adverse terrain forklift.



## Description

The power train consists of the engine, a countershaft transmission, driveline, differentials, and axle assemblies. The engine (fig. 1-54) is a CAT 3056E in-line, electronically controlled, six-cylinder diesel. Unlike previous computer controlled CAT engines, this one is equipped with an ECM to control the fuel pump and engine rpm. The transmission is a power shift type, with four forward speeds and three reverse speeds. It has five shafts consisting of an input shaft assembly, output shaft assembly, and three gear shafts. The torque converter turbine drives the input shaft assembly. The power from the transmission goes to both front and rear assemblies, which contain standard differentials. This setup allows the forklift to have four-wheel drive at all times. Both axles contain two planetary gear sets for gear reduction and disc service brake assemblies. The service brake discs are located inside the differential carrier and are the wet-disc style. The parking brake is a two-shoe, internal expanding-type assembly mounted on the output shaft of the transmission. The brake is applied with a manual lever and cable assembly. This vehicle is not equipped with a chassis air system.



Left side view of the 3056E engine

- (1) Crankshaft pulley
- (2) Engine coolant temperature sensor
- (3) Fuel lines

- (4) Machine interface connector (MIC)
- (5) Engine oil pressure sensor
- (6) Speed/timing sensor

- (7) Electronic control module (ECM)
- (8) Engine oil filter
- (9) Electronic fuel injection pump

Figure 1-54. CAT 3056E diesel engine.

## Electrical system

The electrical system is 24 VDC with two batteries wired in series. One battery is located on each side of the rear of the forklift. Circuit breakers and fuses protect the system. The circuit breakers are located on the left hand side of the forklift below the winch and crane. The main circuit contains a 60-amp breaker and the alternator circuit contains a 90-amp breaker. The cab contains all the controls (fig. 1-55) for the vehicle, except for the battery disconnect switch, which is located in the engine compartment. The fuse panel is located in the console on the right side of the cab. To jump-start the forklift, a NATO jump-start receptacle (fig. 1-56) is located on the left side of the cab below the winch and crane assembly.

**WARNING:** This forklift has a 24-volt starting system. Use only equal voltage for jump-starting. The use of a higher voltage will damage the electrical system.

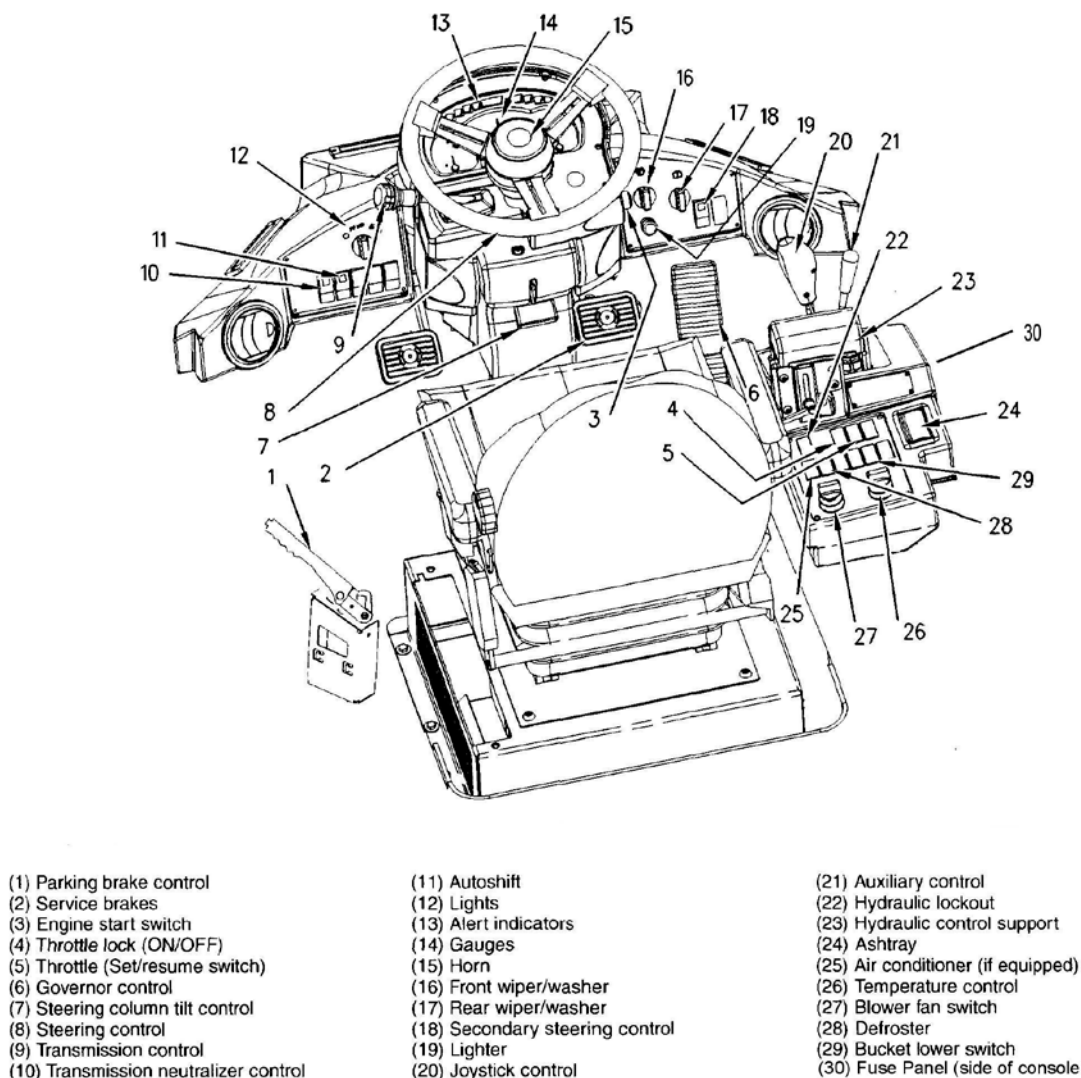


Figure 1-55. Cab interior controls.

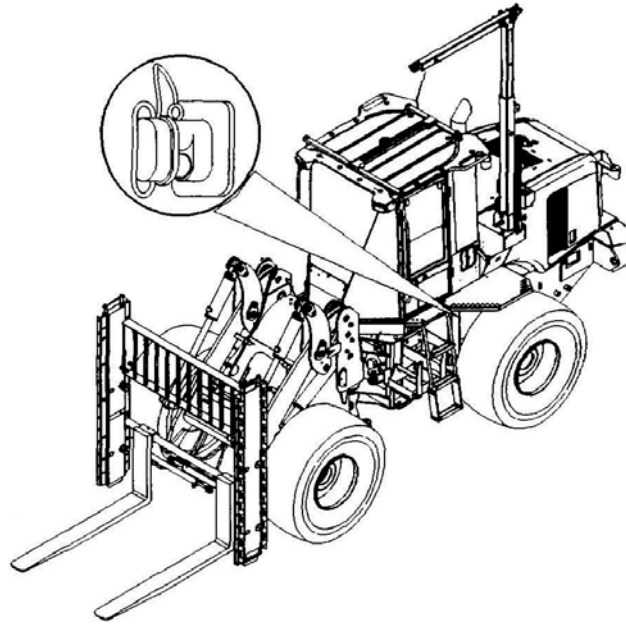
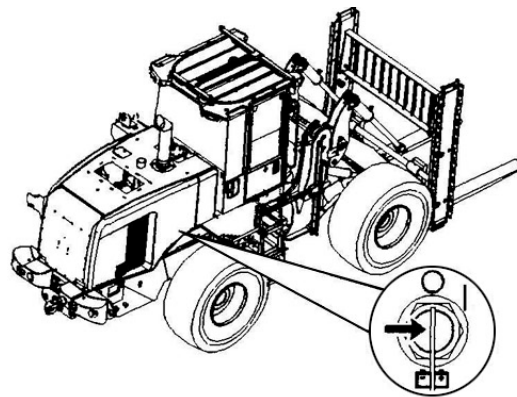


Figure 1-56. NATO jump-starts receptacle location.

### *Battery disconnect switch*

To access the battery disconnect switch, open the access cover on the right side of the engine compartment (fig. 1-57).



Open the access cover on the right side of the forklift. The battery disconnect switch is located in the engine compartment.



-  ON – Turn the battery disconnect switch clockwise in order to activate the electrical system. The switch must be ON before you start the engine.
-  OFF – Turn the battery disconnect switch counterclockwise to turn off the entire electrical system.

Figure 1-57. Battery disconnect switch.

The battery disconnect switch and engine start switch serve different functions. When the battery disconnect switch is turned off, the entire electrical system is disabled. When only the engine start switch is turned off, the battery remains connected to the electrical system. Verify the battery disconnect switch is in the OFF position when servicing the electrical system or any other components on the vehicle.

To prevent the electrical components from draining the battery, turn the battery disconnect switch to the OFF position when you leave the vehicle for an extended period of one week or longer.

**WARNING:** *Never* turn the battery disconnect switch to the OFF position with the engine running. Electrical system damage could result.

### Electronic controls

The adverse terrain forklift incorporates electronic computer controls for most of its operation. There are two ECMs (fig. 1-58) on the vehicle. The engine ECM focuses on engine and fuel management. The machine ECM monitors engine operations in addition to controlling the transmission and powertrain. The Caterpillar Electronic Technician scan tool is used to troubleshoot the electronic controls on the forklift. The scan tool contains software that can be used with a computer and communication adaptor cable.

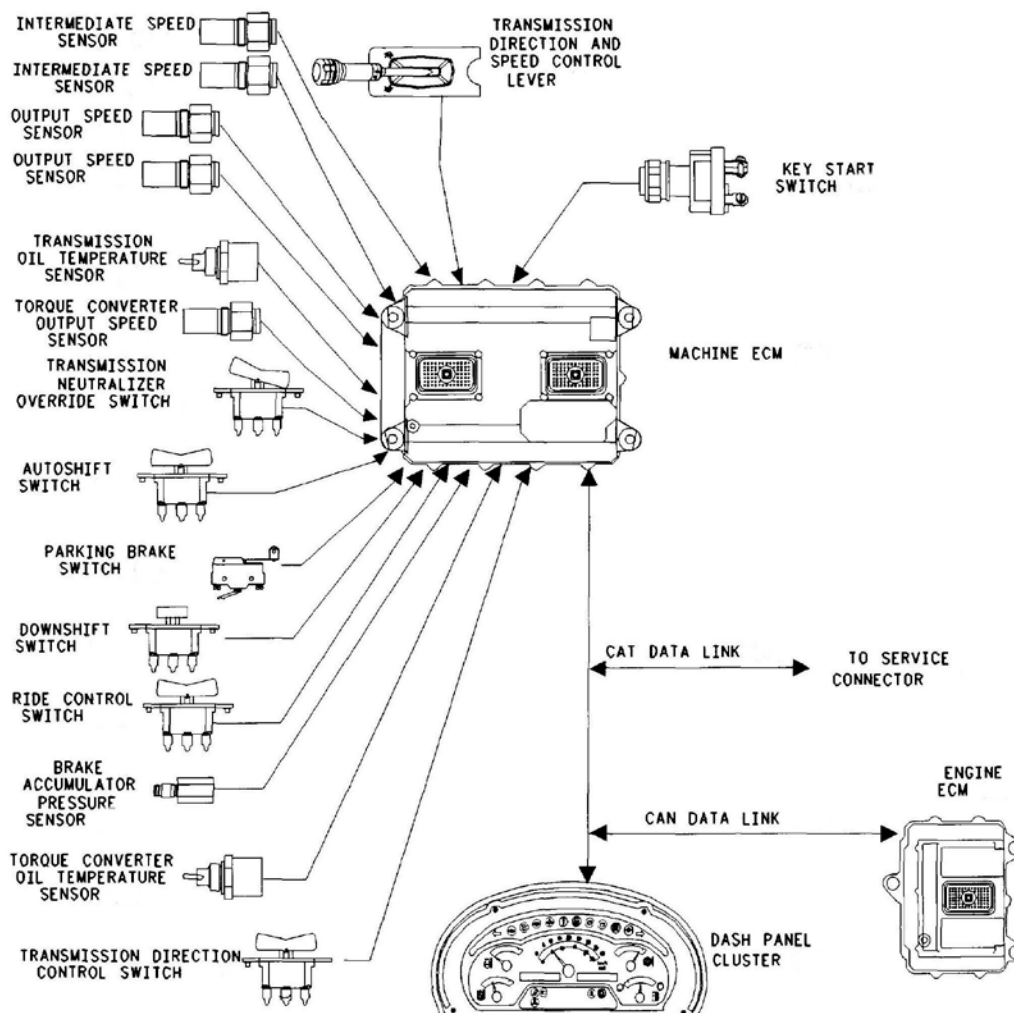


Figure 1-58. Engine and machine ECM.

### Hydraulic system

The hydraulic functions of the adverse terrain forklift are controlled by pilot operated valves. The controls in the cab operate the pilot valves. These valves control pilot pressure from the steering pump. When a function is selected, the pilot valves send pressure to the main control valve (fig. 1-59), to actuate the function. Once actuated, the main control valve sends pressure from the implement pump to the function's cylinders. The implement pump is a vane-type pump, and is driven off the transmission. The three implement functions on the forklift are (1) raise/lower, (2) tilt forward/back, and (3) fork spread. The raise/lower and tilt circuits use load control valves to hold the lift cylinders in place in the event of a hydraulic line failure. There is no emergency pump for the implement systems. In the event of engine failure, an accumulator provides pressure to activate the pilot operated valves to lower the lift cylinders.

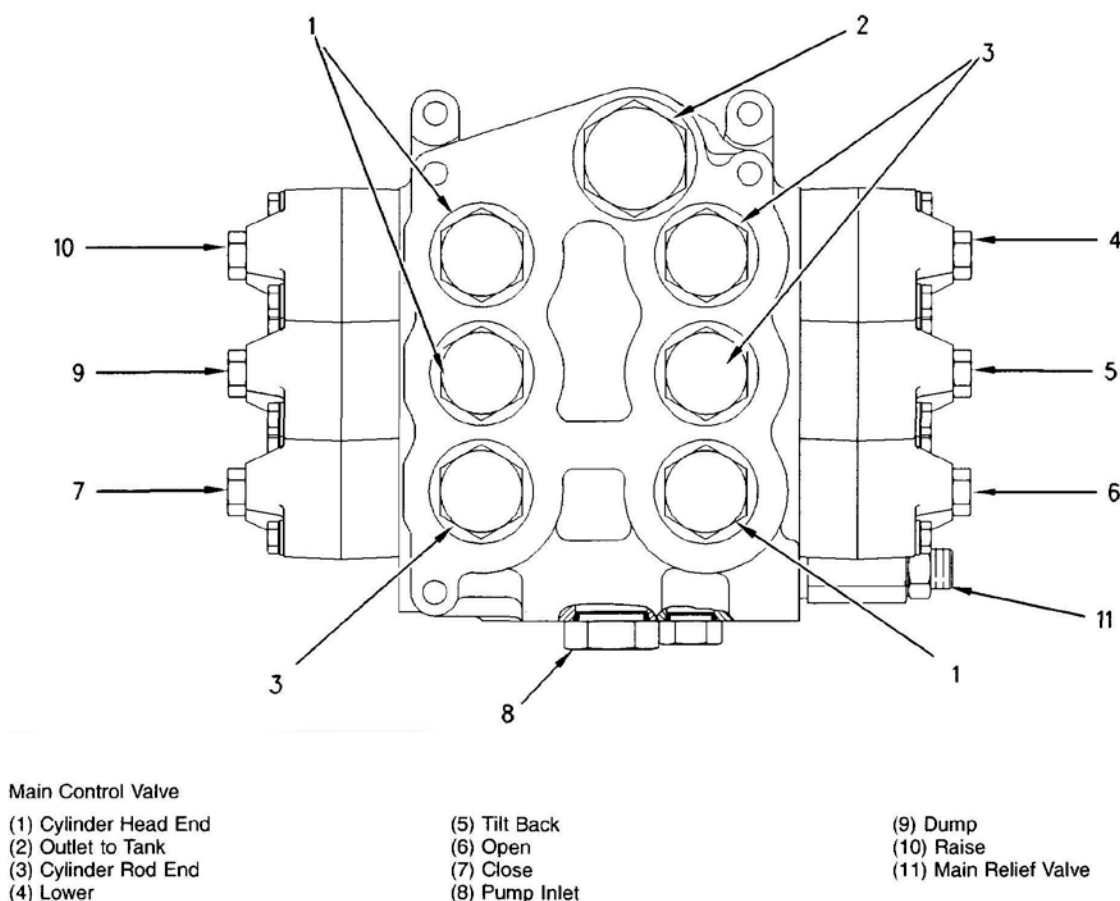


Figure 1-59. Hydraulic main control valve.

The hydraulic steering system changes the forklift's angle of articulation (fig. 1-60). The main components in the steering system are the piston pump, the metering pump, and the steering cylinders. The steering pump is a pressure compensated variable displacement axial piston pump. This pump provides flow to the steering cylinders and is located on the left side of the vehicle under the operator's platform. The metering pump controls the flow of oil from the piston pump to the steering cylinders. It contains a control valve and a metering section. The control valve section of the metering pump connects to the steering wheel through a mechanical linkage.



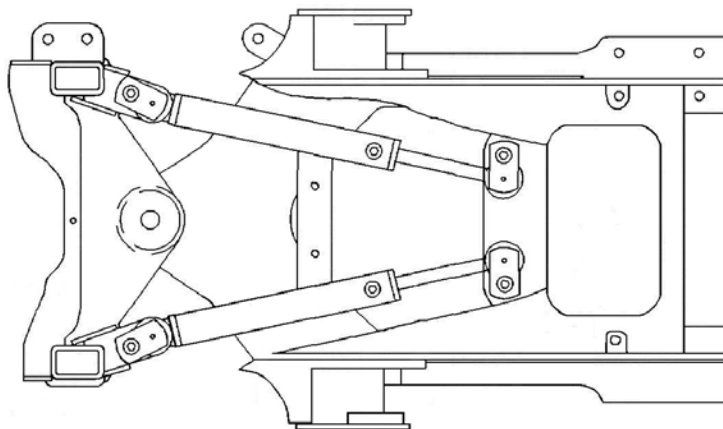


Figure 1-60. Steering articulation.

The CAT adverse terrain forklift also has a secondary steering system in the event of primary system failure. The secondary system consists of a 24 VDC electric motor, gear-type secondary pump, and relief valve.

A steering frame lock link (fig. 1-61), secures the frame for maintenance. This ensures the vehicle will *not* articulate. *Always* install the lock link before any maintenance in the center pivot section. The steering frame lock link is located on the left side of the vehicle.



Figure 1-61. Steering frame lock link.

### Main relief valve adjustment

Located in the inlet section of the main control valve (fig. 1-59) is the main relief valve (fig. 1-62). The main relief pressure setting is 3,000 +/- 44 pounds per square inch (psi). If the forklift is experiencing hydraulic problems, the main control valve may need to be adjusted. Always follow troubleshooting procedures outlined in the technical order.



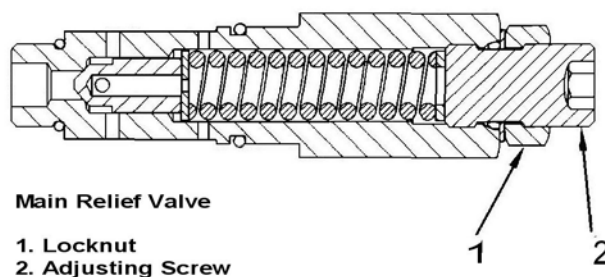


Figure 1-62. Main relief valve.

**NOTE:** Be sure to release the pressure in the hydraulic system before adjusting the main relief valve. Always follow the proper procedures for releasing the hydraulic pressure in the technical order.

To adjust the main relief valve proceed as follows:

1. After hydraulic pressure is released, install specified hydraulic pressure gauge in test port (A) on the manifold (B) located on right side of vehicle (fig. 1-63).
2. Start the engine and raise the fork carriage off the ground. Tilt back the fork carriage until the cylinder rods are fully retracted.
3. Increase the engine speed to high idle. Move the tilt lever to the TILT BACK position. Record the reading from the pressure gauge.
4. Lower the fork carriage and stop the engine.
5. Tighten the locknut.
6. Repeat steps 2 thru 4 to verify pressure is within specification.

Loosen the locknut (1), turn the adjusting screw (2) (fig. 1-62) clockwise for an increase in pressure, and counter clockwise to decrease the pressure setting in the relief valve.

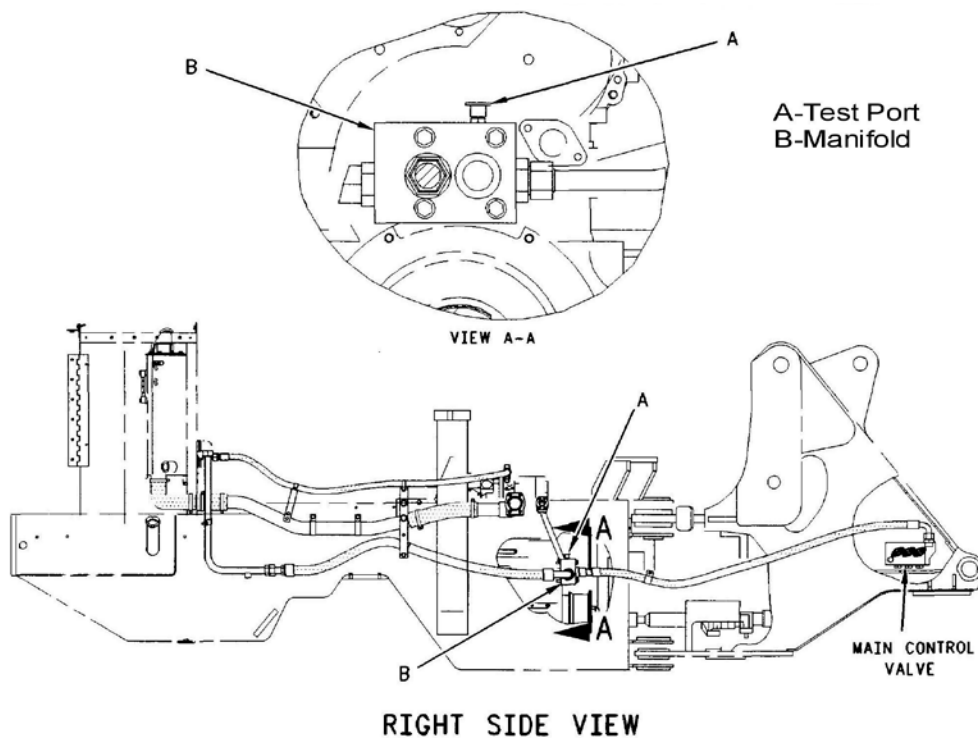


Figure 1-63. Main relief valve test port location.

**Air transportability**

The CAT IT28 forklift is capable of driving onto United States Air Force (USAF) aircraft for transportation by air.

**NOTE:** Before the vehicle is driven onto the aircraft, you must remove several assemblies, such as the cab, counterweights, and exhaust stack. Other items, which may interfere with the loading process, must also be removed. Always follow the step-by-step procedures in the technical order.

The cab of the CAT adverse terrain forklift is removable. To remove the cab, a winch and crane assembly is provided on the left side of the vehicle.

The removal of the cab assembly consists of:

1. Configuring the cab removal device (crane) in position over the cab. Mount cab removal attachment assembly to the top of the cab. The attachment assembly is bolted to the right side of the vehicle below the engine cover for storage.
2. Remove cab mount bolts. Disconnect wiring harnesses, hoses, and other applicable items.
3. Position the back of operator's seat forward and tilt steering wheel fully downward.
4. Attach cab removal device (crane) with suitable straps on each side to help control the cab during removal.
5. Remove cab from the vehicle.

**NOTE:** The maximum lifting capability of the cab removal device (crane) is 1,000 pounds.

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**Self-Test Questions**

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

**206. Caterpillar adverse terrain forklift**

1. What component controls the fuel pump and engine rpm on the CAT 3056E diesel?
2. Where is the internal expanding-type parking brake mounted?
3. How are the batteries wired in the CAT adverse terrain forklift electrical system?
4. Where is the NATO jump-start receptacle located?
5. What is the function of the machine's ECM?
6. What are used, in the raise/lower and tilt circuits, to hold the cylinders in place in the event of a hydraulic line failure?

7. List the hydraulic secondary steering system components.
8. What secures the frame during maintenance and prevents the vehicle from articulating?
9. What must you accomplish before adjusting the main relief valve?
10. What assemblies must you remove before the adverse terrain forklift can be driven onto an aircraft?

---

### **Answers to Self-Test Questions**

#### **201**

1. Allow it to be transportable by C-130 aircraft.
2. Standard diesel, biodiesel, or JP-8.
3. One or four engine parameters and diagnostic trouble codes.
4. SAE J1939 Controller Area Network.
5. Three forward and three reverse.
6. Two-wheel drive high and four-wheel drive low.
7. The front is a limited-slip and the rear is a locking type.
8. It has no suspension.
9. For additional stability when doing an “on-rubber” lift or when the load must be transported to another site.
10. The 15-gpm pump.
11. The accumulators.
12. Two-wheel conventional steering is when the front wheels steer only. Four-wheel coordinated steering is when the front and rear wheels turn in opposite directions. Four-wheel crab steering is when the front and rear wheels turn in the same direction.

#### **202**

1. Tandem gear type and it is driven off the torque converter.
2. Two joystick manipulators.
3. They are closed by spring pressure and opened by pilot pressure.
4. Rotary manifold.
5. Each outrigger has a double acting cylinder with a hold valve.
6. Bubble indicators.
7. Swing bearing assembly.
8. When the output tries to drive the input.
9. Outer race of the swing bearing assembly.
10. Collector ring.
11. One double acting cylinder.
12. Hold the suspended load.
13. Reeving is the process of running cable through sheaves.
14. The load on hook is between 85 percent and 99.9 percent of the rated capacity.
15. Load pin sensor.

16. Boom length and boom angle.
17. Prevent the operator from raising the hook-block into the boom fly tip or lowering the boom fly tip onto objects.
18. Winch up, boom down, and boom extend.
19. Mounted to the swing hydraulic motor on right side of the crane.
20. Winch up, boom down, boom extend, swing left, and swing right.

### 203

1. Most of the control cables, as used on previous older model earth moving tractors, have been replaced with hydraulic controls, resulting in much smoother and precise tractor operation.
2. Directions on the tractor are based on viewing the compartment from sitting in the operator's seat.
3. The pedals on the floorboard.
4. The electronic data monitor sounds a buzzer and illuminates a light.
5. To select the range and travel direction.
6. Three forward speeds and three reverse speeds.
7. When the shift lever is placed in neutral, the external contracting-type parking brake is automatically applied by springs.
8. This crawler tractor has a multipurpose bucket to perform several functions without changing attachments, while a bulldozer typically has a straight blade and is used for pushing and leveling materials only.
9. To give you the option of changing bucket configurations by simply opening or closing the bucket clamshell.
10. Hydraulically driven and is located on the rear of the tractor.

### 204

1. Because of their high torque output at a lower engine rpms.
2. The fan system can be reversed to meet changing weather conditions.
3. Direction should be changed to pull the cold air through the radiator to remove the heat for summer operation.
4. 24 VDC.
5. Hydraulic pilot operated control system. Hydraulic implement (attachment) system, transmission, steering, and brake systems.
6. Gear-type pilot pump located on the right front of the engine.
7. Hydraulic power shift mechanism.
8. Double reduction spur-type gears.
9. By slowing or stopping one track at a time.
10. The steering clutches are spring applied and hydraulically released by fluid pressure from the transmission.
11. The master link is the initial disassembly point of the track chain. It is used to break the track apart to replace the chain or perform maintenance on any of the track support rollers and guides.
12. The raised bars on the track shoes, which grip the ground.
13. The idler provides a guide and support of the track chain and protects the track mechanism from damage or shock.
14. When the front idler receives a shock load, the force is transmitted to the track spring by a slide-mounted mechanism the idler is attached to.
15. A misaligned idler will cause wear on the front idler center flange, the sides of the track links, and the sides of the roller flanges.
16. To carry the weight of the track over the top of the frame.

17. To distribute the weight of the vehicle over a large ground area.

**205**

1. Four-stroke, four cylinder, naturally aspirated diesel.
2. Priming lever.
3. 12 VDC negative ground.
4. By pulling on the handle of a mechanical cable. The cable is connected to the disconnect switch's lever
5. The D+ terminal and the field terminal.
6. Small drive shaft off the crankshaft.
7. Gear-type.
8. Vane-type.
9. Four.
10. Attached to the main control valve.
11. Three.
12. Double acting.
13. Under the operator's seat.
14. Bottom of the steering column.

**206**

1. ECM.
2. Output shaft on the transmission.
3. Two 12 VDC batteries are wired in series.
4. Left side of cab below the winch and crane assembly.
5. Monitors engine operations and controls the transmission and powertrain.
6. Load control valves.
7. 24 VDC electric motor, gear-type secondary pump, and relief valve.
8. Steering frame lock link.
9. Release hydraulic system pressure.
10. Cab, counterweights, and exhaust stack assemblies.

**Do 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) How many forward and reverse gears does the Arva crane have?
  - a. 2 forward and 2 reverse.
  - b. 3 forward and 1 reverse.
  - c. 3 forward and 3 reverse.
  - d. 4 forward and 1 reverse.
2. (202) The main hydraulic pump on the Arva crane is a
  - a. single gear-type pump.
  - b. tandem gear-type pump.
  - c. single gerotor-type pump.
  - d. tandem gerotor-type pump.
3. (202) A warning light will flash accompanied by an audible warning when the load on the Arva crane's hook is at or above
  - a. 70 percent.
  - b. 75 percent.
  - c. 80 percent.
  - d. 85 percent.
4. (203) How many steering clutch packs are used in the Fiat Allis crawler tractor?
  - a. 2.
  - b. 4.
  - c. 6.
  - d. 8.
5. (203) Which type of parking brake is used on the Fiat Allis crawler tractor?
  - a. Internal expanding.
  - b. External expanding.
  - c. Internal contracting.
  - d. External contracting.
6. (203) The Fiat Allis crawler tractor's bucket clamshell uses which type of hydraulic cylinder?
  - a. Vane.
  - b. Piston.
  - c. Single-acting.
  - d. Double-acting.
7. (204) What *prevents* movement of the steering clutch outer drum on the Fiat Allis crawler tractor during a turn?
  - a. Brake band.
  - b. Accumulator.
  - c. Slave cylinder.
  - d. Hydraulic piston.



8. (204) Which holds the track chain together on the Fiat Allis crawler tractor?
  - a. Machined pins.
  - b. Case-hardened pins.
  - c. Case-hardened rivets.
  - d. Machined bolts with lock plates.
9. (204) What *carries* the weight of the track over the top of the track frame on the crawler tractor?
  - a. Sprockets.
  - b. Front idler.
  - c. Track rollers.
  - d. Carrier rollers.
10. (204) What distributes the weight of the vehicle over a large ground area on the crawler tractor?
  - a. Sprockets.
  - b. Front idler.
  - c. Track rollers.
  - d. Carrier rollers.
11. (205) With the Hyster 10K forklift, engine power is generated in the Perkins 1004-4 diesel engine through the
  - a. power axle and torque converter assembly.
  - b. Allison transmission and torque converter assembly.
  - c. torque converter to a two-speed power shift transmission.
  - d. torque converter to a three-speed power shift transmission.
12. (205) Where is the emergency disconnect switch located on the Hyster 10K?
  - a. Left side-mast.
  - b. Right side-mast.
  - c. In the engine compartment.
  - d. In the operator compartment.
13. (205) The Hyster 10K main hydraulic pump outlet port is connected by line to the main
  - a. control valve.
  - b. mast cylinder.
  - c. steering valve.
  - d. hydraulic tank.
14. (205) Which arrangement of hydraulic cylinders raises the carriage and extends the telescoping weldments, on the Hyster 10K?
  - a. Two double-acting and one single-acting cylinders.
  - b. Two single-acting and one double-acting cylinders.
  - c. Three double-acting cylinders.
  - d. Three single-acting cylinders.
15. (206) How is the parking brake applied on the Caterpillar adverse terrain forklift?
  - a. Electrically by the use of a switch.
  - b. Pneumatically by use of foot pedal.
  - c. Manually by use of lever and cable assembly.
  - d. Hydraulically by use of lever and cable assembly.

16. (206) The hydraulic functions of the Caterpillar adverse terrain forklift are controlled by
- a. engine power.
  - b. remote control.
  - c. pilot operated valves.
  - d. pilot operated relays.
17. (206) How is the metering pump control valve section connected to the steering wheel on the Caterpillar adverse terrain forklift?
- a. Mechanical linkage.
  - b. Hydraulic coupling.
  - c. Anchor bolts.
  - d. Rack piston.

**Please read the unit menu for unit 2 and continue ➡**

## Student Notes

## Unit 2. Flight Line Servicing Vehicles and Equipment

<b>2-1. Windrow Sweeper .....</b>	<b>2-1</b>
207. Windrow sweeper fundamentals.....	2-1
<b>2-2. Snow Blower .....</b>	<b>2-9</b>
208. Snow blower fundamentals.....	2-9

**I**N THE FOLLOWING LESSONS, we will cover flightline servicing vehicles. These vehicles keep runways clear of debris and provide safe aircraft take-offs and landings. This unit will cover the regenerative sweeper, the snow blower, and the Windrow® sweeper broom vehicles. The snow blower and Windrow sweepers are especially important in cold weather regions, as their function is to remove snow from runways. Gaining knowledge about maintaining these vehicles is vital to ensuring clear paths for the Air Force to complete its mission.

### 2-1. Windrow Sweeper

The Windrow sweeper, also known as a sweepster, has the ability to remove up to five inches of unpacked snow at speeds of 15 miles per hour (mph). It can also sweep light sand and gravel at speeds of 20–30 mph. It is composed of a front-mounted, hydraulically driven broom, and a carrier-mounted power unit. The sweepster also has a hydraulically-driven hurricane-force air blower mounted to the rear of the vehicle.

#### 207. Windrow sweeper fundamentals

The sweepster unit, shown in figure 2-1, is truck mounted and can be removed if needed. We will go over the functions and components of the Windrow sweeper.



Figure 2-1. Windrow sweeper mounted on truck.

## Control panel

The main control panel (fig. 2-2) is positioned on a stand that is mounted to the floor of the truck cab. It is angled toward the operator for ease of control during use.

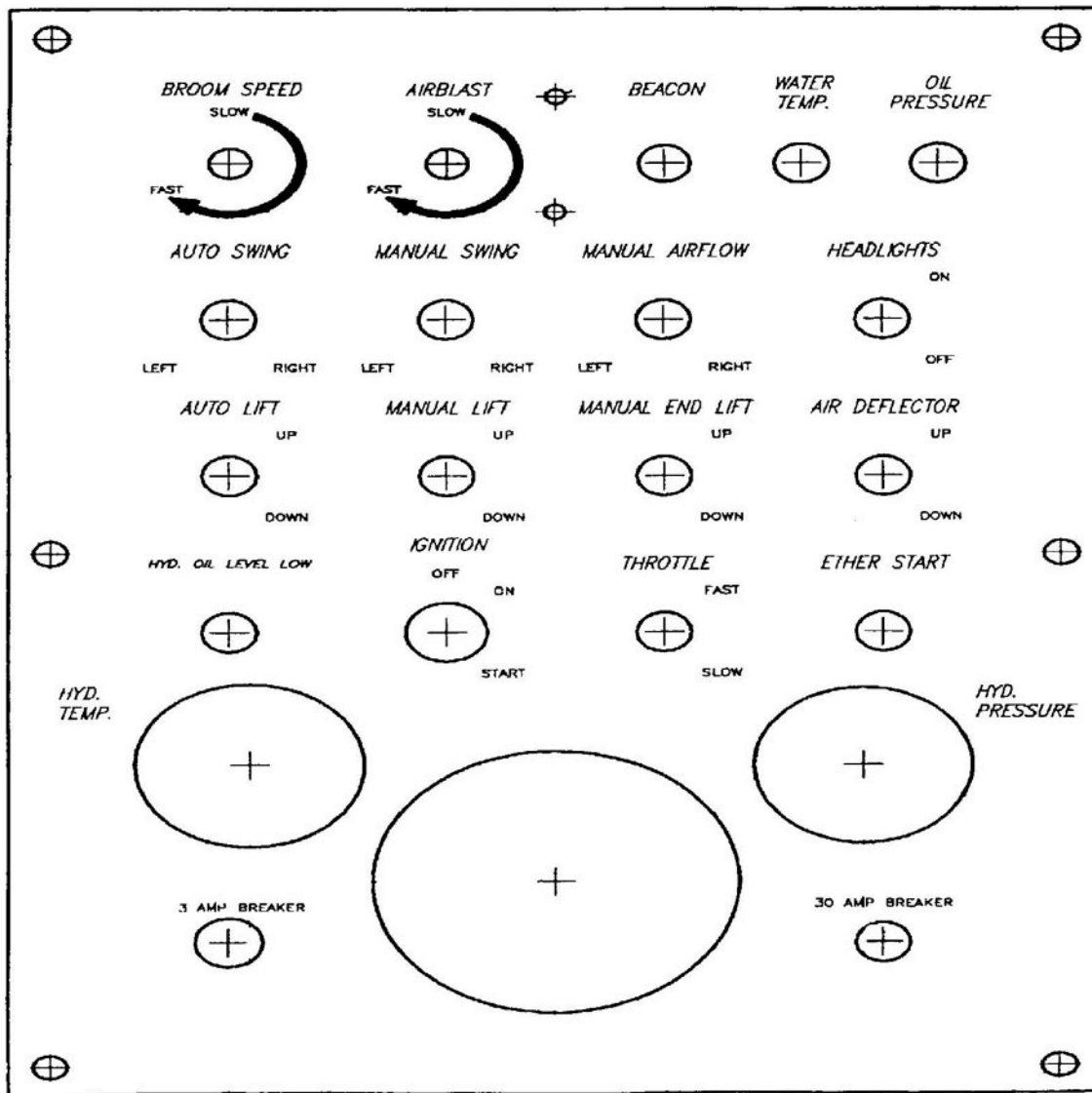


Figure 2-2. Main control panel.

### Broom speed dial

The broom speed dial runs the broom from 0 to 500 rpm depending on the position of the dial. There are three ranges for heavy, normal, and light sweeping. Remember that you only want to run the broom fast enough to do the task, thereby maximizing bristle life. *Always* keep the broom speed at zero when starting the unit or the broom will start rotating upon engine start.

### Air-blast speed dial

This switch controls the air-blast speed. Air blast is designed to be operated with the auxiliary engine at full throttle. Make sure this switch is OFF when starting the engine and when shutting it down.

### ***30-amp breaker***

The 30-amp breaker is wired into all controls on this panel except the broom and air speed dials. It is a safety device designed to protect the controls from excessive current draw. If this circuit breaker trips, current flow to the main control panel, with the exception of the broom and air speed dials, is removed. It can be reset by pushing the circuit breaker back in. If this problem occurs frequently, troubleshoot the system to determine the problem. Troubleshooting procedures will be covered later in this lesson.

### ***3-amp breaker***

The 3-amp breaker is wired into the broom and air speed dials, as well as the blower and broom amplifier cards. Like the 30-amp circuit breaker, if this breaker trips, current flow to the broom and air speed dials is removed, and it can be reset by pushing it back in.

### ***Auto swing switch***

This three-position switch swings the broom and blower at the same time. The center position allows you to stop the broom from swinging if desired. This switch must be in the centered position when starting the auxiliary engine. If not, the broom may swing immediately and cause damage to other equipment or injure personnel. When operating the swing or airflow manually, this switch must be in the center position.

### ***Manual swing switch***

This switch allows the broom to swing independently of the air-blast system. In order to use this operation, you must have the auto swing switch in the center position.

### ***Manual airflow switch***

This switch allows the operator to change the direction of the air-blast system without changing the broom angle. To use this, you must have the auto swing switch in the center position.

### ***Auto lift switch***

This three-position switch lifts the broom and air-blast system at the same time. It must be in the center position when starting the auxiliary engine so the broom does not rise. It must also be in the center position if you are using the manual lift or manual end lift switches.

### ***Manual lift switch***

This three-position switch raises and lowers the broom independent of the air-blast system. The auto lift switch must be in the center position to use this function.

### ***Manual end lift switch***

This three-position switch raises and lowers the air blast without raising the broom. The auto lift switch must be in the center position to use this function.

### ***Air deflector switch***

This up and down switch is self-centering. For best results, run the deflector in the highest position. If excessive amounts of snow/debris are carrying over the broom, adjust the deflector to minimize the carryover of snow/debris.

### ***Oil level light***

This indicates the level of the hydraulic oil level. Occasionally during operation, the light will flicker when you are turning the vehicle sharply. This is due to fluid moving in the tank and is normal. This light does not show how much fluid is in the tank; you must visually check the reservoir. Do not operate the auxiliary engine with this light continuously on or severe damage to the system may result.



### Throttle switch

This is a three-position switch with a neutral center position. When you start the auxiliary engine, this switch must be in the slow position so the engine does not go to the full throttle position. You may place this switch to the desired throttle position after auxiliary engine starts.

### Ether start button

Use this button *only* during cold weather starting. The only time ether can be used is when the ignition switch is in the start position.

### Broom

Next, we discuss the broom brush head, casters, stripper bar and air deflectors.

### Brush head

The broom (fig. 2-3) is 16 feet wide and composed of wire, polyurethane, or a half-and-half mixture of both. You must maintain the sweep pattern between two to four inches.

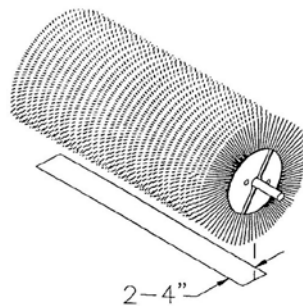


Figure 2-3. Broom brush head.

### Caster wheels and brake

The caster wheels (fig. 2-4) support the weight of the sweepster broom. Each caster wheel assembly is equipped with a caster brake.

The caster brake (fig. 2-4) is designed to stop caster shimmy. This is accomplished by allowing the brake to tighten against the wide side of the offset on the brake disk when the unit is moving forward. As the unit turns or backs up, the caster brake turns with the spindle. This brings the narrow side of the caster brake offset against the brake pad, which decreases the brake pressure and allows the castor to pivot freely.

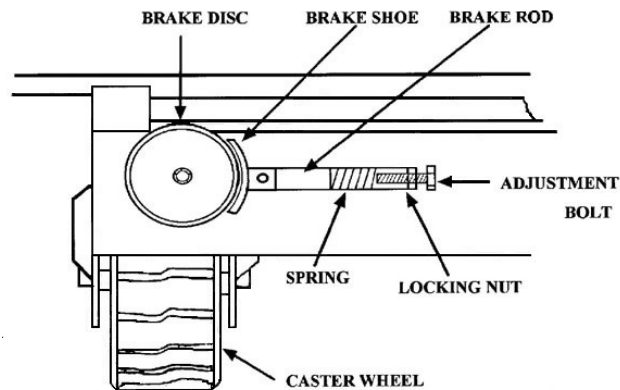


Figure 2-4. Caster wheel and caster brake.

### Stripper bar

The stripper bar (fig. 2-5) is located on the inside front edge of the brush hood. It strips debris from the brush head bristles, thus preventing the debris from dropping off behind the brush head. It also prevents the buildup of snow and ice under the hood. Adjust the hood so the stripper bar is 1/4 to 3/8 inches from the bristles.

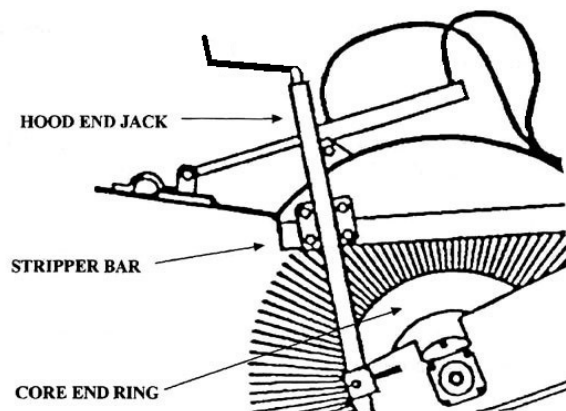


Figure 2-5. Stripper bar.

### Air deflector

With the variable brush speed and air deflector, you can control the debris from reaching the vehicle, even when sweeping into the wind (fig. 2-6). Slowing the brush prevents debris from being thrown into the air. For sweeping sand and gravel, position the air deflector to the lowered position. For sweeping light snow, position it between the lowered and middle position. For heavy snow and slush, position the air deflector to the raised position.

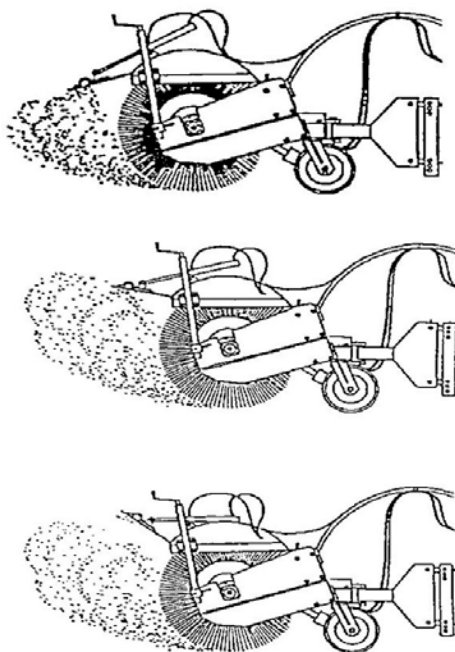


Figure 2-6. Air deflector positions

## Hydraulic system

The hydraulic system's reservoir, pumps, filtration, hydraulic lines, manifold, and motor and air-blast system are covered next.

### Reservoir

The hydraulic reservoir has a 15-gallon capacity tank. The fluid level is checked using a sight gauge.

### Pumps

There are three hydraulic pumps: brush pump, air-blast pump, and compensator pump. Before adjusting any pump, you must consult the proper technical order for specifications and procedures. All pumps are driven by the auxiliary engine through the pump drive.

1. The *brush pump* is set preset at the factory for 5,400 psi and only needs to be adjusted if a new pump is installed.
2. The *air-blast pump* is set at 4,500 psi, but should never reach this pressure as it is limited by its attachment to the blower.
3. The *compensator pump* is set at 2,000 psi and is used for the hydraulic controls.

### Filtration

A filter located on the tank accomplishes hydraulic system filtration. Change this filter after every 250 hours of operation under normal conditions, or every 150 hours under dusty conditions.

### Hydraulic lines

This system uses both rigid and flexible lines. The flexible lines connect dynamic components to static ones. When connecting quick disconnects, be sure to clean them to prevent contamination of the hydraulic system. When replacing hydraulic lines, ensure they meet proper specifications.

### Hydraulic manifold

The hydraulic manifold is located in the auxiliary engine compartment. It contains delta selector valves and delta poppet valves to actuate the selected hydraulic function. When you select a valve, you are opening the return passage, and the poppet across from that valve is the pressure side.

### Hydraulic motors

There are two hydraulic motors—the broom motor and the air-blast motor.

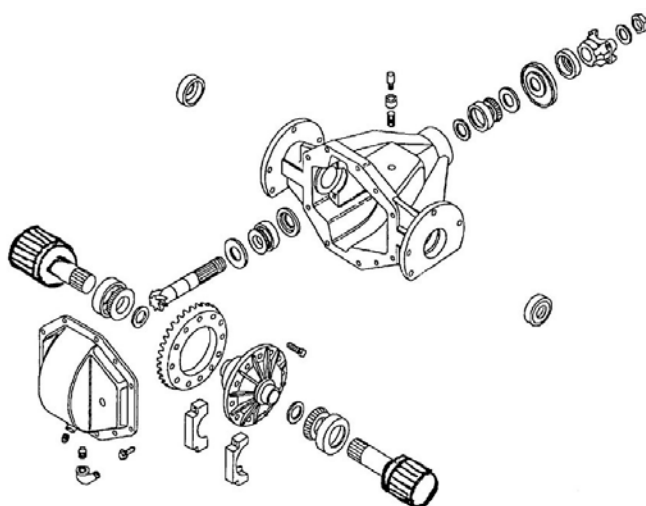


Figure 2-7. Broom differential.

#### Broom motor

The broom motor drives a differential (fig. 2-7) that turns the broom segments. The differential uses chain couplers to connect to the broom segments.

#### Air-blast motor

The air-blast motor turns the blower turbine. The motor output shaft is splined to the turbine.

### *Air-blast system*

The air-blast system is a hydraulically driven turbine capable of producing air speeds of 375 mph. Air can be directed as needed using the switches on the control panel.

### *Auxiliary engine*

The diesel engine is operated from the control panel located in the cab and a control panel located on the rear engine cowling (fig. 2-8). You must check all fluid levels before operating the unit. The unit is equipped with an engine shutdown for low oil pressure and high coolant temperature.

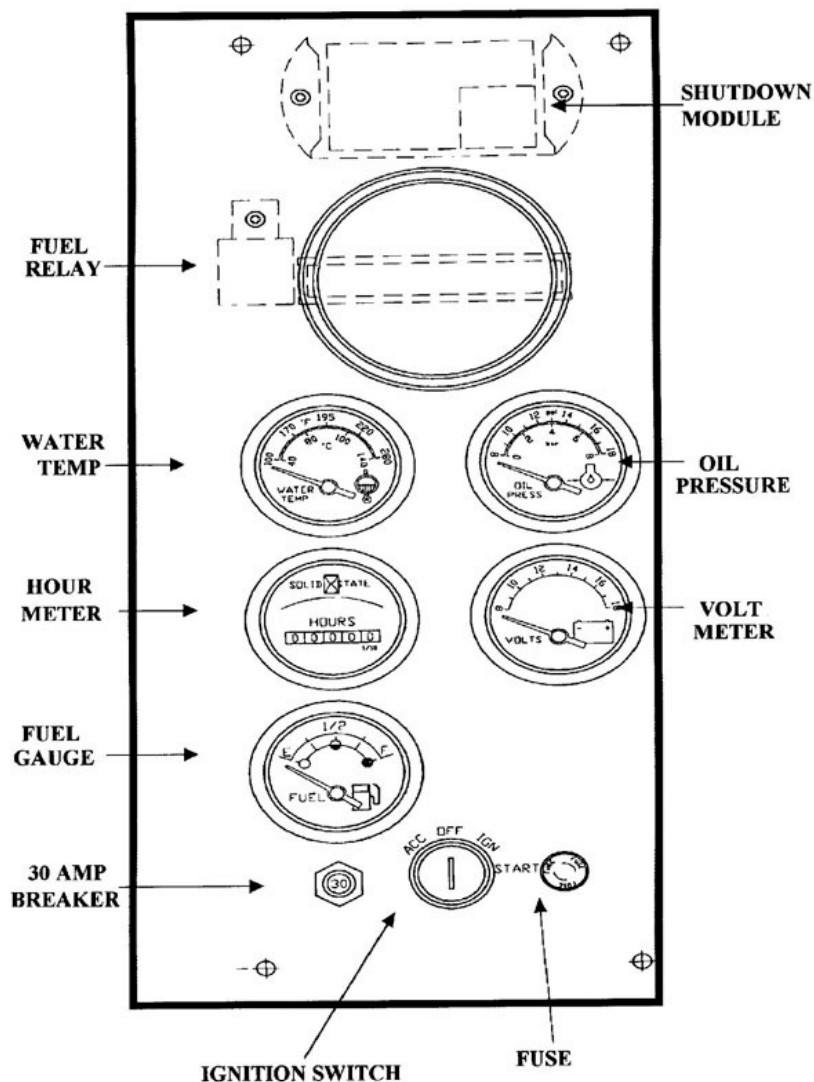


Figure 2-8. Rear engine control panel.

### *Electrical system*

The next system covered is the electrical system, which includes the amplifier cards, proportional coil, and shutdown module.

### *Amplifier cards*

There are two amplifier cards—one for the broom and one for the air blast. They are used to set maximum hydraulic output flow and to set the time that it takes for the pump to reach maximum output.

***Proportional coil***

The coil is used to stroke the pump. It has an override button for easy troubleshooting of the system. All hydraulic functions are electric over hydraulic with no means of manual override except for the proportional coil.

***Shutdown module***

This is a safety device for the engine. It allows the engine to start and run for 30 seconds without oil pressure. It will shut down the engine when the oil pressure is below 5–10 psi or the coolant temperature is above 185–195 degrees.

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**Self-Test Questions**

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

**207. Windrow sweeper fundamentals**

1. What safety device is designed to protect the Windrow sweeper controls, except the broom and blower speed dials and amplifier cards from excessive current draw?
2. What safety device protects the broom and blower speed dials and amplifier cards from excessive current draw?
3. What allows a direction change of the air-blast system without changing the broom angle?
4. What button should be used only during cold weather starts?
5. What size sweep pattern must you maintain on the broom brush head?
6. What is the purpose of the casters?

7. What is the purpose of the caster brake?
8. What is the purpose of the brush stripper bar?
9. How many hydraulic pumps are used on the Windrow sweeper?
10. What are the types of valves used in the hydraulic manifold?
11. How is power transferred from the broom hydraulic motor to the broom segments?
12. What type of safety shutdown device does the auxiliary engine have?

## **2-2. Snow Blower**

The Air Force has used snow blowers for many years. Numerous improvements have been made because of technological advances and expanded mission requirements. These changes produced a state-of-the-art multipurpose snow removal vehicle, which is designed to clear aircraft runways, taxiways, ramps, as well as streets and parking lots. Blower and plow attachments are used with the truck to remove snow. The following lesson will introduce you to the fundamentals and maintenance procedures of the snow blower.

### **208. Snow blower fundamentals**

The snow blower (fig. 2-9), also referred as the rotary snow blower, is an asset you are likely to find at many bases that undergo heavy amounts of snowfall during cold weather months. Becoming familiar with its operating systems is key to maintaining this vehicle properly and ensuring that base and flightline operations will not be hindered by weather conditions.



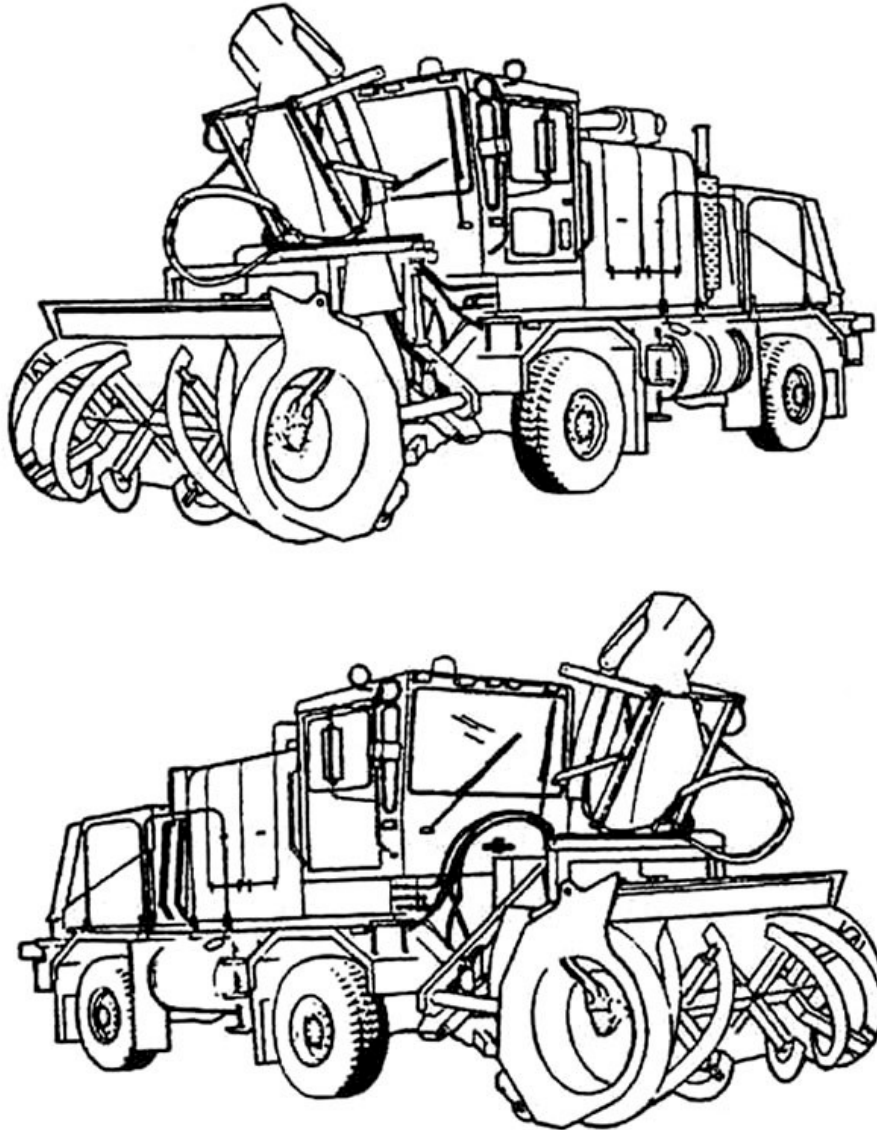


Figure 2-9. Snow blower.

### **Carrier**

This snow blower is built to be operator friendly. The cab sits at the forward edge of the frame to give the operator the best possible forward and peripheral view. It has one door and seating for two. The instrument panel and controls can easily be seen and accessed by the operator. The windshield is constructed of safety glass, electrically heated, tinted, and inclined forward to provide the operator better vision of the attachments during operation.

### ***Multipurpose truck***

The multipurpose truck is shown in figure 2-10 without attachments. The vehicle weighs approximately 13 tons and is equipped with a railed catwalk on the left and right sides for easy access to the engines.

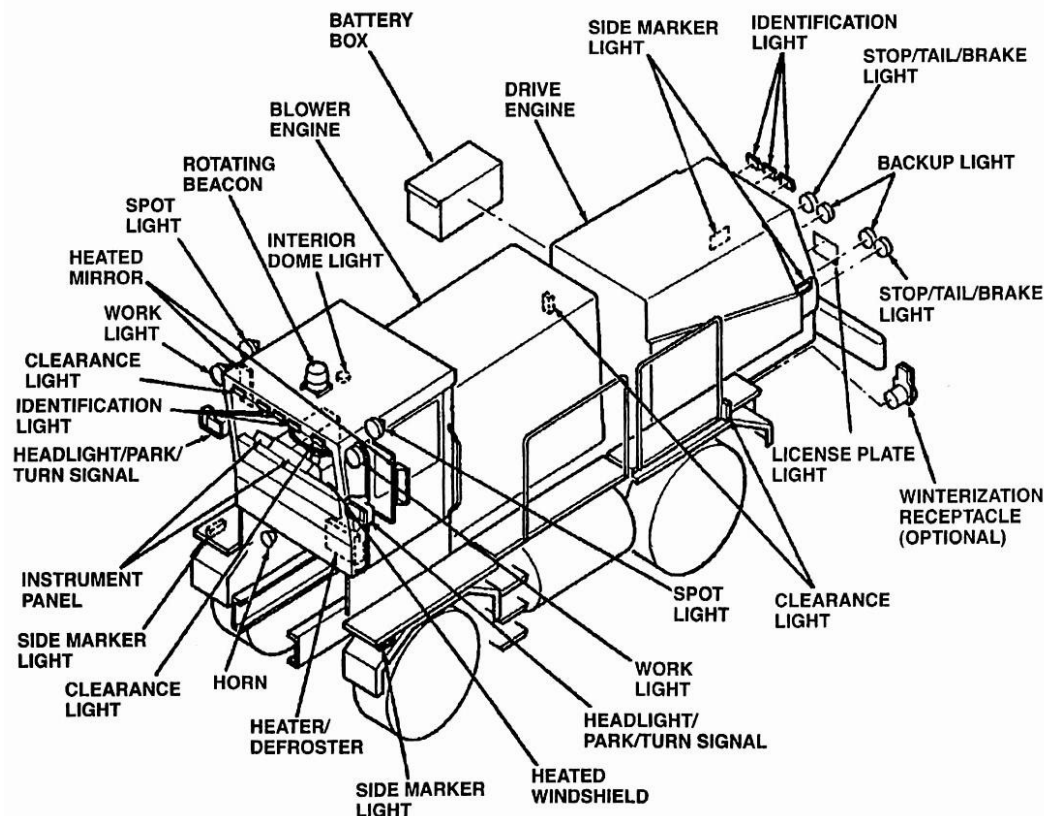


Figure 2-10. Multipurpose truck.

The vehicle houses two diesel engines:

1. The rear engine drives the vehicle. It is an in-line six cylinder, rated at 300 hp at 2,100 rpm and has 850 foot pounds of torque at 1,200 rpm.
2. The front engine drives the blower attachment. A 6V92 turbo-charged engine produces 475 hp at 2,300 rpm and has 1,020 foot pounds of torque at 200 rpm.

The electrical circuit is a conventional 12-volt negative ground system. Four 12-volt batteries, connected in parallel supply voltage. Two alternators are mounted on the vehicle's drive engine. One is a 160 amp that supplies voltage to the batteries, starter, heated mirrors, headlights, tail lights, turn signals, spotlights, clearance lights, beacon light, cab interior, reverse alarm, instrument panel, horn, and solenoid valves.

The other, a 75-amp alternator supplies voltage to the heated windshield and other functions when the cab switch is engaged and the drive engine is running. All electrical components are protected against overloads by manual reset circuit breakers located on the side of the control panel, to the right of the operator.

### *All-wheel drive*

This vehicle is all-wheel drive with a five-speed Allison transmission and a manually shifted two-speed transfer case. In total, this configuration provides 10 forward and two reverse gears.

### **Blower system**

The rotary blower consists of an auger, impeller, and rotary head. The auger digs into the snow as the vehicle advances. Snow is forced by the auger into the impeller and out of the rotary head. This assembly will cut a path 102 inches wide and project snow up to 173 feet in either direction, left or

right, of the truck. It is capable of moving 3,228 tons of snow per hour. Power to drive the impeller section is obtained from the diesel engine and drop box assembly using interconnected drive shafts.

### Blower housing

The blower housing (fig. 2-11), is raised and lowered by two double-acting cylinders, and includes the following components:

Component	Function
Augers	Two hydraulic motors drive the augers. They dig into the snow as the vehicle advances, forcing snow into the impeller.
Caster wheels	There is one caster wheel on each side, which provides a means to adjust the clearance between the scraper blade and the ground.
Impeller housing	The impeller housing is made of steel and surrounds the impeller. It directs snow to the left, right, or up to the chute.
Impeller	The impeller is a balanced fan used to discharge snow.
Push frame	The push frame is made of steel and connects the blower to the carrier.
Scraper blade	The scraper blade is mounted on the bottom of the blower housing and removes snow down to 1/2 inch from the surface.
Skid plates	Skid plates are mounted under the blower housing. They provide a wearing surface for the blower assembly.

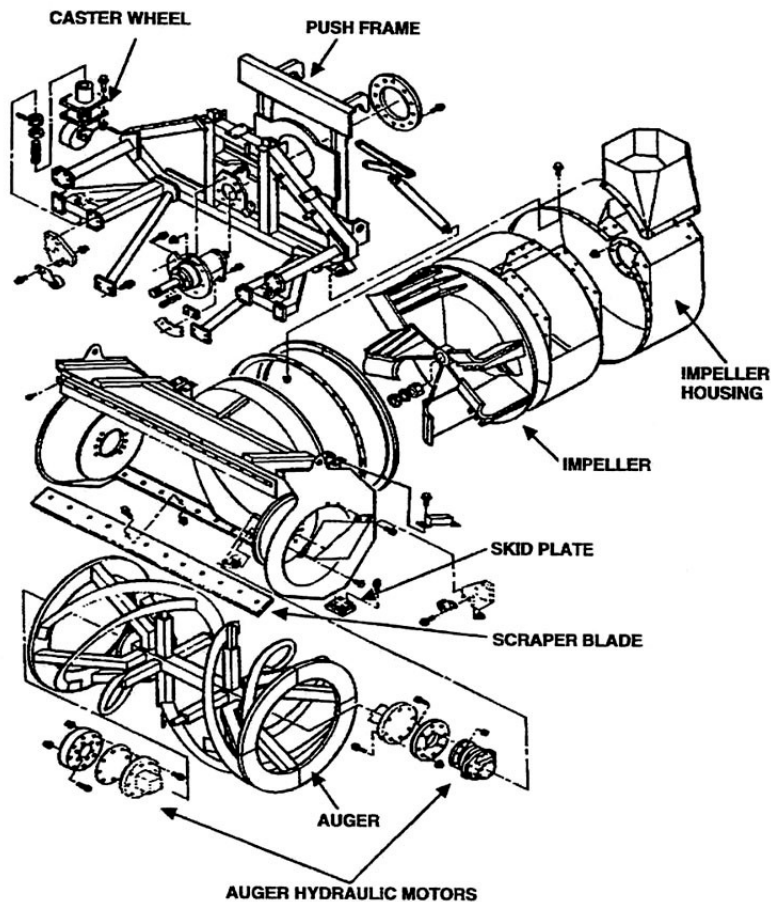


Figure 2-11. Blower assembly, exploded view.

Some models have an optional loading chute (fig. 2-12) mounted on top of the blower assembly. The loading chute can rotate left or right 240 degrees and is for bulk removal of snow during side-by-side vehicle operation. The chute extends and retracts for directional control of the snow.

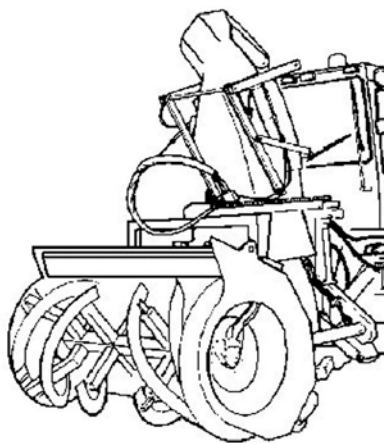


Figure 2-12. Optional loading chute.

### Blower drive train

The drive train incorporates a diesel engine *solely* dedicated to the blower attachment. This engine provides power for the impeller and the augers by driving the auger hydraulic pump.

A drop box clutch, which is lever operated from the cab, transfers power from the blower engine to the drop box. The clutch is a dual plate, snap over center, dry clutch assembly. The drop box receives blower engine power when the clutch is engaged. Input rpm is reduced and power is transferred through a helical gear arrangement to a lower output shaft. A safety flange connects the drop box to the drive shaft and protects the drive train from binding at the impeller by using two shear bolts. A drive shaft then transfers power from the drop box to the impeller.

### Electrical/control system

All operations are controlled from the cab by electric switches or manual levers. Figures 2-13 and 2-14 give you an idea of where these controls are located. This basic information is on the multipurpose vehicle, snow blower, and snowplow. Even though blowers and plows may look alike, remember that vehicles and equipment continuously undergo upgrades. For this reason ensure you consult the proper technical order for the make, model, and type of equipment you are working on.

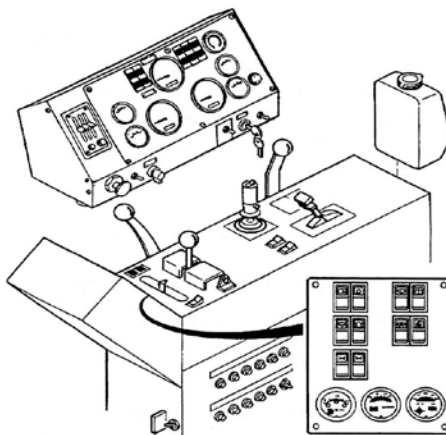


Figure 2-13. Control panel.

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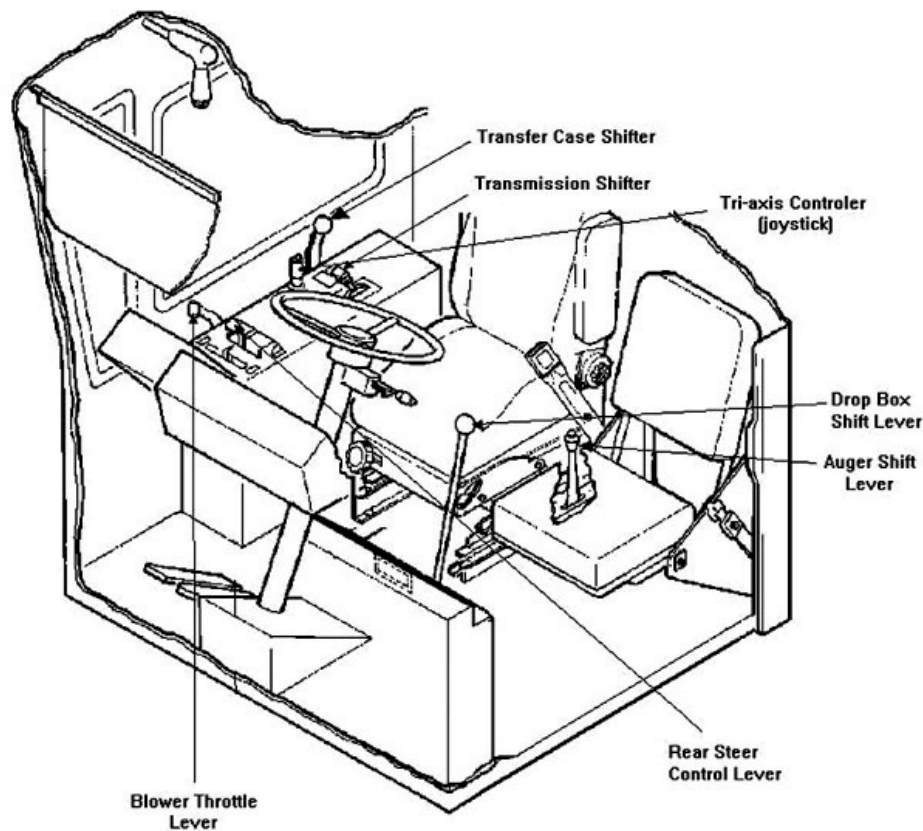


Figure 2-14. Vehicle controls and indicators.

### Blower hydraulics

The blower has two separate hydraulic systems, one for the augers and the other for blower assembly control.

The auger operating system starts at the hydraulic reservoir, which has a 20-gallon capacity and is located behind the front engine. A rotary piston-type pump, driven by the blower engine, supplies up to 33 gpm for the two speed reversible motors that drive the augers. The system incorporates a cable-operated two-speed valve body, which controls the speed of the auger motors. A safety switch prevents rotation of the auger unless the impeller is engaged.

The blower control system's hydraulic reservoir is located behind the rear engine and has a 20-gallon capacity. This system uses the front half of a tandem vane pump that is driven by the rear engine. The other half of this pump is used for carrier steering. A solenoid-operated valve body, controlled by switches and a joystick in the cab, operates the blower control cylinders.

The following list of cylinders and motors, along with their functions, will give you a better picture of what it takes to operate the blower.

Component	Function
Plow lift cylinders	There are two plow lift cylinders. They are double acting and used to lift the blower or plow attachments.
Impeller housing rotation cylinder	The impeller housing rotation cylinder is double acting and used to rotate the impeller housing left or right for 140 degrees of total travel.

Component	Function
Chute rotation motor	The chute rotation motor is reversible and used to rotate the chute left or right for 240 degrees of total travel.
Leaves extension cylinders	There are two leave extension cylinders. They are double acting and used to extend, hold, and retract the chute.
Flipper cylinder	The flipper cylinder is double acting and used to move the flipper, which is mounted on the end of the chute.

### Steering system

Steering is accomplished with either front only or all-wheel steering. With the front wheel steering, the vehicle can turn a 66-foot diameter circle. With all-wheel steering, it can turn a 43-foot diameter circle.

The steering system uses mechanical linkage with hydraulic power assist. With the drive engine running, hydraulic pressure reduces the effort required to turn the steering wheel. If the drive engine is not running, the wheels can still be turned, but greater effort is required. The steering system is covered in the following paragraphs.

#### *Mechanical linkage*

The steering wheel is connected to the steering gear through a universal joint shaft. The front wheels are connected to a steering gear through a drag link and tie rod combination. The front wheels turn when the steering wheel is rotated right or left. The rear steering axle also contains a tie rod to transfer steering to the other side of the rear axle.

#### *Front-steer hydraulic circuit*

Fluid is drawn from the hydraulic reservoir by the rear half of the tandem pump, which is powered by the drive engine. A separate return line connects the pump to the reservoir to return excess fluid to the reservoir. Fluid from the pump flows through the steering gear then returns to the reservoir. Flow and pressure are only generated when the drive engine is running. The enclosed circuit contains a self-purging feature that removes any air that may be present.

### Brake system

The vehicle brake system is a conventional air type. The multipurpose snow vehicle brake system uses two brake chambers on each axle controlled by a pedal-operated brake valve assembly. When the pedal is depressed, the brake valve assembly applies air pressure to the brake chambers, forcing the brake shoes against each brake drum and stopping the vehicle. The rear brakes are also equipped with spring brake chambers that provide a parking brake function. A dual air pressure gauge is located in the cab and provides readings for both the front and rear air brake systems. The red needle indicates rear system pressure and the green indicates front system pressure. Normal air pressure reading for these systems is 85–120 psi with a minimum of 60 psi. At 60 psi, a low air pressure warning alarm sounds. At start-up, this alarm sounds until sufficient air pressure is built to operate the vehicle safely.

#### *Service brakes*

The service brake system is a split type, with wedge-actuated brake shoes on the front axle and an S-cam-actuated brake shoe system on the rear axle. Each brake system, front and rear, is independent of the other. A failure in one system will not affect the other and will result in only partial loss of braking power.

#### *Parking brakes*

The parking brake is spring-actuated and incorporated in the spring brake chambers on the rear axle. When the chambers are pressurized, large coil springs are compressed, releasing the parking brakes.



Exhausting air pressure from the chambers allows the spring to expand, engaging the parking brakes. A push/pull switch located in the cab controls parking brake operation. A red parking brake indicator light illuminates to indicate the parking brake is engaged.

### ***Emergency brakes***

Emergency braking is controlled by the brake pedal through the function of a spring brake control valve assembly. The spring brake control valve assembly constantly monitors rear axle service reservoir pressure. If a loss of rear axle pressure occurs, the operator is alerted by the LOW AIR indicator and alarm located on the dashboard. If you then depress the brake valve assembly, the spring brake control valve assembly reacts by sensing front axle delivery pressure and applies and releases the rear axle spring brakes until the remaining air is depleted. The rear brake application is in direct proportion to the front axle pressure signal. This action provides the operator with modulated braking and the feel of a normal service brake stop. Loss of front brake circuit pressure causes failure in the front brake system only. The rear axle service brakes will still function in a normal manner.

### **Air system**

An air compressor located on the drive engine supplies air pressure for the system. The compressor automatically maintains sufficient air pressure to operate the air system through the function of an air governor. A dual air pressure gauge and low-pressure indicator are mounted on the instrument panel to enable the operator to monitor the air system. An air dryer is contained in the system to collect and remove any moisture and contaminants present in the system air before it reaches the first air reservoir. The air dryer contains a heater and thermostat assembly to prevent freeze up in the purge drain valve when the dryer is used in severe winter conditions. Each of the three air reservoirs contains a manual drain valve to allow the operator to drain them daily to remove accumulated moisture present in the systems.

### **Fuel system**

The fuel system consists of two 128-gallon diesel fuel tanks plus the necessary piping, valves, fuel/water separators, and fittings to deliver fuel to each engine independently. The fuel tanks are plumbed together by a crossover hose that ensures the fuel level will be the same in each tank. Fuel passes through a fuel/water separator and secondary filter before it is delivered to the fuel injection system. Inside each injector is a separate plunger-type pump for that cylinder. This pump delivers a metered amount of fuel under high pressure into the cylinder. Both fuel tanks and fuel/water separator provide drains for removal of condensation and sediment from the system.

### **Optional equipment**

This multipurpose vehicle has an array of optional equipment for use during snow removal operation.

### ***Tri-axis controller***

The tri-axis controller (joystick) located in the cab is a multiposition, spring-loaded momentary switch used to position the blower, optional chute, and optional plow. The functions of the tri-axis controller are listed below.

#### ***Forward***

Push the joystick forward to PLOW DOWN position to lower blower or optional plow. Press the push button FLOAT SET switch while joystick is in the forward position to place blower into float mode.

#### ***Backward***

Pull the joystick backward to the PLOW UP position to raise the blower or optional plow. Pulling the joystick backward also disengages the float mode.

*Left*

Move the joystick to the left to rotate the impeller housing or optional chute to the left a maximum of 90 degrees, depending on setting of CHUTE/BLOWER ROTATE switch. If the optional plow is attached, the plow will rotate to the left a maximum of 35 degrees.

*Right*

Move the joystick to the right to rotate the impeller housing or optional chute to the right a maximum of 90 degrees, depending on the setting of the CHUTE/BLOWER ROTATE switch. If the optional plow is attached, the plow will rotate to the right a maximum of 35 degrees.

*Loading chute*

The loading and spotting chute provides a means to load a parallel-traveling vehicle for bulk snow removal. The chute is capable of 240 degrees of rotation and contains one extendible section and one flipper section. The chute is controlled hydraulically by switches and a joystick located in the cab.

*Reversible plow*

A hydraulically controlled reversible plow assembly is available for high-speed snow and slush removal. The reversing feature, 35 degrees right and left of the centerline, allows the operator more flexibility by selecting the direction of snow removal. The controls for the plow are located in the cab for operator convenience. The plow is mounted on adjustable height, self-steering, trailing-type wheels that are designed for carrying heavy loads at high speeds. It is designed to remove snow or slush at speeds of up to 30 mph. Located at the top of the plow is a deflection strip designed to prevent snow from being thrown over the upper edge and onto the windshield.

*Multisection plow*

The multisection plow (fig. 2-15) is a three-segmented, spring return, trip-type plow. When the plow encounters an obstacle during forward travel, the affected section of the plow turns upward and slides over the obstruction. The plow is designed to return to its clearing position within 3 feet after passing over a six-inch obstruction. Curb protection shoes are provided for protection when bumping against curbs, sidewalks, and other high boarders that are difficult to locate under snow. From the cab, the operator can adjust the plow to an angle of 35 degrees to the right and left of the centerline. The plow comes equipped with two trailing-type caster wheels that permit adjustment to maintain an exact distance between the cutting edge and the roadway. By maintaining a correct adjustment on the caster wheels, wear on the cutting edge is held to a minimum. Located at the top of the plow is a deflection strip designed to prevent snow from being thrown over the upper edge and onto the windshield.

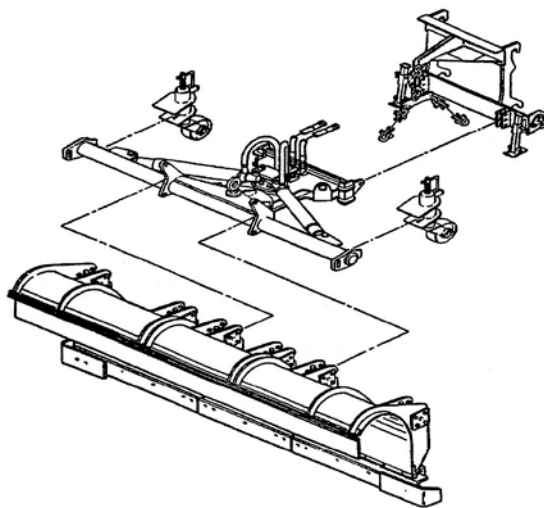


Figure 2-15. Multisection plow.

### Winterization system

The winterization system (fig. 2-16) consists of a separate coolant heater and optional oil heater for both drive and blower engines along with an optional battery heater. The heaters are wired to a 50-amp receptacle located at the left rear of the vehicle. 115 volts alternating current (VAC) of external voltage is supplied to a receptacle through the 25-foot long connecting cable that is part of the winterization system package. The winterization electrical components are protected against overloads by manual reset circuit breakers installed on the junction boxes on the vehicle.

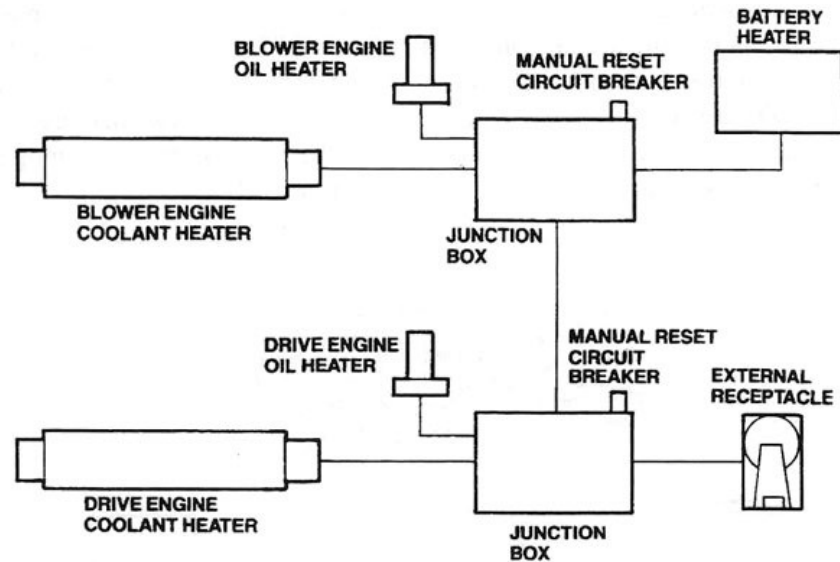


Figure 2-16. Winterization system.

## Self-Test Questions

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

### 208. Snow blower fundamentals

1. How do you describe the characteristics of the vehicle's cab?
2. How many and what types of engines does the snow blower incorporate and what are their uses?
3. Why are two alternators used in the electrical system?
4. How is the electrical circuit protected?
5. What are the major components of the blower system?

6. How many hydraulic systems does the blower have and what are their uses?
7. What type of brake system does the vehicle use?
8. What is the purpose of the crossover hose that connect the two snow blower fuel tanks?
9. What optional equipment is available for use on the multipurpose snow blower vehicle?

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### Answers to Self-Test Questions

#### 207

1. 30-amp breaker.
2. 3-amp circuit breaker.
3. Manual airflow switch.
4. Ether start button.
5. Two to four inches.
6. To support the weight of the sweeper.
7. Stop caster shimmy.
8. To strip debris from the bristles.
9. Three—brush, air-blast, and compensator pumps.
10. Delta selector and delta poppet.
11. The broom motor drives the differential, which turns the broom segments using chain couplers.
12. Low oil pressure and high coolant temperature.

#### 208

1. The cab sits at the forward edge of the frame to give the operator the best possible forward and peripheral view.
2. Two diesel engines. The rear engine drives the vehicle; the front engine drives the blower attachment.
3. One 160-amp alternator supplies voltage to batteries, starter, heated mirrors, headlights, tail lights, turn signals, spot lights, clearance lights, beacon light, cab interior, reverse alarm, instrument panel, horn, and solenoid valves. One 75-amp alternator supplies voltage to heated windshield and other functions when the cab switch is engaged and the drive engine is running.
4. Manual reset circuit breakers.
5. Augers, caster wheels, impeller housing, impeller, push frame, scraper blade, and skid plates.
6. Two separate hydraulic systems. One for the augers and one for blower assembly control.
7. Air type.
8. To ensure the fuel level is the same in both tanks.
9. Tri-axis controller, loading chute, reversible plow, multisection plow, and winterization system.

**Do 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.

**Do not return your answer sheet to AFCDA.**

18. (207) The purpose of the casters on the Windrow sweeper is to
  - a. ensure a proper sweep angle.
  - b. ensure a proper sweep pattern.
  - c. support the weight of the stabilizer bar.
  - d. support the weight of the sweepster broom.
19. (207) The three hydraulic pumps used on the Windrow sweeper are the
  - a. transmission, steering, and the power takeoff (PTO).
  - b. brush, air blast, and the compensator.
  - c. transmission, auxiliary, and the PTO.
  - d. brush, filtration, and the compensator.
20. (207) The Windrow sweeper's engine shut down module shuts down the engine when oil pressure is
  - a. above 60 pounds per square inch (psi) or coolant temperature is below 150 degrees Fahrenheit.
  - b. below 5–10 psi or coolant temperature is above 200–210 degrees Fahrenheit.
  - c. below 5–10 psi or coolant temperature is above 185–195 degrees Fahrenheit.
  - d. above 75 psi or coolant temperature is below 140 degrees Fahrenheit.
21. (208) The snow blower's 75-amp alternator provides power to the
  - a. reverse alarm.
  - b. heated mirrors.
  - c. heated windshield.
  - d. beacon and clearance lights.
22. (208) How many extendible sections does the snow blower vehicle's loading and spotting chute have?
  - a. Four.
  - b. Three.
  - c. Two.
  - d. One.

**Please read the unit menu for unit 3 and continue ➔**

## Unit 3. Flightline Support Vehicles

<b>3-1. Regenerative Sweeper .....</b>	<b>3-1</b>
209. Regenerative sweeper fundamentals.....	3-1
<b>3-2. Aircraft Towing Tractor .....</b>	<b>3-12</b>
210. Aircraft towing tractor fundamentals.....	3-12
<b>3-3. Aircraft Deicer .....</b>	<b>3-20</b>
211. Deicer features and fundamentals.....	3-21
212. Deicer boom fundamentals .....	3-30
213. Deicer dispensing and heating system fundamentals.....	3-36

**I**N THE FOLLOWING LESSONS, we will cover flightline support vehicles. This unit will cover the regenerative sweeper, aircraft towing tractor, and aircraft deicer. Learning how to maintain these vehicles is vital to generating sorties on time in support of the Air Force mission.

### 3-1. Regenerative Sweeper

The regenerative sweeper's main purpose is keeping aircraft runways clear of potential foreign object damage. Additionally, it keeps base streets clean. It is self-propelled and has the capability to collect the debris it sweeps up, like a much larger version of a household vacuum. In this section, we will discuss the regenerative sweeper's fundamentals, key systems, and repair and adjustment procedures.

#### 209. Regenerative sweeper fundamentals

The Young Manufacturing Company® (TYMCO) manufactures the most common regenerative sweeper in the Air Force inventory. The operating principle of a regenerative sweeper is to use high velocity air and vacuum to clean streets and runways. It combines the street-sweeping capability of gutter brooms with the efficient cleaning of a vacuum system. This lesson covers the sweeper's functions and major components. Figure 3-1 shows the configuration of the sweeper from the top and side views.

#### Operating speeds

In order for the TYMCO sweeper to perform at peak efficiency, it must operate at the correct speeds. Three factors must be considered when desiring peak efficiency:

1. Auxiliary engine rpm.
2. Type of material being swept.
3. Speed of the sweeper passing over the swept surface.

**NOTE:** You must travel slower and use a higher auxiliary engine rpm when sweeping heavier materials.

**CAUTION:** Do not allow the auxiliary engine to exceed 2,500 rpm.



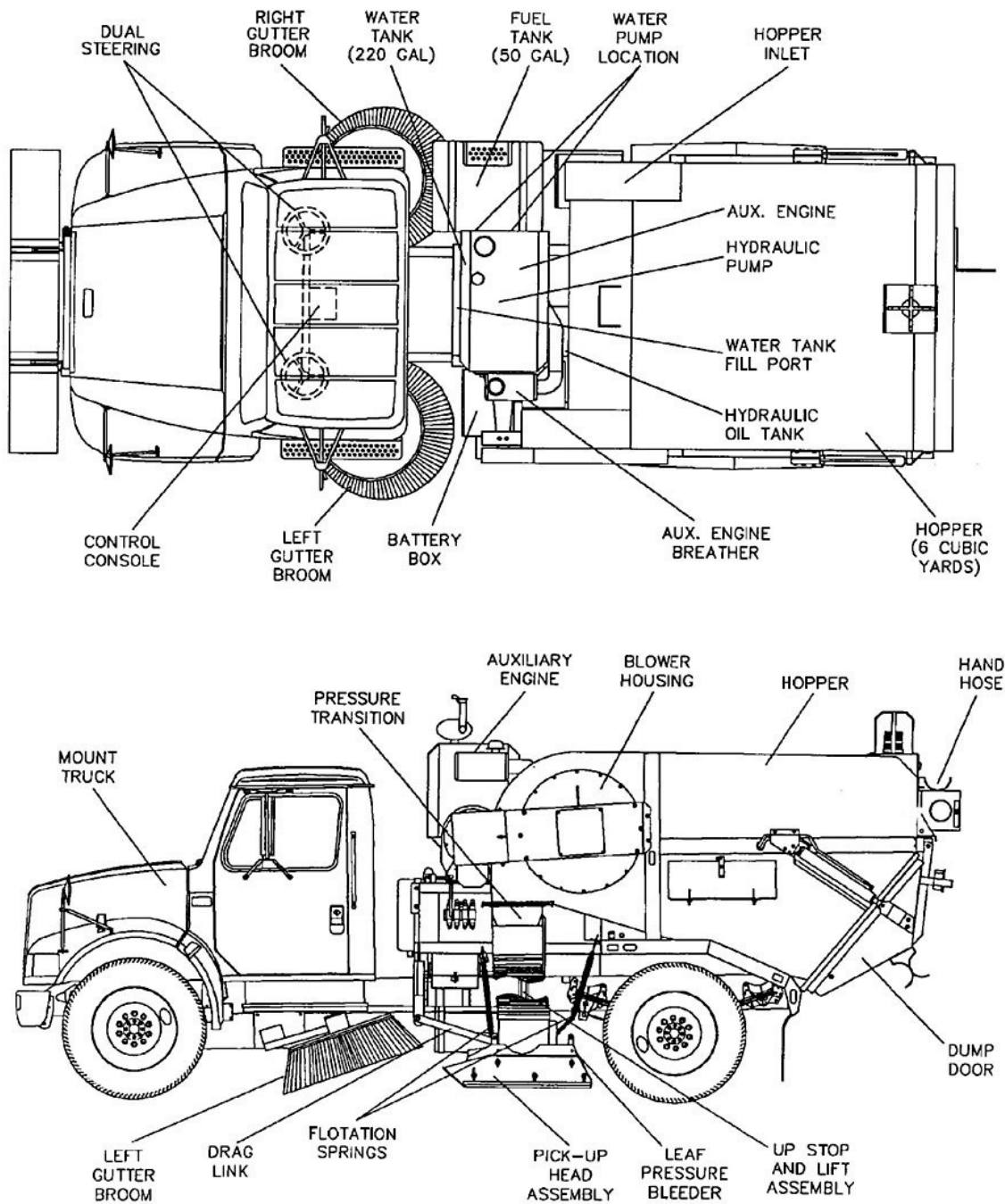


Figure 3-1. Sweeper configuration.

Use the following chart for recommended operating speeds:

Recommended Sweeper Operating Speeds		
Auxiliary Engine RPM	Material	MPH
1,800	Paper, leaves, and light trash.	5–10
2,000–2,200	Normal accumulations of dirt, sand, and gravel.	3–5
2,200–2,500	Heavy accumulations of dirt, sand, and gravel.	1–3

With the vehicle's sweeping speed ranging from 1–10 mph, the sweeper is not meant to sweep an entire 10,000-foot runway, only specific areas. These areas are where aircraft have their engines running and are parked or moving slowly, such as parking ramps, taxiways, ends of runways, or roads that cross runways. These are where the aircraft engines are most vulnerable to foreign object damage.

### Carrier truck

The sweeper can be mounted on a variety of trucks. The primary purpose of the carrier truck is to adequately support and safely carry the sweeper and all of its accessories. The only unique characteristic about the cab is that it can be driven from either side. There are dual steering wheels, accelerator and brake pedals, and a console between the seats to control the auxiliary engine and sweeper functions.

### Engines

Both the carrier and sweeper unit are equipped with diesel engines. The type of carrier engine varies depending on the truck manufacturer, while the auxiliary engine is an in-line four cylinder. Both engines draw their fuel from the same tank, but the auxiliary engine will run out of fuel first since the fuel lines to the auxiliary engine are shorter. The auxiliary engine is located behind the cab and in front of the hopper. The carrier engine provides power for the carrier only, while the auxiliary engine drives the blower and the hydraulic pump for the system.

All gauges and necessary components to start and monitor the auxiliary engine are on the control panel (fig. 3–2). The central location of the control panel allows the operator to conveniently operate the entire system from either side of the truck cab.

### Automatic shutdown system

TYMCO sweepers use an automatic shutdown system that shuts down the auxiliary engine if it overheats or loses oil pressure. If this system detects one or both of these conditions, it will stop the engine 30 seconds after detection.

The system employs a circuit breaker with a built-in 30-second timer. With the sweeper engine ignition switch placed in the ON position (engine off), a red light will start blinking. After 30 seconds, the red reset button next to the ignition switch will pop up (fig. 3–2, item 34).

As long as the reset button is up, the engine will not start. If the switch is in the “popped” (activated) position, it has detected a problem. If you traced the electrical schematic with the switch activated, electrical current cannot pass through the switch to the fuel injector pump solenoid. If the injector pump solenoid does not receive current, which allows fuel flow, the engine will not start.

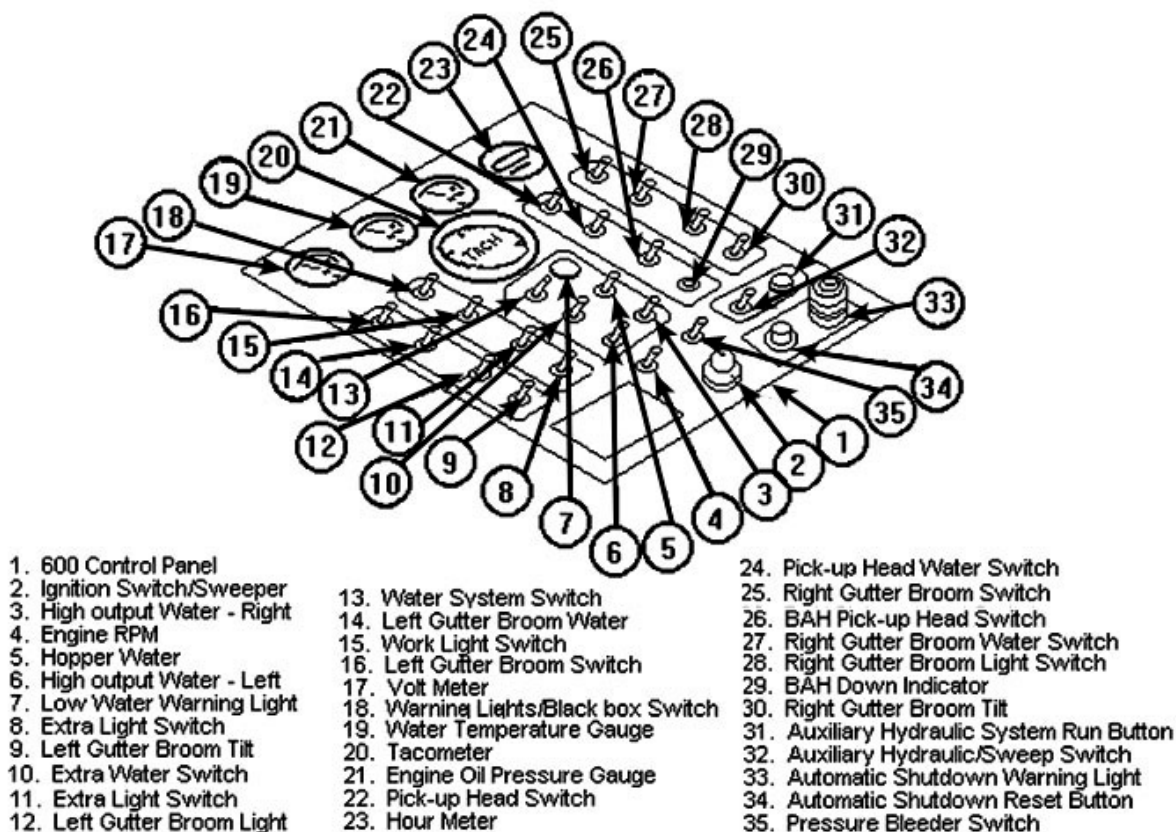


Figure 3-2. Control panel assembly.

### Hopper and blower assembly

Once the sweeper engine starts, it uses the same air repeatedly. This is why it is labeled a closed loop system (regenerative). To make this possible, the system *must* be sealed and the air within cleaned. This section covers how the air flows through the system with a brief explanation about each component. Airflow in a closed loop system starts and ends at the blower.

Refer to figure 3-3 as we go over the airflow. As the high-pressure air leaves the blower, it passes through a pressure hose to the pressure chamber of the pick-up head. Air then passes through a set of turning vanes, which distributes the air evenly across the blast orifice. Air is directed at a forward angle to the ground, where it stirs up dirt and debris. The dirt and debris are lifted into the air and pulled up through the suction hose and into the hopper. At the top of the hopper is a screen that removes all the large materials from the air stream. The dirty air that goes through the screen enters the top of the dust separator. Inside the dust separator, the air spins in a circular motion and centrifugal force pulls the fine dust particles out of the air and onto the separator walls. Along the bottom edge of the separator is an opening called the skimmer slot, which dumps the dust into a holding area in the hopper. Clean air then goes to the blower and the cycle starts over again.

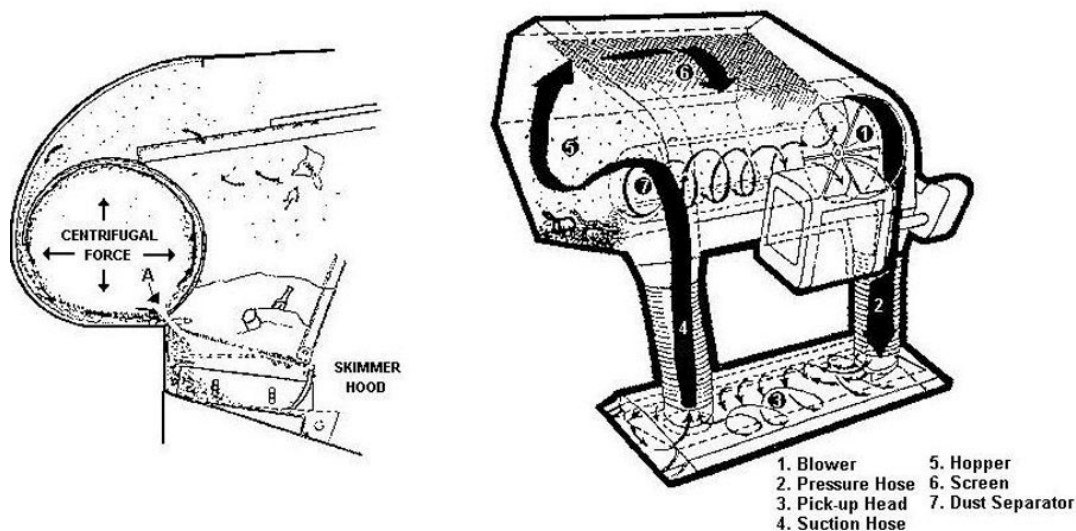


Figure 3-3. Hopper assembly.

The blower is the heart of the system, because it produces the pressurized air and vacuum for the sweeping operation. It is belt-driven by the auxiliary engine and designed for maximum performance with low noise. The blower is constructed of lightweight aluminum for increased efficiency and is geared to spin faster than the engine.

The hopper assembly is a large tank-like structure. It is divided into two sections and is mounted on the rear of the truck. One section holds the debris and dirt swept up by the sweeper. This section is designed so that the weight of the debris is distributed over the rear axle of the carrier. Its shape facilitates dumping of debris directly behind the rear wheels.

**NOTE:** Whenever the sweeper is parked, the dump and inspection doors must be opened to allow the seals on the doors to expand. This provides a better sealing surface when the doors are closed and allows moisture to escape the hopper.

### Pick-up head

The pick-up head (fig. 3-4) is the sweeping and suction component of the system.

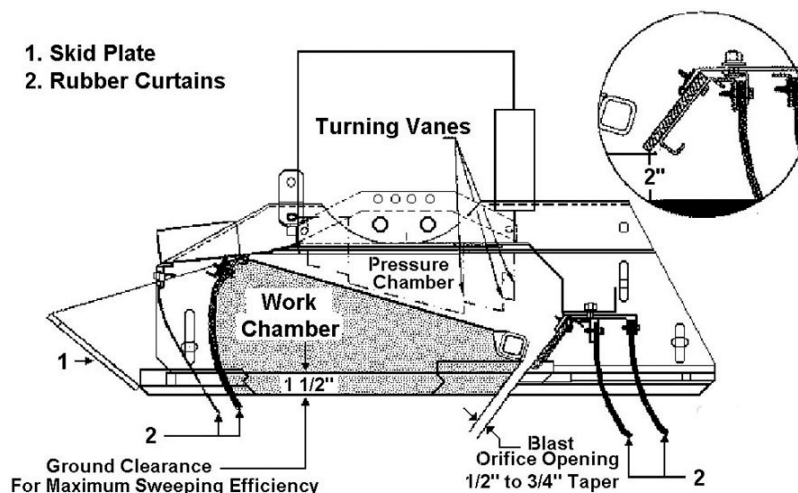


Figure 3-4. Pick-up head.

Several components (e.g., blast orifice, skid plate, floating springs, and deflector and rubber curtains) make up the pick-up head. The following table describes these components:

Sweeper Pick-Up Head Components and Description	
Component	Description
Blast orifice	An adjustable 5/8-inch gap (fig. 3-5) that directs pressurized air from the blower towards the ground, creating an agitating action to loosen and break up debris. It stretches along the back end of the pick-up head, from one side to the other.
Skid plates	Provide these three functions: <ol style="list-style-type: none"> <li>1. Allows adjustment of the height of the blast orifice from the ground.</li> <li>2. Provides a seal for the sides of the pick-up head.</li> <li>3. Provides a wearing surface for the pick-up head.</li> </ol>
Floatation springs	Adjusts the pick-up head pressure on the ground; this prevents excessive wear to the skid plates.
Deflector and rubber curtains	Ensures that debris stays in the path of the pick-up head as it is being swept by the gutter brooms. It is attached to the front of the pick-up head and runs forward along the centerline of the truck to the front axle. It also keeps the debris from being thrown under the truck and into passing traffic or pedestrians. The rubber curtain provides the seal for the front and rear of the pick-up head.

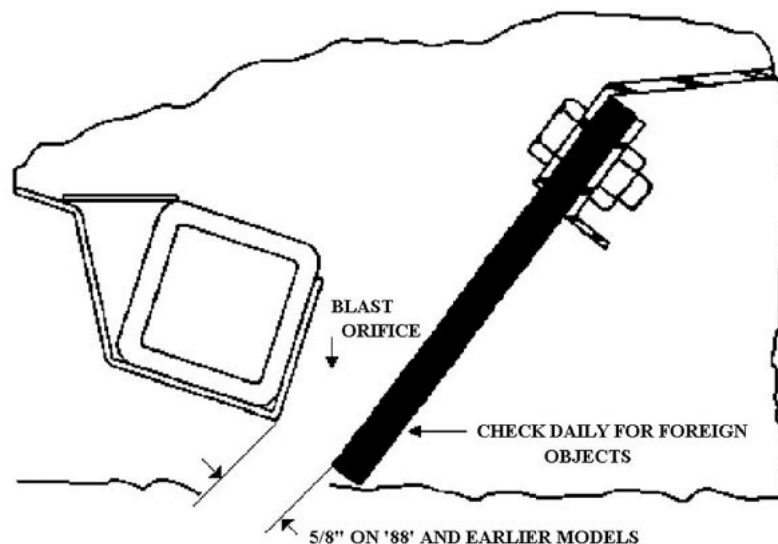


Figure 3-5. Blast orifice.

### Pressure and suction hoses

The pressure hose is on the truck's left side. It provides a way for air to get from the blower to the pick-up head. The suction hose is on the truck's right side. It provides a way for debris to get from the pick-up head to the hopper. It can be unlatched for easy cleaning or suction plate installation. The suction plate diverts the suction to a handheld hose on the back of the hopper. The handheld hose is used for cleaning areas the truck cannot reach.



### Gutter brooms

The gutter brooms (fig. 3-6) sweep dirt and debris into the path of the pick-up head. The brooms are driven, raised, and lowered hydraulically. The bristles are made of wire or polypropylene. Refer to the technical order for procedures on how to perform maintenance on the gutter brooms.

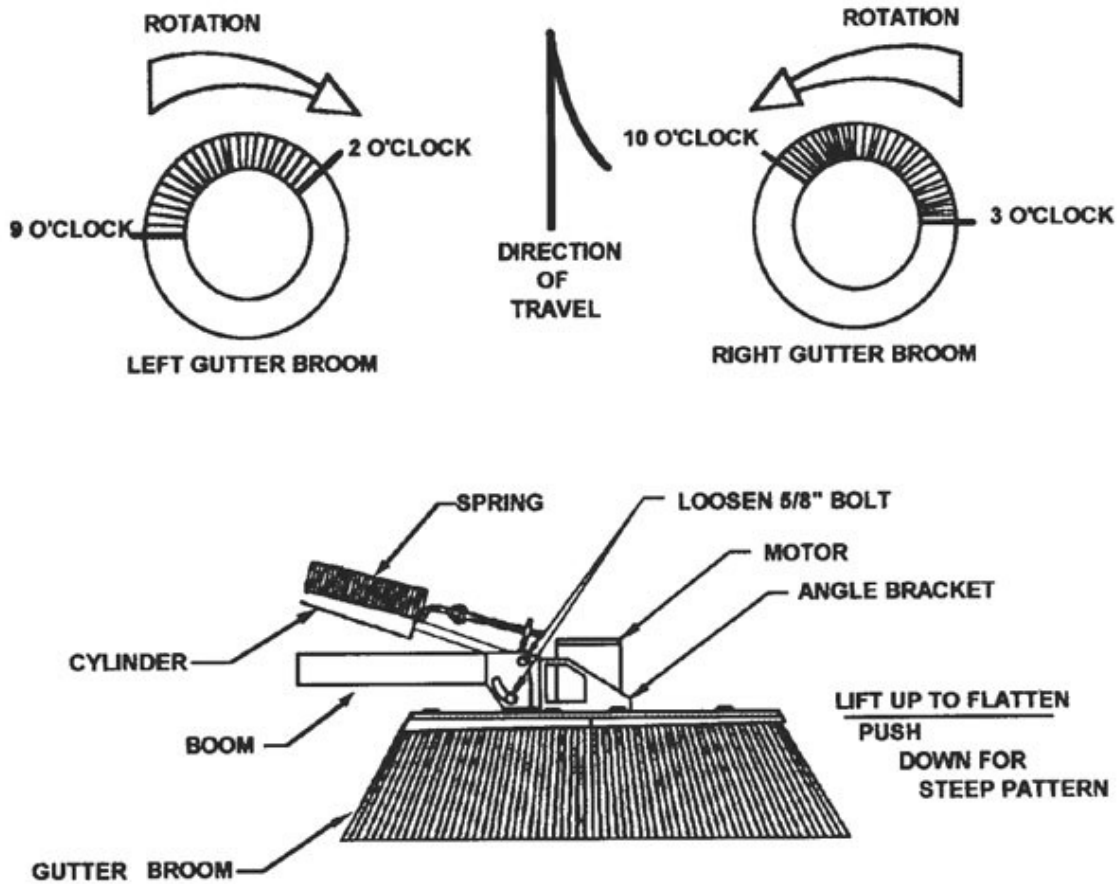


Figure 3-6. Gutter broom.

### Hydraulic system

The hydraulic system on the sweeper provides the power necessary to operate the cylinders that open and close the hopper doors, raise and lower the pickup hood, and drive and position the gutter brooms.

Figure 3-7 shows the hydraulic system with a portion of the electrical system included. The reservoir is located on the left side of the truck between the auxiliary engine and the hopper. It holds 9½ gallons of hydraulic fluid with a dipstick on the cap that is used for checking the fluid level.





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### *Open center system*

The hydraulic system is an open-center system that uses a vane-type hydraulic pump with a built-in relief valve. The relief valve is set at 2,500 psi and is gear-driven by the auxiliary engine. The valve bank consists of four electric solenoid actuated spool-type control valves. They direct fluid to the six double-acting cylinders (two dump door/two pick-up head/one for each gutter broom) and two torque motors.

Between the gutter broom valves and the valves for the dump door and pick-up head, there is a bypass valve and a secondary pressure relief valve. The bypass valve must be opened (electrically or manually) at the same time the pick-up head or dump door is operated. The secondary pressure relief valve is set at 1,350 psi and is the maximum pressure allowed to any cylinder or seal damage will occur. However, the torque motors use the full 2,500 psi to operate the gutter brooms.

### *Hydraulic valves*

There are three additional hydraulic valves by each gutter broom. They are explained in the following table:

<b>Gutter Broom Hydraulic Valves and Description</b>	
<b>Valve</b>	<b>Description</b>
Cartridge	Sends 1,350 psi to each broom cylinder, then allows 2,500 psi to the broom motors. It also protects the system from shock damage when the broom encounters solid objects.
Solenoid lock	Holds the broom up in the stowed position. It must be energized for the broom to go down.
Flow control	Controls the raising speed of the broom. Before the fluid returns to the reservoir, it goes through an oil cooler located in front of the auxiliary engine radiator, then to a return filter.

### *Water system*

The sweeper uses a water system to control the amount of dust produced during sweeping operations. The operator activates a spray of fine water mist on the road surface before the road is swept. Water also aids the dust separator in filtering dust from the air. Electric toggle switches activate each of the four nozzles: one for each broom, one for the pick-up head, and one for the hopper. The hopper water system controls internal dust and protects the blower from damage.

### *Water tank*

The capacity of the water tank depends on the model of the sweeper. The TYMCO model 600, the most common Air Force model, has a tank capacity of 170 gallons. The interior of the tank has a protective coating to prevent corrosion. The tank is fitted with a drain valve to facilitate rapid emptying. The water system components are shown in figure 3-8.

The water pump is a 12-volt, low-pressure pump with an output of 2.8 gpm. It is rated at 30 psi and is located on the left side under the blower and in front of the hopper.

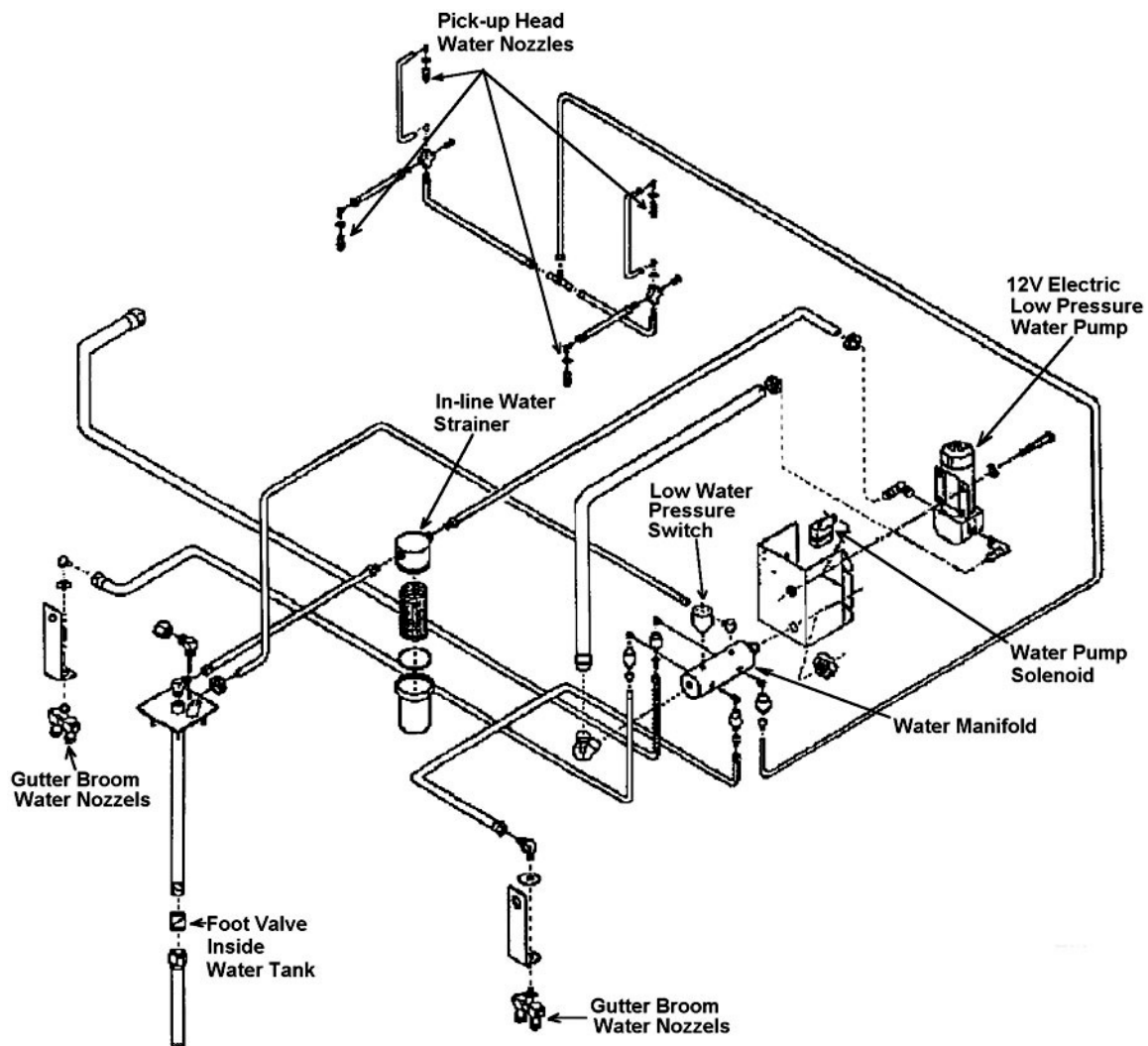


Figure 3-8. Water system.

There are four areas where water filters are placed to protect the system. They are described in the following table:

Water Filters and Description	
Filter	Description
Metal cone screen	The end of the 2½-inch fire hose that connects to fire hydrants has a metal cone screen that is held in place by an O-ring.
Foot valve/strainer	Located inside the water tank, it prevents large particles from entering the system and prevents back flow, assuring a good water supply in the suction line to the pump.
In-line strainer	Located between the tank and pump, it prevents fine particles from entering the system. Operators must remove and clean this strainer on a daily basis.
Nozzle screens	A small screen under each nozzle cap that keeps the nozzle from becoming plugged.

***Water safety system***

Some models use an automatic low water shutdown switch while others use a float switch in the tank to protect the pump from operating if it loses prime or the tank runs out of water. If the electric pump runs dry for an extended period, it may overheat and malfunction. A green indicator light in the cab illuminates to let the operator know that the water pump is not working because the pump has lost its prime or the tank is out of water.

**NOTE:** To lubricate the pump and internal components of the water system, add one (1) quart of water-soluble oil or the equivalent to the water tank every 150 hours of operation. It is important that the oil be water-soluble.

---

**Self-Test Questions**

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

**209. Regenerative sweeper fundamentals**

1. What is the operating principle of the regenerative sweeper?
2. What are the recommended RPMs and operating speeds of the TYMCO sweeper?
3. What does the auxiliary engine drive on the TYMCO sweeper?
4. What is the purpose of the auxiliary engine automatic shutdown system?
5. What is the heart of the TYMCO air system and what does it produce?
6. What item is the sweeping and suction component of the TYMCO sweeper?
7. What are the purposes of the skid plates?
8. What purpose does the deflector curtain serve?

9. What are gutter brooms used for?
10. What problem does overfilling the hydraulic tank cause on the TYMCO sweeper?
11. Describe the TYMCO sweeper hydraulic pump.
12. What use does the TYMCO sweeper solenoid lock valve serve?
13. What controls the raising speed of the gutter brooms?
14. What is the purpose of the TYMCO sweeper water system?
15. What does a green light on the TYMCO sweeper center control panel tell the operator?

## **3-2. Aircraft Towing Tractor**

The Air Force towing tractor tows aircraft, aerospace ground equipment, and various other pintle hook equipped equipment. These vehicles are compact and combine engine torque with low gear ratios to pull heavy loads. The Air Force uses several different types of towing tractors. However, in the following lessons, we will focus on the Entwistle® MB-4 towing tractor.

### **210. Aircraft towing tractor fundamentals**

The Entwistle MB-4 towing tractor (fig. 3-9) is used primarily for towing military aircraft, but can also be used for general equipment towing. The MB-4's towing capacity is 175,000 pounds for aircraft and 93,000 pounds for all other towing operations.

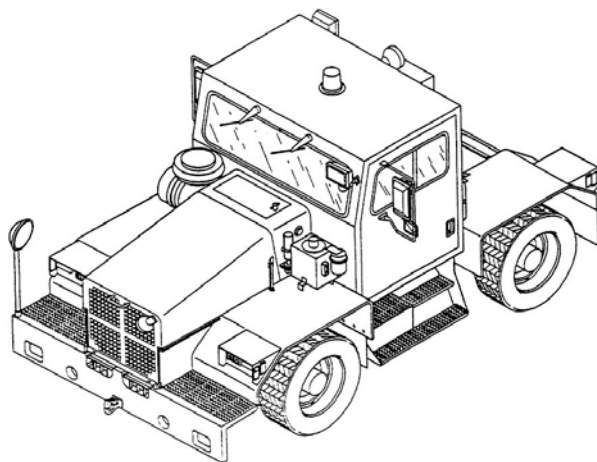


Figure 3-9. MB-4 towing tractor.

### Drive train

The MB-4 gross vehicle weight is 20,000 pounds and is powered by a six-cylinder turbocharged diesel engine. An automatic transmission with four forward gears and one reverse gear delivers power to a two-speed transfer case. The transmission can be shifted manually by a shift lever located on the dash. The transfer case provides full time four-wheel-drive in two ranges, high and low.

The electric high range/low range control switch, mounted on the dash in the cab, is used to select the desired transfer case range. The high range/low range switch electrically activates a valve in the hydraulic manifold. This valve directs fluid under pressure to a cylinder on the transfer case to move a shift fork, shifting it between high and low range. The transfer case is splash lubricated with 90-weight oil. Figure 3-10 illustrates the layout of the drive train.

**CAUTION:** Do *not* shift the transfer case while vehicle is in motion. Damage to the drive train can result!

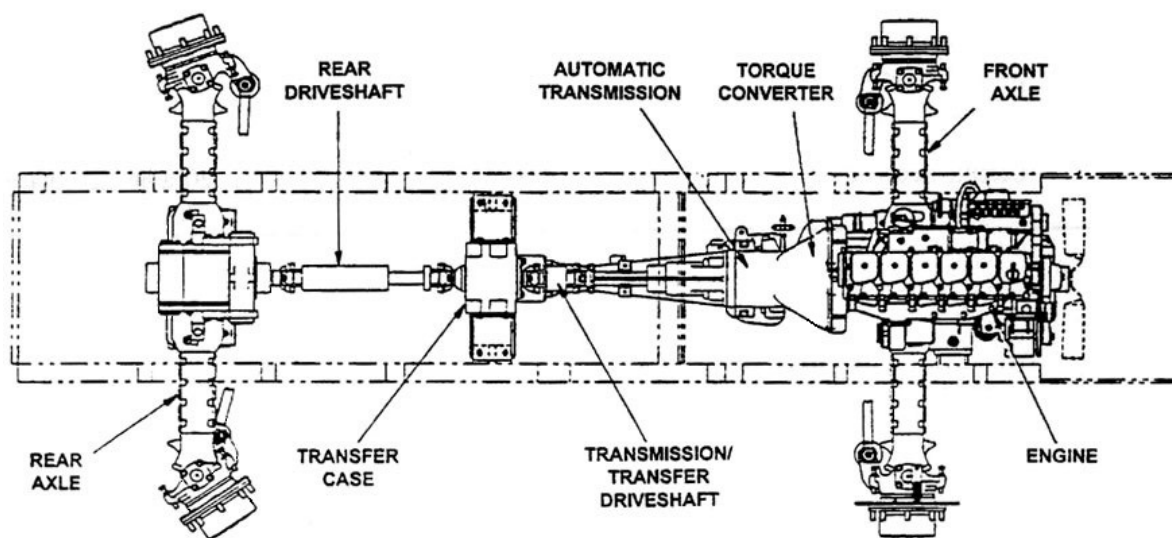


Figure 3-10. Drive train.

Power from the transfer case is transferred to the front and rear axle assemblies through drive shafts. The front and rear axle assemblies are identical and are mounted to the frame through two compression springs, two suspension links, and a sway bar. On the ends of the axle assemblies are the final drive hubs. The final drive hubs have planetary gears that increase torque at each of the four drive wheels.

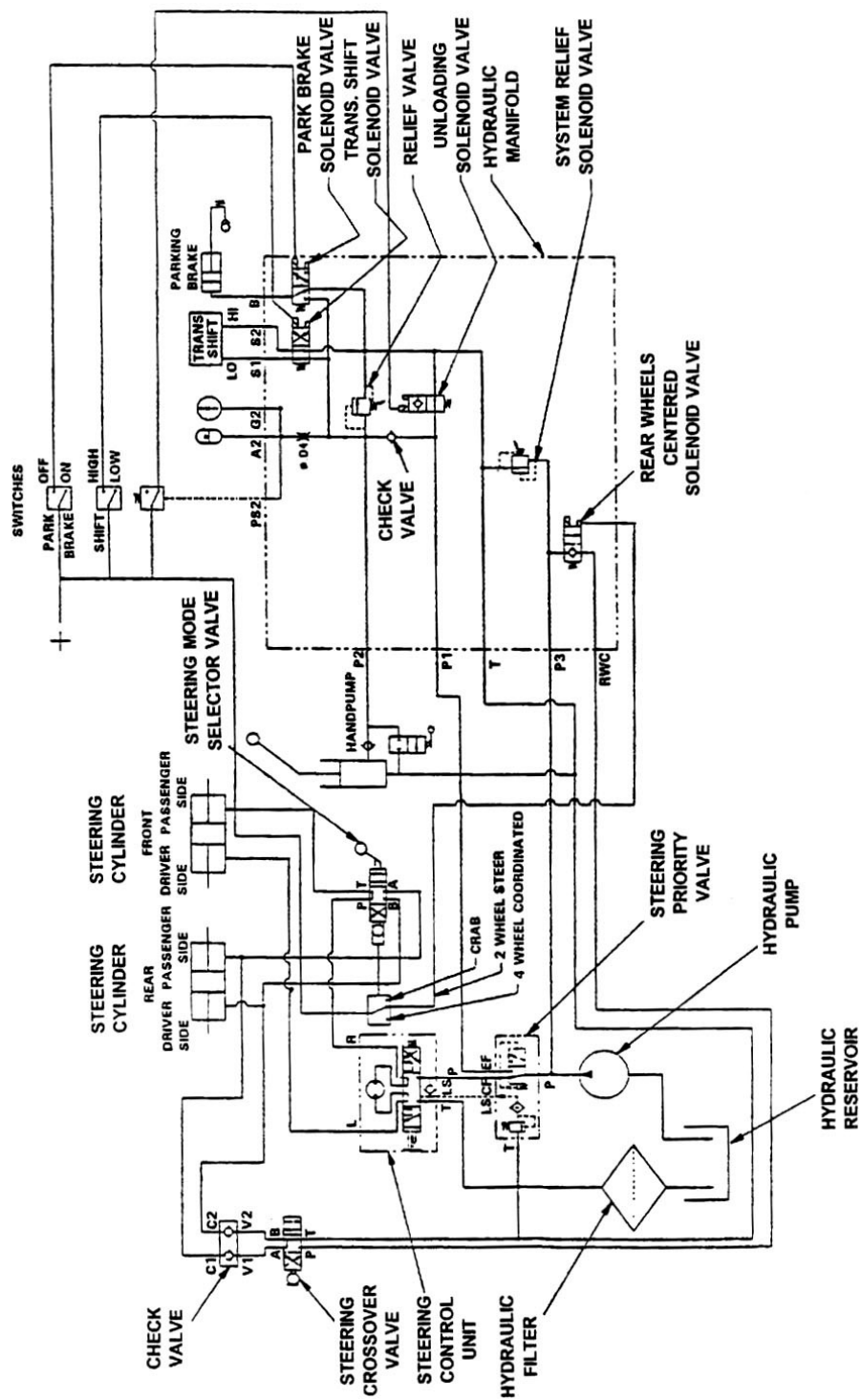


Figure 3-11. Steering system.



### Steering system

The steering system (fig. 3-11) uses a hydraulic gerotor control unit and hydraulic fluid under pressure to actuate a steer cylinder mounted on each drive axle. With the engine running, hydraulic pressure is used to reduce the effort required to turn the steering wheel (power-assist steering). If the engine is not running, the wheels can still be turned, but much greater effort is required.

There are three steering modes:

- 1) Two wheel (only the front wheels turn).
- 2) Four wheel or coordinated (rear wheels are turned in the *opposite* direction of the front wheels).
- 3) Crab or oblique (rear wheels are turned in the *same* direction of the front wheels).

A control lever mounted in the cab selects the steering mode. A wheel position sensing system illuminates lights on the dash to indicate the mode selected.

### Mechanical linkage

The steering wheel is directly coupled to the hydraulic gerotor control unit, which controls the flow of fluid to the front and rear steering cylinders through a series of control valves and dividers. Selecting a steering mode will change the hydraulic fluid flow and give the operator the right maneuverability for the task.

In the coordinated mode, the rear wheels are turned in the opposite direction of the front wheels for a tighter turning radius. However, in the oblique mode the rear wheels are turned in the same direction as the front wheels to allow the vehicle to travel in a diagonal direction.

### Hydraulic system

The hydraulic pump is mounted to and driven by the vehicle's air compressor. The hydraulic pump draws fluid from an external reservoir located on the right front fender. A separate hose connects the pump to the reservoir and returns the excess fluid back to the reservoir. Fluid from the pump flows through the steering control unit then returns to the reservoir. Pressurized hydraulic flow is only generated when the engine is running.

The parking brake is spring applied and hydraulically released. Adjusting the parking brake circuit requires specific procedures and if performed incorrectly may cause damage to the brake disc packs. Always follow the technical order procedures.

In the event of a hydraulic pump failure or when the vehicle needs to be towed, the hydraulic system includes a hand pump that can pressurize the system manually so the parking brake can be released and the vehicle steered to a safe location.

### Air and brake system

The MB-4 uses an air-over-hydraulic service brake system (fig. 3-12). An engine-driven air compressor generates pressure for the air portion of the brake system. The air pressure generated is stored in air reservoirs, mounted to the vehicle frame. Each air reservoir is equipped with a heated moisture ejector to remove moisture from the reservoirs automatically. The air compressor runs continually whenever the engine is running. However, the air produced is limited by the compressor governor. An air dryer is also mounted near the reservoirs and is connected between the compressor and the primary reservoir.

When the brake pedal is depressed, air from the air reservoir is directed through the two-way check valve to the treadle foot valve. The air is directed from the treadle to two pressure converters where it pressurizes the brake fluid in the pressure converter's reservoirs. This pressurized brake fluid flows through the brake lines to actuate the service brakes located on the front and rear axles. Braking is

accomplished by multiple wet clutch disks. If the vehicle is equipped with the trailer option, the first inch of treadle valve travel will direct air pressure to the trailer service brakes *before* the vehicle's service brakes are applied.

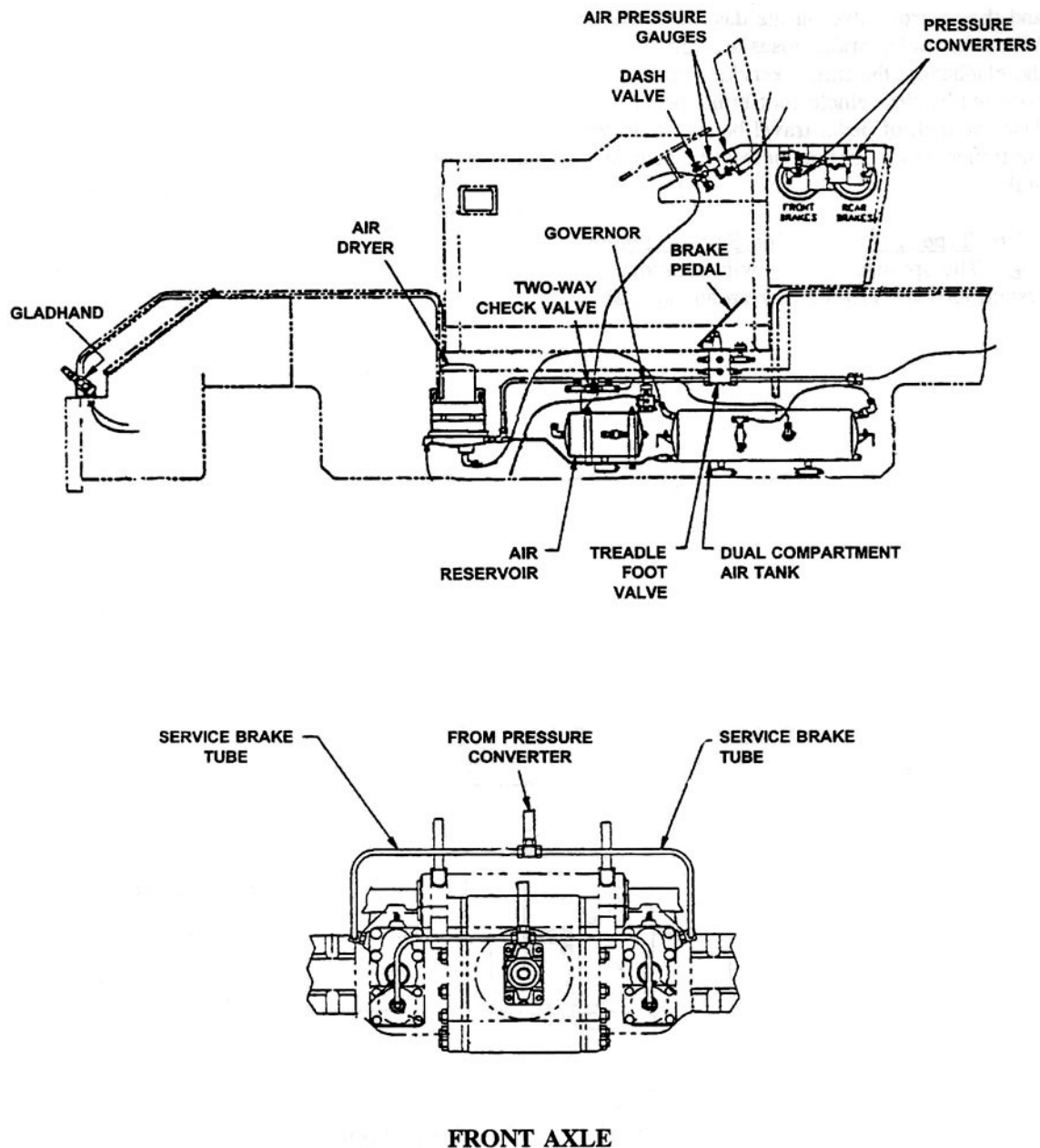


Figure 3-12. Air and brake system.

Spring-applied and hydraulically released parking brakes are contained in both axles. The parking brake is released using an electrical switch on the dashboard, which energizes the parking brake solenoid valve, allowing fluid pressure to release the brakes. Pressure for the hydraulically released parking brake and the hydraulically shifted transfer case is produced by the hydraulic pump and stored in an accumulator.

Accumulator pressure is controlled by a relief valve and an electrically controlled unloading valve located in the hydraulic manifold. The accumulator is precharged with 400 psi of dry nitrogen. The parking brake incorporates a hand pump in the cab to pressurize and release the parking brake for towing.

### Electrical system

The MB-4 has a 12 VDC negative ground electrical system. Three batteries, mounted under the cab, supply current for starting and operation of controls, lights, and accessories, all of which are protected by fuses. A battery disconnect switch is located on the cab floorboard. An engine-mounted alternator charges the batteries and supplies current to the electrical system when the engine is running.

### Winterization system

The standard MB-4 configuration comes equipped with Type C winterization. Type A winterization is optional.

#### *Type C winterization system*

The Type C winterization system includes a 181 to 203 degrees Fahrenheit (°F) engine coolant thermostat and antifreeze protected to -40°F. It also includes ether injection at the intake manifold and has a hard top cab with a personnel heater and windshield defroster.

#### *Type A winterization system*

The optional Type A winterization system receives 115 VAC from an external source. Connection is made through an extension cord that is attached to a receptacle mounted on the left side of the vehicle. Current flows to the coolant, oil, and battery heaters through a junction box. This system is protected from overload by a circuit breaker mounted on the junction box. The heaters are controlled by a 110 VAC thermostatic switch that opens when maximum temperature is reached and closes when the temperature drops below the minimum limit.

### Operator control panel

The vehicle controls, instruments, lights, and accessories are all within reach from the driver's seat. Figure 3-13 displays the operator control panel. The following table lists its components and their functions.

MB-4 Towing Tractor's Operator Control Panel		
Number	Control/Indicator	Function
34	Emergency shutdown	Stops engine in an emergency by shutting off fuel supply.
35	Cold start	Energizes solenoid valve to inject measured amount of ether into diesel engine air connection.
36	Tachometer/hourmeter	Displays engine rpm and total hours engine has operated.
37	Speedometer/odometer	Displays vehicle speed and total miles vehicle has been driven.
38	Front wheel position	Indicates position of front wheels.
39	Rear wheel position	Indicates position of rear wheels.
40	Off/on/start switch	Off – Disables electrical system and deenergizes fuel shutdown solenoid. On – Energizes the vehicle's electrical system. Start – Energizes the diesel engine starting circuit.
41	Fuel gauge	Displays approximate level of fuel in tank.

MB-4 Towing Tractor's Operator Control Panel		
Number	Control/Indicator	Function
42	Rear wheel centered light	When lit, indicates rear wheels are centered.
43	Turn signal light	When flashing, indicates turn signal light is on.
44	High beam	When lit, indicates high beam headlights are on.
45	Low oil pressure	When lit, indicates low engine oil pressure.
46	Engine overheat	When lit, indicates engine is overheated.
47	Low air pressure	When lit, indicates low air pressure in system.
48	Transmission overheat	When lit, indicates transmission is overheated.
49	Winterization power	When lit, indicates winterization system extension cord is connected to vehicle and heaters are operating.
50	Oil pressure gauge	Indicates diesel engine oil pressure.
51	Voltmeter	Indicates voltage level of battery.
52	Trans temp gauge	Indicates transmission oil temperature.
53	Water temp gauge	Indicates engine coolant temperature.
54	Panel light	Lights the dash panel controls and indicators.
55	Air pressure gauge	Indicates air pressure at the air system trailer couplings.
56	Air pressure tank gauge	Indicates air pressure at the air system reservoir.
57	Trailer air supply	When pressed with the engine running, activates air system for trailer towing.
58	Park brake indicator	When lit, indicates parking brake is set.
59	Park brake switch	On – Sets parking brake. Off – Releases parking brake.
60	Wiper/washer	Turns windshield wipers on and off or operates windshield washer.
61	Shift range	High – Shifts transfer case to high range. Low – Shifts transfer case to low range.
62	Steering mode	Crab – Selects oblique steering mode. 2 wheel – Selects two wheel steering mode. 4 wheel – Selects coordinated steering mode.
63	Heat	Pull on – Turns on cab heater. Push off – Turns off cab heater.
64	Lights – beacon	Turns beacon on and off.
65	Lights – rear work	Turns rear work light on and off.
66	Lights – front pintle	Turns front pintle light on and off.
67	Lights – dash	Selects high or low intensity of the panel lights and gauges.
68	Lights – headlights	Turns headlights, marker lights, and taillights on and off.

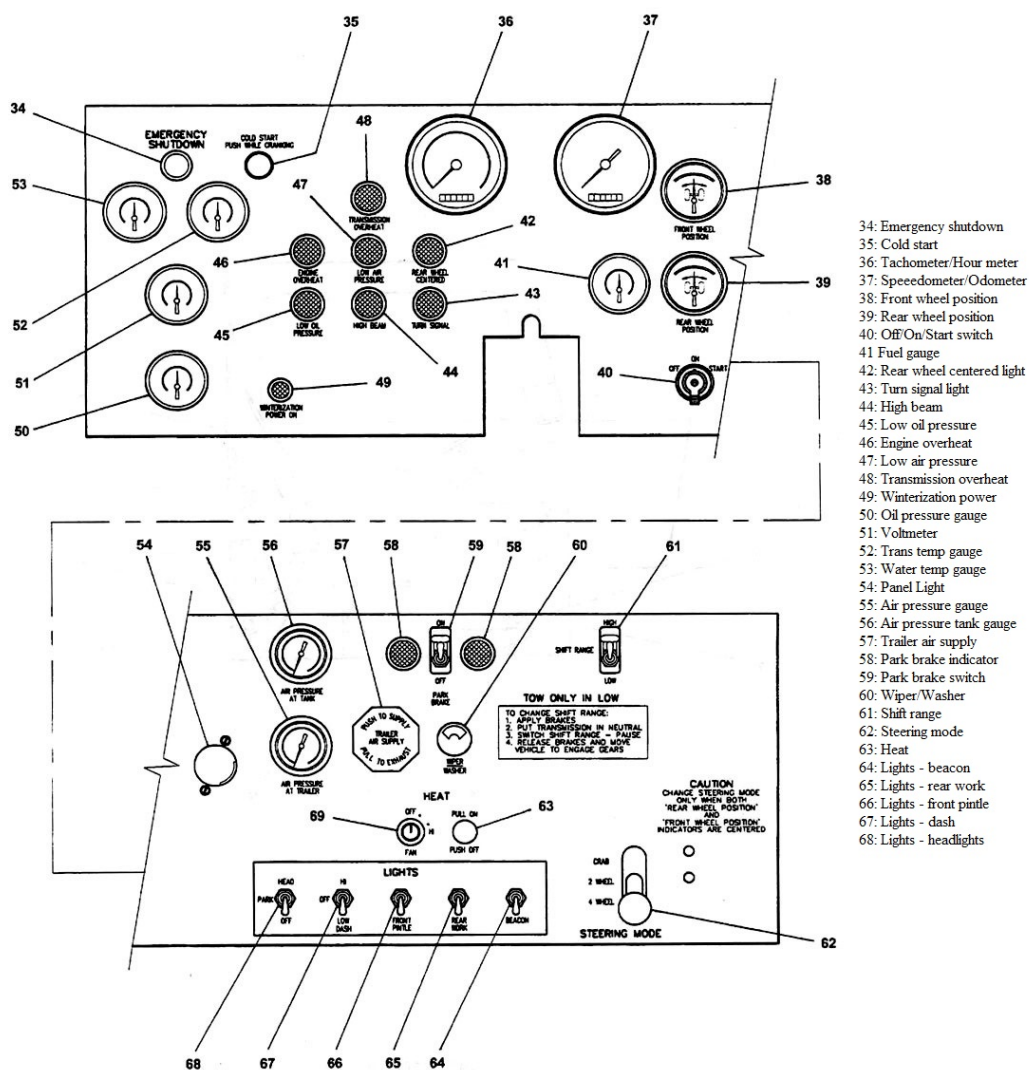


Figure 3-13. Operator control panel.

## Self-Test Questions

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

### 210. Aircraft towing tractor fundamentals

1. What is the MB-4's towing capacity?
2. How many gears does the MB-4's transmission have?
3. What type of MB-4 control unit actuates its steering system?

4. How is the MB-4's hydraulic pump driven?
5. How is MB-4's parking brake system controlled?
6. What type of service brake system is used on the MB-4?
7. What happens during the first one inch of treadle valve travel if the MB-4 is equipped with the trailer option?
8. What protects the MB-4's optional winterization system from overload?

### 3-3. Aircraft Deicer

Aircraft are engineered to exact specifications to provide adequate lift for flight and to maintain control of the aircraft once in flight. When ice or snow builds up on an aircraft, it disrupts airflow and can hinder or prevent safe operation of an aircraft. Because of this, it is critically important for the ice and snow buildup to be removed. This is the function of the Global® GL1800AP truck-mounted deicer (fig. 3-14).



Figure 3-14. Global GL1800AP deicer.

The deicer maneuvers around an aircraft while deicing and inspecting the plane. One operator drives the vehicle while the other dispenses fluids, air blasts, or a combination of both. The vehicle has many unique features and subsystems to accomplish this task. These include the electrical, hydraulic,



dispensing, and heater subsystems. Understanding how the vehicle and subsystems function is an essential part of troubleshooting the vehicle. This section covers some of the deicer features and fundamentals as well as addresses the different subsystems.

### 211. Deicer features and fundamentals

The vehicle chassis can be either a Freightliner® business class M2 or an International® 4700 series truck. Both models have a front and rear heavy-duty spring package to accommodate the total weight of the deicer. All the subassemblies connect to a subframe. The subframe increases the vehicle's capability to support the boom. It is attached to the vehicle frame using six shear plates. A torsion bar assembly uses the subframe and rear springs to enhance vehicle stability.

The torsion bar (fig. 3-15) mounts to the subframe over the rear axle. As the deicer moves over an uneven surface, the deicer fluid sloshes side to side, creating an uneven load. To balance this uneven load, the torsion bar pushes down on the rear leaf springs, preventing the springs from compressing. This action by the torsion bar turns the subframe and rear suspension into one solid unit, eliminating the need for outriggers.

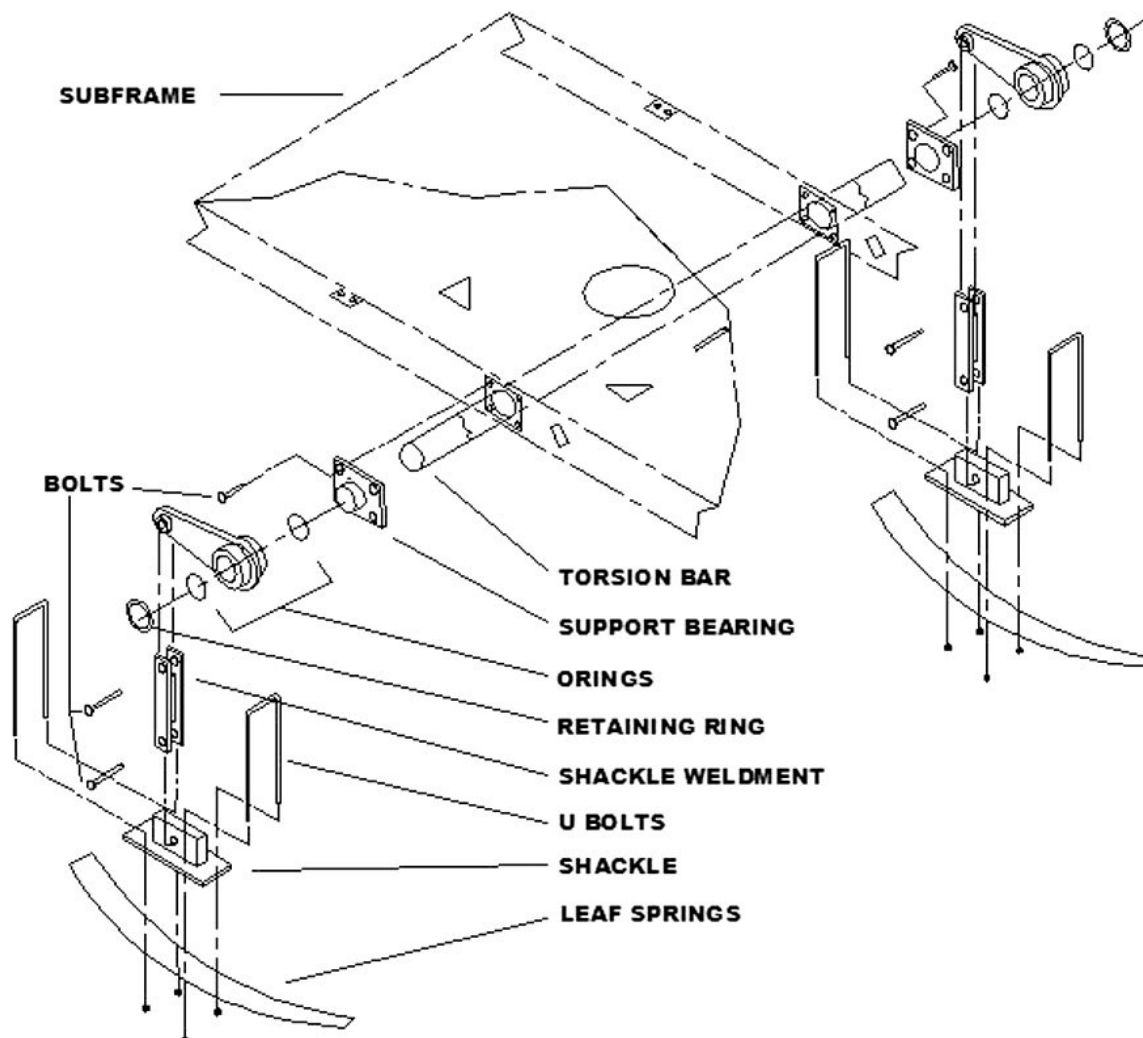


Figure 3-15. Torsion bar.

Controlling the vehicle speed not only increases the vehicle stability, but also is vital for a stable boom platform. When the boom is out of its rest (saddle), a boom down indicator switch on the rear side of the saddle sends 12 volts to a relay, which sends 12 volts to the chassis electronic control module (ECM). The ECM activates a cruise control software feature that limits the engine rpm, which limits the vehicle speed to four mph.

### Control panels

Figure 3-16 displays two main and six operator control panels, listed below:

- Two main control panels: main and heater.
- Six operator controls panels: left, right, *AirPlus!*®, dispensing, truck, ground control.

The main electrical and heater control panels are located in the auxiliary engine compartment. The six operator control panels are in various locations. The ground control panel is on the rear of the driver side of the vehicle.

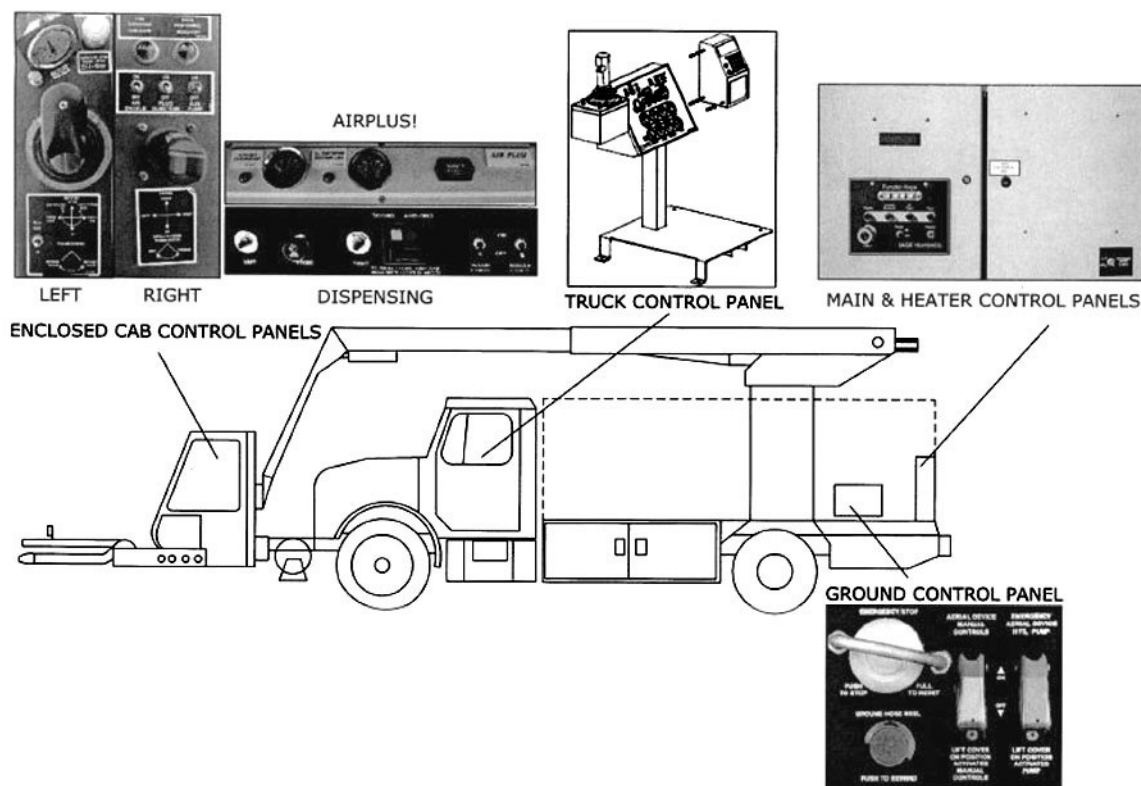


Figure 3-16. Control panel.

There are four control panels in the Fluid Efficient Delivery System (FEDS) enclosed cab and one in the vehicle truck cab.

The four control panels in the enclosed cab are the left-and right-hand joystick, the *AirPlus!*, and dispensing controls. The left-hand joystick controls the boom functions. The right-hand joystick controls the monitor assembly. The monitor assembly consists of the Task Force® and Scorpion® nozzles. The Task Force is the top nozzle of the assembly and dispenses either deicing or anti-icing fluids. The Scorpion nozzle blasts air from the *AirPlus!* system.

The *AirPlus!* system control panel is located above the enclosed cab door. There are two gauges and lights on it that allows monitoring of the self-contained oil lubrication system. The right side overhead control panel is the dispensing control panel. The panel has floodlights and wiper switches, along with the dispensing selector switch.

The truck cab control panel (fig. 3-17) contains the auxiliary engine and heater controls. There are a few important switches and indicator lights to cover.

- The auxiliary engine switch provides voltage to start the auxiliary engine and run the subsystems.
- The pump switch controls the auxiliary engine speed and dispensing subsystem.
- The heater switch located to the right of the pump switch.
- The red “refill fluid tanks” light, illuminates when the dispensing anti-icing subsystem, deicing subsystem, or the hydraulic system has a low-fluid level. This light will be covered in more detail in related lessons.
- Finally, the “reset E-stop” (emergency stop) light. There are three E-stop switches that can illuminate this light: one in the enclosed cab, one on the truck control panel in the cab, and one on the ground control panel. Anytime any one of these switches is depressed, the red E-stop light illuminates and the auxiliary engine shuts down or will not start.



Figure 3-17. Truck control panel.

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## Electrical system

Located under the cab on the driver's side, two batteries supply 12 volts for the chassis electrical system. A battery in the auxiliary engine compartment supplies 12 volts for all the Global subsystems. An isolator switch next to the auxiliary engine is used for jump-starting (fig. 3-18). To jump-start either engine turn the isolator to the CONNECTED position.

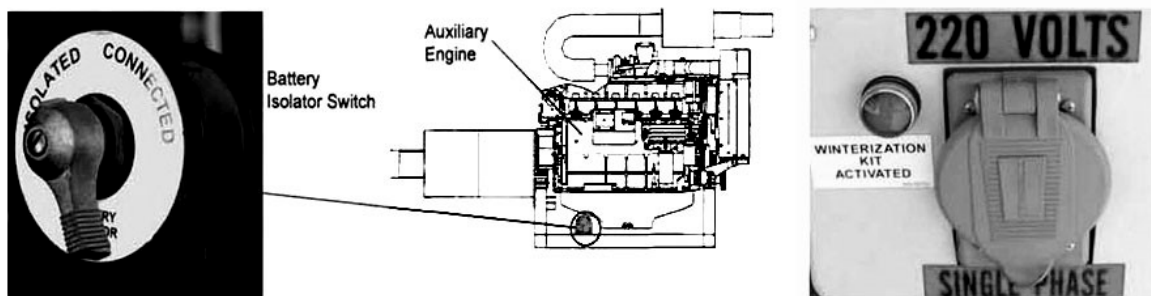


Figure 3-18. Isolator switch and winterization connection.

The isolator switch provides additional amperage, but does not increase voltage. After the engine starts, move the switch to the ISOLATE position. The isolator switch should be in the ISOLATE position at all times except when jump-starting. Leaving the switch in the CONNECT position with both engines running can cause damage to the charging systems.

At the left rear of the vehicle is the winterization system. An external 220 VAC plug-in station supplies the winterization system's power. A yellow light on the winterization box illuminates when connected to an external voltage supply.

## Auxiliary engine

Regardless of whether it is built on an International or Freightliner chassis, all GL1800AP deicer auxiliary engines are six-cylinder turbocharged diesels, built by Deutz®. However, the engine uses a different ECM, depending on who manufactures the chassis.

International-chassis deicers use an A Proportional Engine Control System (APECS) ® 3000 ECM, bolted to the side of the auxiliary engine. Freightliner-chassis deicers use a Deutz ECM mounted to the boom pedestal. Both ECMs control the auxiliary engine speed, which idles at 1,250 rpm, and increases to 2,150 rpm when the pump switch is activated.

To protect the engine, the APECS 3000 ECM engine protection program uses three switches to monitor engine condition: an oil pressure, coolant temperature, and coolant level switch. If the ECM recognizes low oil pressure, high coolant temperature, or low coolant level, the auxiliary engine shuts down. A red light emitting diode (LED) on the side of the ECM module will continuously flash a number "4" fault code. Once you turn OFF the ignition switch, the code will erase.

The Deutz ECM engine protection program reads the same three switches; however, only two (the oil pressure and coolant temperature switches) will cause the auxiliary engine to shut down: The ECM illuminates the red fault light, located on the truck cab control panel, if there is an unsafe condition. The coolant level switch controls the orange warning light on the truck control panel.

## Enclosed cab

The enclosed FEDS cab protects the operator from the elements while deicing aircraft. Both the vehicle and deicing operators can communicate using cab-to-cab headphones. In front of the FEDS cab door is the monitor assembly. To enter the enclosed cab an operator must lower the monitor nozzle assembly from its vertical stowed position. To lower the monitor nozzle assembly, turn ON the

auxiliary engine ignition switch and activate the nozzle stow switch on the right side of the enclosed cab. Once in the enclosed cab, you will find the previously mentioned control panels.

### AirPlus! system

The *AirPlus!* system dispenses high volume/low pressure unheated air. The air travels at 700 mph at 11–13 psi out of the Scorpion nozzle. The *AirPlus!* system's main component is a supercharger.

Located under the enclosed cab operator seat is the *AirPlus!* supercharger assembly. It consists of a hydraulic motor, belts, gear reduction supercharger, and an oil pump. The hydraulic motor drives the supercharger with a heavy-duty belt and drives the oil pump with a regular V-belt. A scatter shield between the seat and supercharger assembly protects the operator from injury during a supercharger failure.

Figure 3–19 depicts the *AirPlus!* self-contained lubrication system. The oil reservoir for this system is located behind the enclosed cab left side vent panel. Oil flows from the oil pump through an oil cooler and in-line filter to the pressure regulator. The pressure regulator maintains oil pressure at 45 psi before going to the supercharger. An oil pressure switch, oil temperature sending unit, and a vacuum switch monitor the oil system.

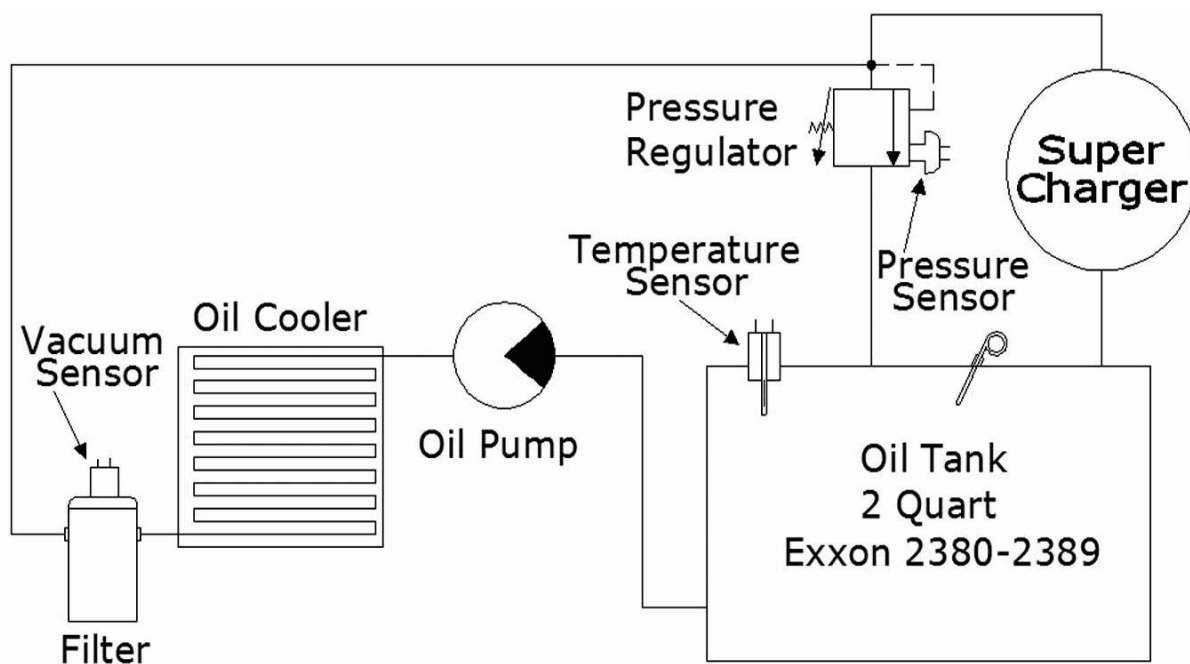


Figure 3–19. AirPlus! oil system.

Recently, Global has manufactured deicers equipped with superchargers that are self-lubricating, eliminating the oil reservoir, cooler, pump, and regulator. If your trucks are equipped with this system, there is no need to monitor the oil pressure. The only gauge necessary is the oil temperature.

**CAUTION:** Do *not* operate the air system with personnel or debris in the air-blast radius.

### Hydraulic system

The hydraulic system is the heart of the deicer. It affects every subsystem in some manner, which is why it is so important to understand hydraulic system fundamentals. In this lesson, we will cover components common among multiple systems and the hydraulic pumps.



### Hydraulic Tank

The vented hydraulic tank is located on the driver side rear of the vehicle. It holds 65 gallons. There is a sight gauge at the rear of the tank and a hydraulic low (HL)-level switch on the backside of the tank. The low-level switch works with a six-second time delay (TD) relay to protect four hydraulic pumps. Both the HL switch and TD relay control the HL relay electrical circuit.

### Hydraulic low level

Figure 3-20 shows how the HL-level circuit works. In the first part of the circuit, supply voltage from the ignition switch goes through CB 4, the enclosed cab E-stop switch, the HL coil, through the TD relay, and stops at the open HL-level switch. Supply voltage also goes through the normally closed HL-level relay contacts, the two E-stop switches, and the engine run relay (ERR) coil to ground. With supply voltage and complete ground at the ERR coil, the normally open contacts in the second part of the circuit closes. With these contacts now closed auxiliary engine battery voltage goes to the auxiliary engine ECM, allowing the auxiliary engine to start.

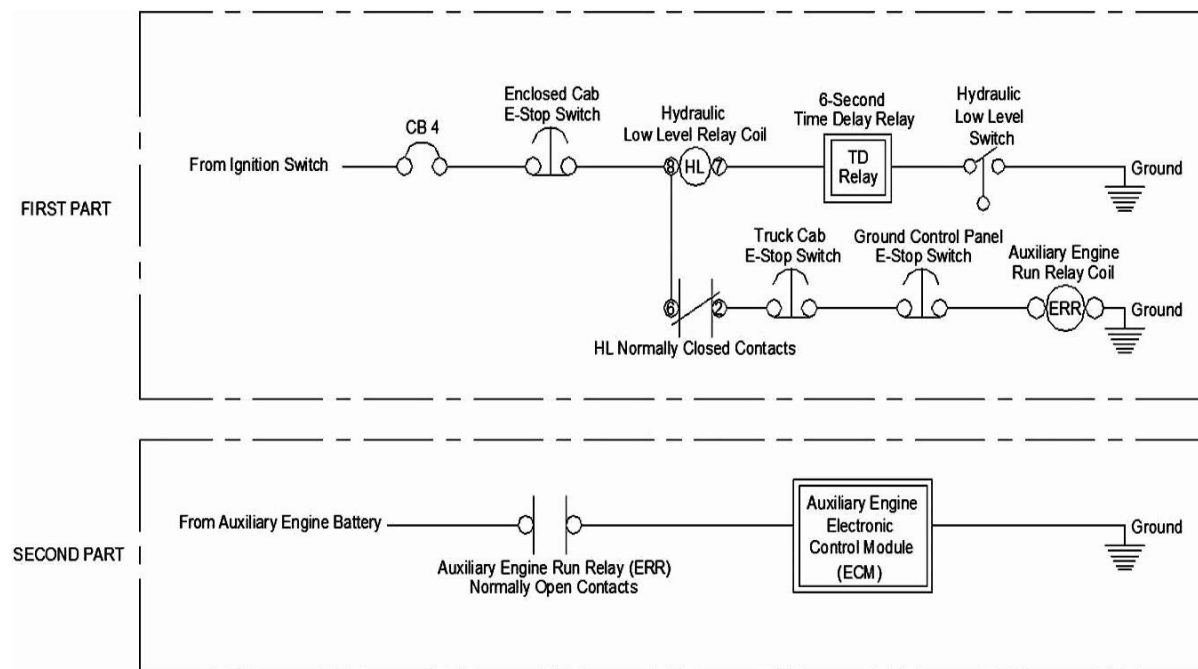


Figure 3-20. HL-level circuit.

The TD relay provides the six-second delay to account for fluid sloshing in the tank during operation. As fluid sloshes, the low-level switch may momentarily close. The TD relay prevents premature shutdown of the auxiliary engine.

The following conditions occur when the HL-level circuit activates:

1. The auxiliary engine will crank, but not start.
2. The red refill tank and E-stop lights illuminate.

### Pumps and circuits

Three of the four hydraulic pumps (5, 90, and 100 series) are mounted to, and driven by, the auxiliary engine. All three pumps have maintenance shut-off valves in the supply lines on the backside of the hydraulic tank. The fourth pump, an emergency pump, mounts under the boom control valve

manifold and allows for operation of the boom in the event of an engine malfunction or emergency shutdown.

### 5-series pump

The third and smallest of the three pumps attached to the auxiliary engine is the 5-series boom pump. Under normal operation, the 5-series pump supplies hydraulic fluid to the boom functions. Figure 3-21 shows how hydraulic fluid travels from the pump to the boom hydraulic control manifold.

Although not depicted in figure 3-21, the control manifold contains a deadman control valve. The deadman circuit is designed to prevent the boom hydraulic system from activating until the operator squeezes the trigger switch on the boom joystick. This system ensures the boom will not move if someone unintentionally moves the joystick.

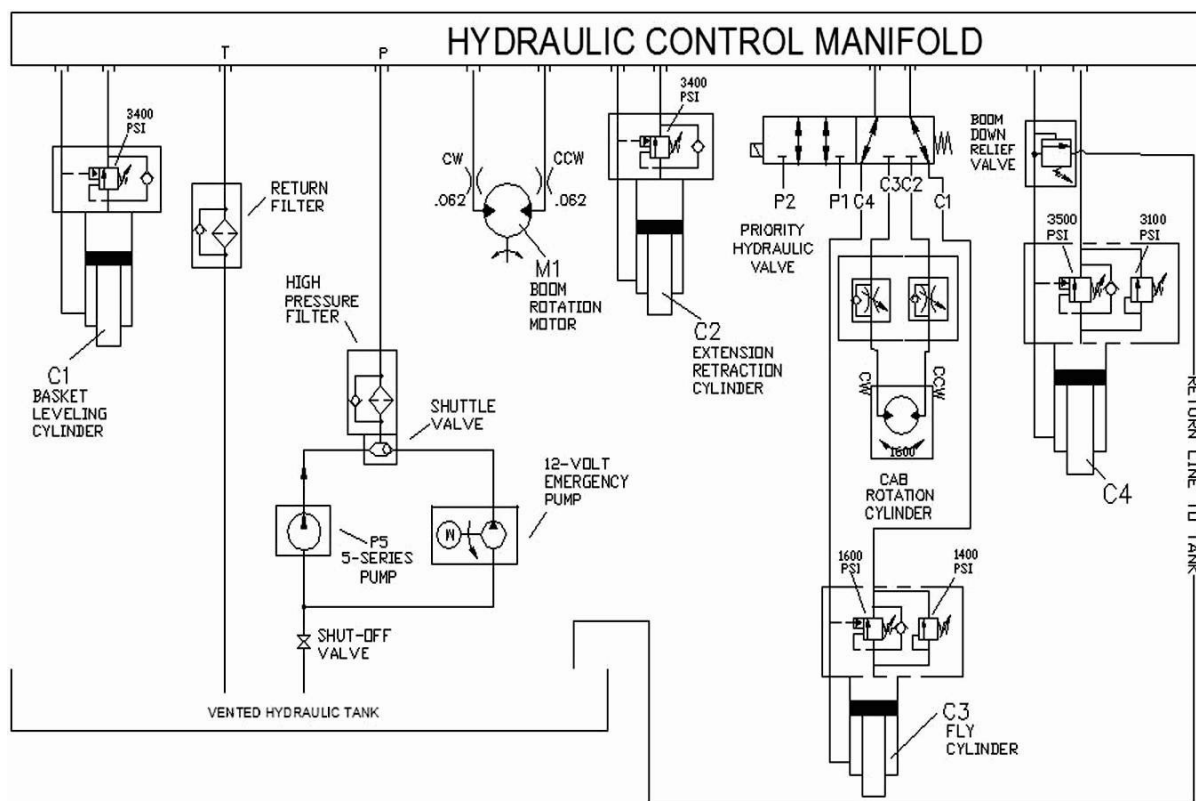


Figure 3-21. 5-series hydraulic circuit.

When the deadman circuit is not activated, fluid flows through the deadman control valve, through the control manifold, the return filter, and returns to the tank. Once the deadman control valve closes, the hydraulic fluid is sent to the different circuits and proportioned to the active boom function(s). The deadman circuit is covered in more detail during the electrical lesson. When the auxiliary engine fails to drive the 5-series pump, the operator can use the emergency pump to operate the boom functions.

### Emergency pump

The emergency pump is a low-volume gear pump attached to a 12-volt electrical motor. The pump supplies enough fluid to operate the boom for short periods. A shuttle valve mounts between the outlet lines of the emergency and 5-series hydraulic pumps. The shuttle valve enables only one pump



to supply fluid to the hydraulic control valve manifold. An operator can activate the emergency pump from the enclosed cab or the ground control panel.

### 90 series

The middle of the three hydraulic pumps attached to the auxiliary engine is the 90 series and is used for the fluid dispensing and the heater systems (fig. 3-22). Fluid from the pump goes to the mono block on the pump skid. The pump skid is located on the passenger side of the vehicle and houses three pumps and the fire suppression system. The mono block distributes the fluid to four hydraulic motors: deicing, anti-icing, heater fuel pump, and heater air blower. Each hydraulic motor has an individual electrically operated hydraulic control valve to activate the system.

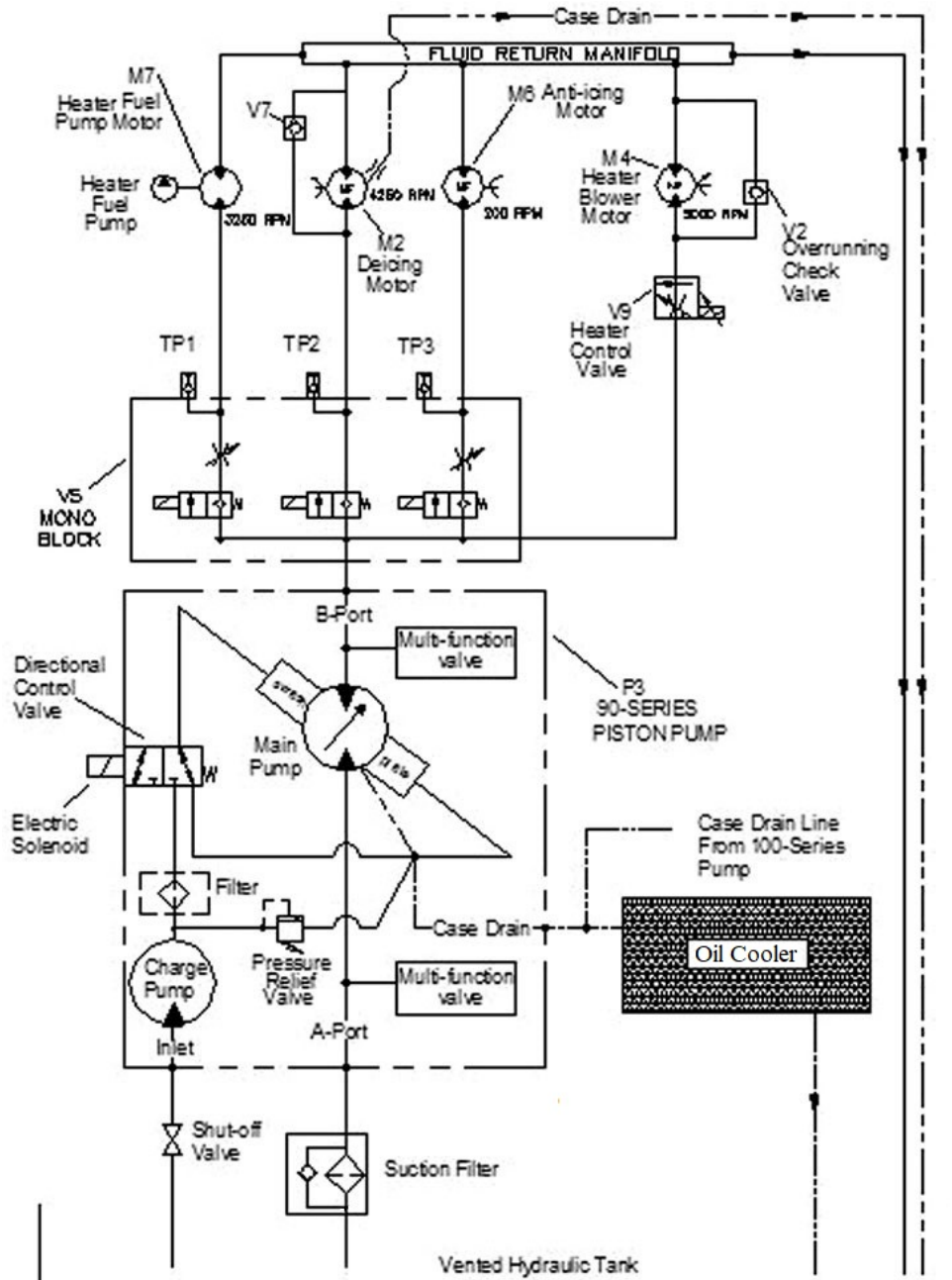


Figure 3-22. 90-series hydraulic circuit.

Three of the control valves are mounted in the mono block. The heater blower motor control valve is mounted near the heater system. There are two adjustable flow control valves on the bottom of the mono block. The valves maintain the motor speed for the anti-icing and heater fuel pump hydraulic circuits.

### *100 series*

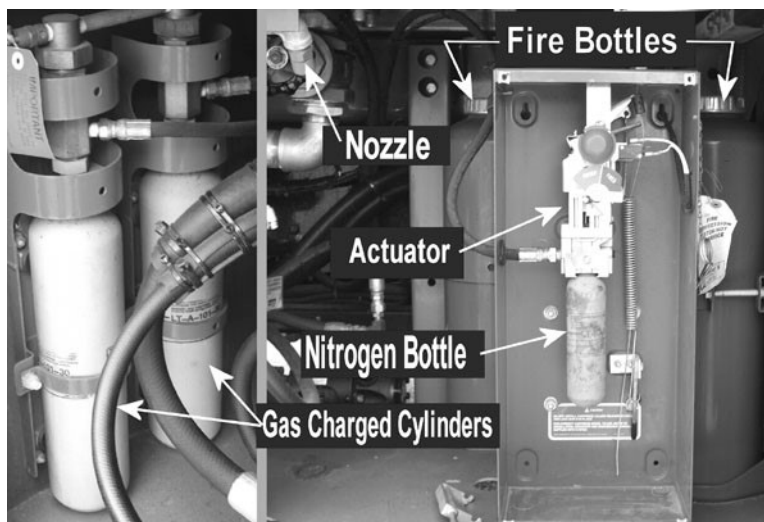
The first hydraulic pump, directly attached to the auxiliary engine flywheel, is the 100 series, which operates the *AirPlus!* system. This pump supplies hydraulic fluid to one motor under the enclosed cab operator's seat. To inspect the motor, remove the operator's seat and scatter shield.

### *90- and 100-series basics*

The 90- and 100-series hydraulic pumps are variable displacement piston-type pumps. They can produce 7,000 psi of hydraulic pressure. To extend the life of the pumps, Global designed the hydraulic systems to operate at less than one-half of the pumps' maximum capacity. Additionally, both pumps share a hydraulic oil cooler. The oil cooler system has a temperature controlled fan to keep the hydraulic fluid at an optimal temperature of 160°F.

### **Fire suppression system**

The deicer's Ansul® fire suppression system (fig. 3-23) consists of a firebox, gas charge cylinders, dry chemical fire bottles, cables with temperature sensitive fusible links, and discharge nozzles. The system design allows for automatic or manual discharge of a dry chemical agent.



**Figure 3-23. Fire suppression system.**

The firebox contains a spring-loaded actuator, nitrogen bottle, and cable release handle. The actuator arm has a mechanical lever to lock the spring tension in the coiled position. Cables with temperature sensitive fusible links keep the spring in the coiled position. With the mechanical lever locked, the actuator is ready for operation.

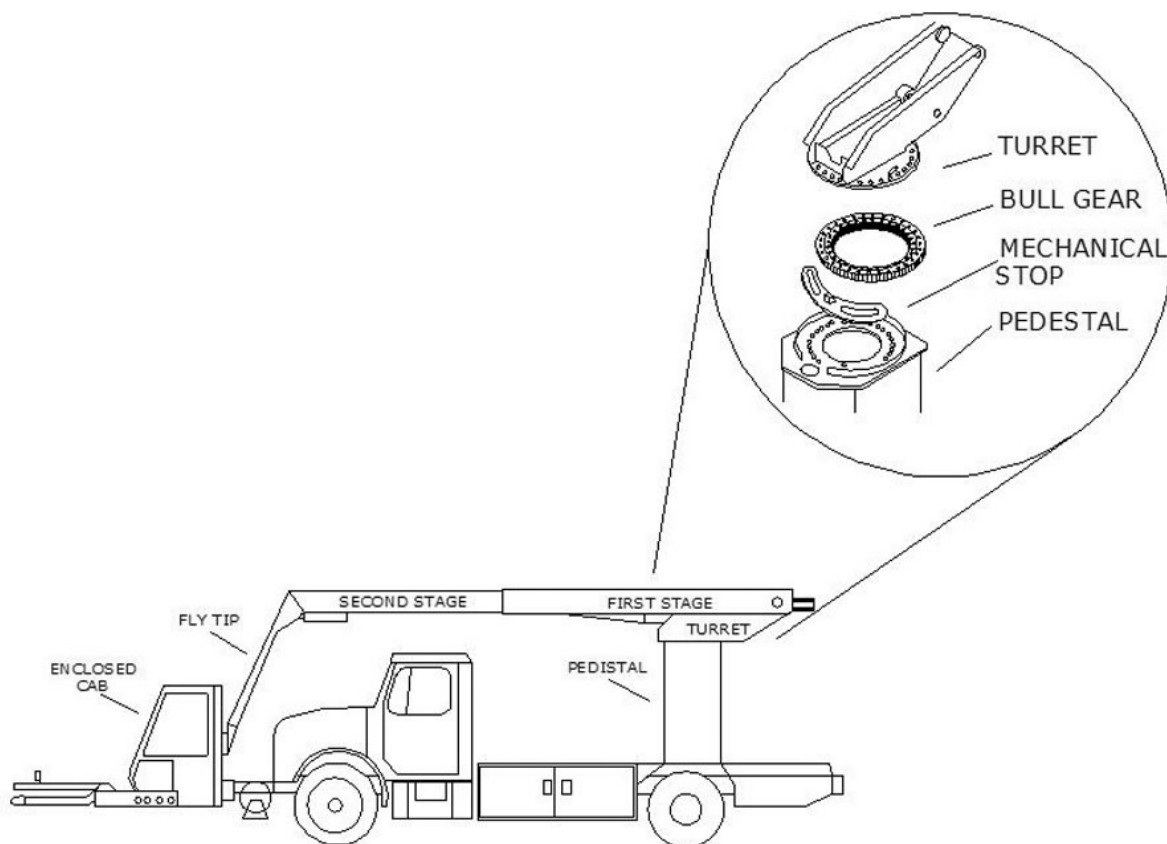
When a fusible link melts, or the manual release button on the front of the firebox is pressed, the fire suppression system is activated. The mechanical lever of the actuator releases the needle. The needle moves down, piercing the nitrogen bottle. The nitrogen gas travels through the outlet line to break the bursting seals on top of the two gas-charged cylinders. The gas-charged cylinders pressurize the two dry chemical fire bottles; one bottle for the auxiliary engine compartment and the other for the pump skid. With the fire bottles pressurized, the fire extinguishing agent flows through piping to the fire

nozzles. The nozzles distribute the agent throughout the auxiliary engine and pump skid compartments.

## 212. Deicer boom fundamentals

This lesson introduces the deicer boom components and its operation fundamentals. The deicer uses five cylinders and a motor to operate the boom.

To describe the boom assembly, we will begin with the pedestal. The pedestal is the foundation of the entire boom assembly (fig. 3-24). It is mounted over the rear axle, which supports the boom assembly weight. The turret assembly is mounted on top of the pedestal. In between the turret and pedestal are a bull gear (swing bearing) and a mechanical stop.



**Figure 3-24. Boom assembly.**

Fixed to the turret is a telescoping two-stage boom. The first stage of the boom connects to the turret. The second stage rides on wear pads inside the first stage and uses a cylinder to extend the boom six feet. On the end of the second stage boom is the fly tip. The fly tip articulates the enclosed cab for precise movement. The enclosed cab can rotate from side to side. Lastly, the enclosed cab has an automatic leveling system. This system levels the enclosed cab anytime the boom angle changes.

To use these boom functions, an operator uses a joystick from the enclosed cab or the truck cab or the manual levers on the hydraulic control valve assembly near the ground control panel.

The boom functions include the following:

1. Fly articulation.
2. Basket leveling.
3. Boom rotation.
4. Boom elevation.
5. Enclosed cab rotation.
6. Boom extension and retraction.

#### **Parker series 6 manifold**

The 5-series hydraulic pump supplies fluid to the Parker® series 6 manifold (fig. 3-25). The manifold distributes fluid to six different hydraulic actuators (all boom functions). The boom functions will *not* operate without the deadman solenoid being energized. The solenoid requires 12 volts to operate.

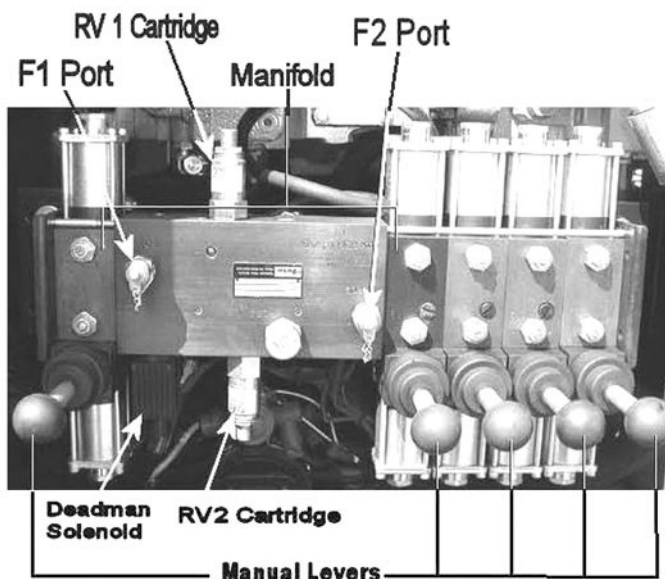


Figure 3-25. Parker series 6 manifold.

The operator must use the boom joystick deadman switch or aerial device manual toggle switch on the ground control panel to activate the deadman solenoid. This will allow the operator to use the manual levers at the ground control manifold to operate the boom functions. The manifold has function solenoids, a deadman solenoid, spool valves, and relief valves. Under normal electrical operation, each boom function solenoid is controlled with a valve driver board (VDB).

#### **Boom elevation**

Boom elevation is also referred to as “topping.” The deicer maximum working height is 47 feet. The boom uses one double-acting hydraulic cylinder to raise and lower the boom. The boom elevation cylinder is equipped with a pilot-operated check valve (hold/lock valve). This valve prevents the boom elevation cylinder from retracting and the boom from falling in the event of a hydraulic failure. As covered earlier, a slow vehicle speed provides a stable platform for when the boom is elevated. The boom down indicator switch (fig. 3-26) activates the speed control feature.

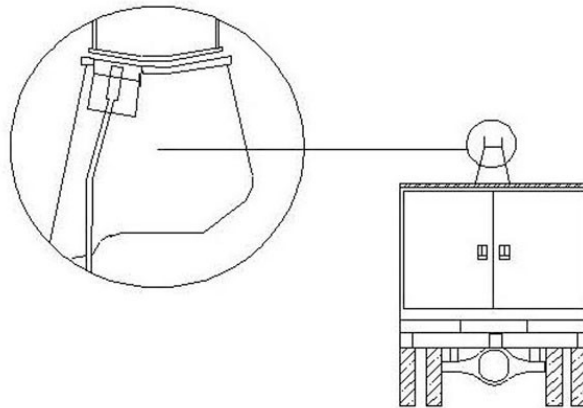


Figure 3-26. Boom down indicator switch.

### Boom extension and retraction

The boom consists of a telescopic two-stage boom. One double-acting cylinder is used to extend the second stage by six feet. The second stage slides in and out of the first stage. Shimmed wear pads prevent metal-to-metal contact and keeps the boom segments aligned.

On the driver's side of the second stage is a movable Cat track (fig. 3-27). The Cat track provides a means of extending and retracting the boom without damaging the hoses and cables that lead to the enclosed cab. The lines route through the center of the pedestal to the Cat track and then to the enclosed cab.

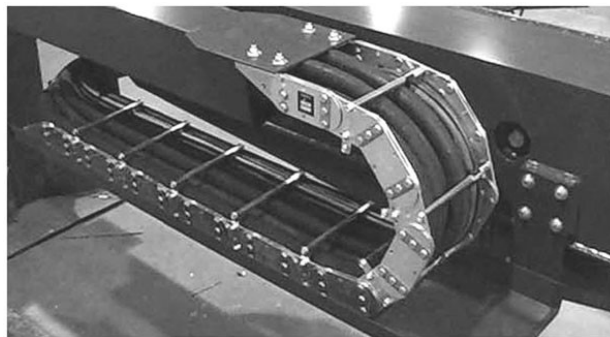


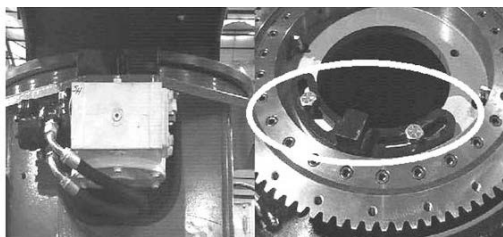
Figure 3-27. CAT track.

### Boom swing

On the upper portion of the pedestal is a stationary hydraulic motor and gearbox assembly (fig. 3-28). This assembly controls the boom swing function. When the operator activates the boom swing function, the hydraulic motor rotates the pinion gear in the gearbox. The pinion gear meshes with a bull gear and rotates the turret assembly. As the bull gear rotates the turret assembly, the sliding mechanical stop (fig. 3-28), stops the boom rotation at 185 degrees in either direction.

### Fly tip

The fly tip is located between the second stage and the FEDS cab. The fly tip moves the end of the boom and the enclosed cab up and down, giving the operator precise movement around aircraft. Like the boom elevation, the fly function uses one double-acting cylinder.



Motor/Gearbox assembly    Sliding mechanical stop

Figure 3-28. Gearbox and bull gear assembly.

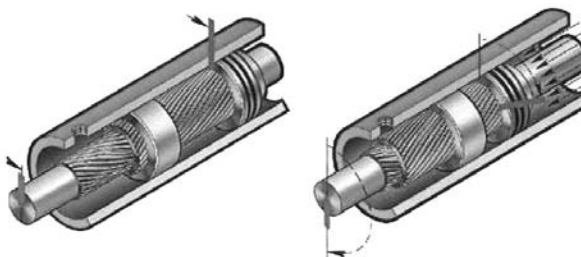


Figure 3-29. Helical hydraulic rotary actuator.

### Enclosed cab rotation

The enclosed cab rotation feature uses a unique double-acting cylinder known as the helical hydraulic rotary actuator (fig. 3-29). Unlike typical hydraulic cylinder rams, this cylinder ram is spiral cut. A sealed gland pack moves up or down on the spiral cut ram. The ram ends attach to the outside housing of the enclosed cab assembly, rotating the entire housing as the cylinder ram rotates.

Two adjustable flow control valve cartridges under the priority valve determine the enclosed cab speed. The priority valve on the end of the second boom hydraulically separates the enclosed cab rotation and fly functions. These two boom functions share the same VDB and electrical circuit, but not the same hydraulic actuators. The enclosed cab rotation and fly functions *cannot* operate at the same time.

### Enclosed cab leveling

The enclosed cab leveling system uses a basket-leveling sensor. The sensor mounts on the end of the fly tip. The sensor signals the leveling VDB when a six degree angle change occurs. Any time the leveling sensor signals the VDB and an operator activates the deadman solenoid or fly function, the enclosed cab levels itself by using one double-acting cylinder.

**SAFETY PRECAUTION:** When adjusting the basket-leveling sensor, the enclosed cab can move automatically, causing personal injury or death. Follow the instructions in the service manual before attempting to adjust the basket-leveling sensor.

### Function speed

The VDB controls the amount of current flow to the functional solenoids on the Parker series 6 manifold. The VDB settings can be adjusted; decreasing the amount of current will slow the function speed and increasing current will make the functions operate faster.

Because the fly and enclosed cab rotation functions share the same VDB, only one function can use the VDB setting to adjust the function speed. The fly function uses the VDB to control the lifting and lowering speed, while the enclosed cab rotation uses two hydraulic flow control valves to control the rotation speed.



The following table lists the boom functions and speed specifications.

Boom Functions and Speed Specifications	
Boom Function	Speed Specifications
Fly tip	21 seconds up/down (adjusted by the VDB).
Boom elevation	40 seconds up/down (adjusted by the VDB).
Boom swing	34 seconds from 0 to 90 degrees (adjusted by the VDB).
Boom extension/retraction	14 seconds to full extension/full retraction (adjusted by the VDB)
Enclosed cab leveling	No speed specification—adjust to achieve safe, smooth cab leveling (adjusted by the VDB).
Enclosed cab rotation	5 seconds stop-to-stop (adjusted by the flow control valves).

### Boom electrical circuit

There are two separate circuits within the boom electrical system: deadman and joystick. Both circuits need to work properly in order to safely operate the boom functions. No boom function will operate unless the deadman solenoid is energized, so the deadman circuit will be covered first.

#### Deadman

To activate the deadman circuit (fig. 3-30), squeeze either of the deadman (red trigger) switches on the joysticks or activate the aerial device manual switch on the ground control panel. This action sends supply voltage to an electrical relay in the main control panel. The relay controls an electrical solenoid on the hydraulic manifold (Parker® series 6 control valve manifold). The solenoid moves a directional control valve, sending hydraulic fluid to the boom function directional control valves in the hydraulic manifold. When the solenoid is *not* energized, the spool valve directs hydraulic fluid to the hydraulic tank, therefore the hydraulic system does not create the necessary pressure to operate any boom functions.

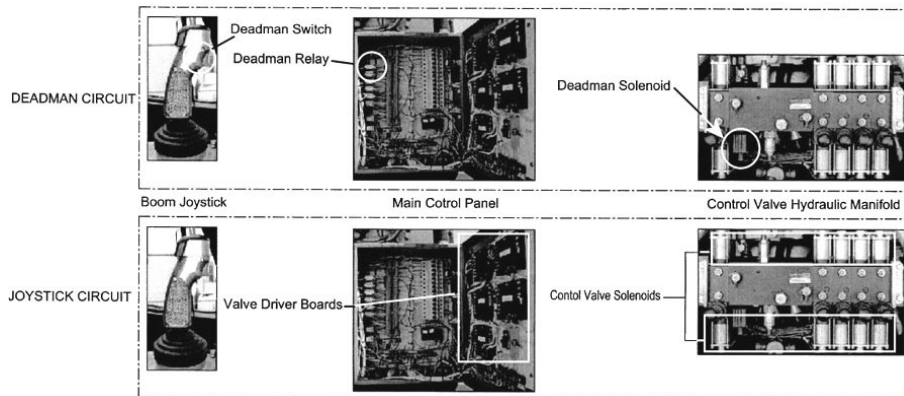


Figure 3-30. Deadman and joystick system.

#### Joystick

It is easier to understand the joystick electrical circuit if we break it into three parts: the control units, input circuits, and output circuits. The control units for all six boom functions are the five VDBs. The joysticks are the inputs and the control valve solenoids are the outputs.

### Control unit/VDB

Use figure 3-31, and the VDB voltage table below, as we explore the joystick electrical circuit. When you turn the auxiliary engine ignition switch ON, the VDB “VS” terminal receives supply voltage. Once the VDB receives supply voltage, it produces a reference voltage at the + (positive) terminal of the input circuit. Reference voltage goes through the joystick resistor to the – (negative) terminal.

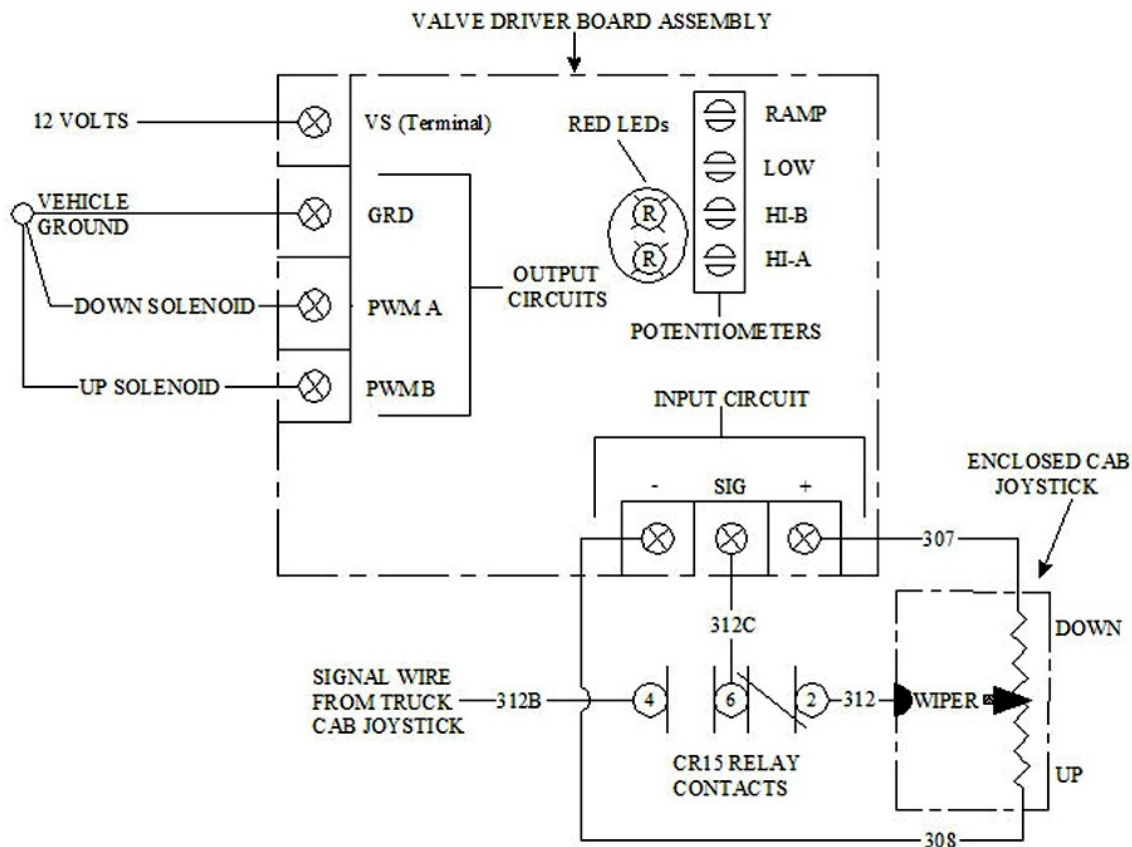


Figure 3-31. Valve driver board assembly.

VALVE DRIVE BOARD VOLTAGE TABLE			
Supply Voltage	Reference Voltage	Signal Voltage	Output Voltage
12 ± 2 volts	6 ± .30 volts	3 ± .36 volts	* 0 – 6 volts
* The output voltage is an <i>estimated value for training use only</i> .			

### Input

The input circuit starts at the joystick wiper. Voltage from the wiper goes through wire 312, the normally closed terminals 2 and 6, of circuit relay 15 contacts, wire 312C, and to the VDB “SIG” terminal. This voltage at the SIG terminal is called signal voltage. Based on the amount of signal voltage, the VDB will determine which output circuit to activate. With no outside influence, the

joystick wipers rest in the middle of the resistor. The VDB recognizes this amount of signal voltage ( $3 \pm .36$  volts) as the neutral position.

### *Output*

The output circuit starts at the pulse width modulated (PWM) terminals on the VDB assembly. PWM A output circuit controls the amount of current flow to the boom down solenoid. The PWM B output circuit controls the amount of current flow to the boom up solenoid. When a PWM output circuit is energized, a corresponding HI-A or HI-B red LED illuminates.

Here is how the boom up-and-down functions work. Move the joystick to the boom up position, the joystick wiper moves down, reducing the amount of signal voltage to the SIG terminal. With less than  $3 \pm .36$  volts, the VDB activates the PWM B circuit. The boom up control valve solenoid moves the hydraulic spool valve in the hydraulic manifold; sending hydraulic fluid to the cylinder, raising the boom. Move the joystick to the down position, the opposite reaction occurs. The remaining boom functions operate in the same fashion.

## **213. Deicer dispensing and heating system fundamentals**

The dispensing system has two subsystems to deliver fluid: deicing and anti-icing. The two types of fluid in the dispensing system require different methods of delivery. However, the two subsystems have a few common components.

One of the common items is a single stainless steel 1,800-gallon dispensing tank assembly behind the truck cab. The tank assembly is a one-piece design divided internally to create two tanks. The larger section is the 1,650-gallon deicing tank and the smaller one is the 165-gallon anti-icing tank. Although the total capacity of the tanks is 1,815 gallons, the manufacturer decided to round the model name down to 1800 for ease of identification.

### **Deicing system**

On the passenger side of the deicing tank is a low-level switch. The switch is part of the deicing low-level electrical circuit. This electrical circuit protects the deicing pump and the heater system when the fluid level is less than 150 gallons by shutting down the pumping function. When the low-level switch closes during deicing operations, the low-level electrical circuit activates, which deactivates several relays. The relays open and close their contacts to perform the following:

- Disable the 90-series pump solenoid.
- Disable the deicing hydraulic motor solenoid.
- Deactivate the auxiliary engine high throttle circuit.
- Remove a signal input to the heater ECM.
- Illuminate the red refill tank light.

During deicing operations, deicing fluid sloshing around in the tank can close the low-level switch, shutting down the system prematurely. To eliminate the situation on newer vehicles, Global installed a time delay relay in series with the low-level switch.

### **Selector switch and valves**

A selector switch on the dispensing panel controls the deicing and anti-icing system. To select the deicing system, the operator presses the selector switch to the deicing position. While the operator holds the switch, an electrical motor and actuator assembly moves the ball valve lever. The lever opens the deicing ball valve, while closing the anti-icing ball valve. The operator continues to hold the switch until the amber light illuminates.

### Fluid flow

Figure 3-32 depicts the deicing and anti-icing subsystems. Deicing fluid travels from the tank through the enclosed cab heater core and back to the tank. Fluid continues to the ground gun, fluid inject valve, and the foot-operated rocker pedal. The operator can use the rocker foot pedal to vary the amount of deicing fluid dispensed through the Task Force nozzle. The operator can also change the spray pattern with the thumb switch on the right-hand control panel nozzle joystick.

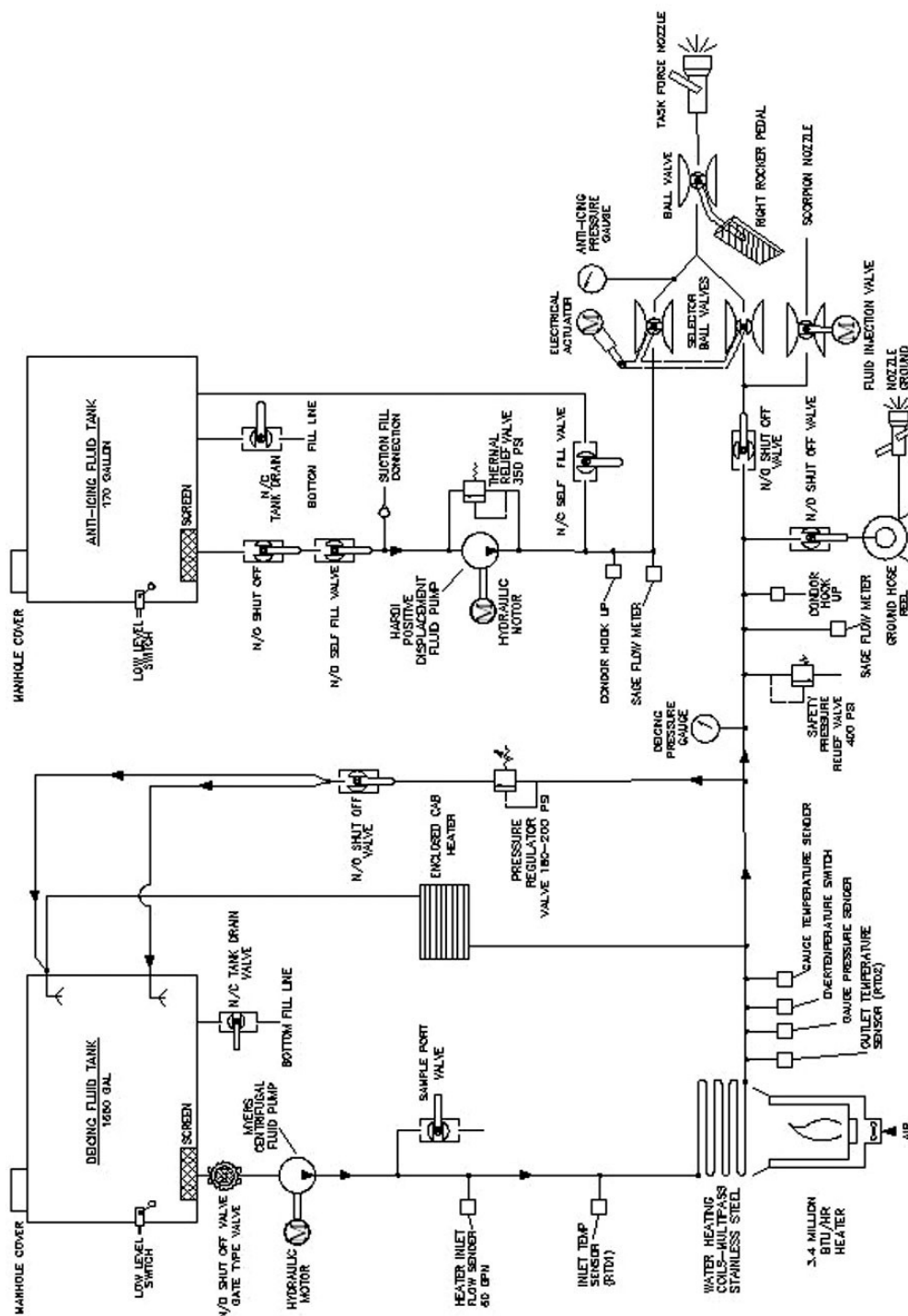


Figure 3-32. Dispensing system.

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### ***Pressure regulator***

With the ground gun and rocker pedal closed, deicing fluid pressure increases. When fluid pressure reaches 180-200 psi the pressure regulator opens. The regulator will maintain system pressure between 180-200 psi until the ground gun or Task Force nozzle is used, decreasing the system pressure, allowing the pressure regulator to close.

Deicing fluid circulates from the tank, through the pump, heater coils, pressure regulator, and back to the tank. As we discussed in the above paragraph, when an operator presses the rocker pedal, system pressure decreases causing the pressure regulator to close, directing all the fluid to the Task Force nozzle. When the rocker pedal closes and pressure builds up, the pressure regulator opens again.

### ***Safety relief valve***

Deicing system pressure will greatly increase if the pressure regulator fails or the shut-off valve located behind it is closed. This excess pressure will open the safety relief valve. Fluid exiting the safety relief valve goes directly to the ground. The safety relief valve is factory set; *do not* attempt to adjust the valve.

### ***Fluid inject system***

The fluid inject valve injects approximately 9 gpm of heated deicing fluid in the *AirPlus!* Scorpion nozzle. The fluid inject valve is under the enclosed cab near the rocker pedal. The fluid inject valve is a motorized ball valve design. An operator can only activate the fluid inject system when using the *AirPlus!* system.

### ***Anti-icing system***

On the driver's side of the anti-icing tank is a low-level switch. The switch is part of the anti-icing low-level electrical circuit. The circuit is designed to protect (shut down) the anti-icing pump anytime the fluid level is less than 20 gallons. When the low-level switch closes during anti-icing operations, the low-level electrical circuit activates a relay, which disables the anti-icing solenoid on the mono block and illuminates the red refill tank light. The auxiliary engine and other systems are not affected when this low-level circuit activates.

### ***Dispensing switch and valves***

Use the same selector switch on the dispensing control panel to activate the anti-icing system. To select the anti-icing system, hold the switch in the anti-icing position until the blue light illuminates. While an operator holds the switch, the electrical actuator opens the anti-icing ball valve and closes the deicing ball valve. The operator *must* depress the rocker pedal all the way to the floor in order to activate the anti-icing system. You cannot vary the amount of anti-icing fluid from the Task Force nozzle.

### ***Fluid flow and self-fill system***

Anti-icing fluid travels from the tank through the maintenance valve, self-fill valve, piston-type pump, selector ball valve, and rocker pedal. Global designed the anti-icing system with the options to fill the anti-icing system from overhead manhole covers or with 55-gallon drums. The self-fill system allows the operator to connect a 55-gallon drum to the suction fill connection. Follow the instruction found on the pump side access door to operate the self-fill system properly.

### ***Thermal relief valve***

The thermal relief valve mounts between the inlet and outlet of the anti-icing six-piston diaphragm pump. The thermal relief valve protects the pump from excess pressure. Excess pressure in the anti-icing derives from heat transfer. During heater operation, 180°F deicing fluid circulates back to the tank. Some of the heat transfers through the wall in the tank assembly to the anti-icing fluid. Heated anti-icing fluid that is trapped between the selector valve and the pump can create enough pressure to

damage the diaphragms in the pump. The thermal valve protects the pump before the pressure causes damage. When the thermal valve opens, it sends the excess pressure from the outlet side into the suction side of the system.

### Deicer heater system

The Sage Company® manufactures the computer controlled 3.4 million British thermal unit (BTU) heater system, which heats the deicing fluid to 180°F, as mentioned before. The ECM has a 16-stage (fig. 3-33) software program to control the heater's air and fuel systems. The program uses various inputs and outputs to determine the correct BTU demand for each stage.

#### Heater Stages

**Note:** The values in the following chart for the Blower Signal and Blower Speed are approximate except for Stage 14. Use the value listed in the chart for Stage 14.

Stage	Air Pressure (psi)	Fuel Pressure (psi)	Burner Number On	Blower Signal	Blower Speed (rpm)
14 - Default	0.75	0	0	500	1000
14 - Light Off	1.25	150	1	1000	1,600
1	3.5	200	1	2100	2,800
2	4.5	250	1	2300	3,200
3	5.5	300	1	2500	3,700
4	6.75	150	1 and 2	2700	4,000
5	7	200	1 and 2	2800	4,200
6	7.1	250	1 and 2	2900	4,300
7	7.5	300	1 and 2	3100	4,400
8	8.1	200	1, 2 and 3	3200	4,500
9	8.25	250	1, 2 and 3	3300	4,600
10	8.5	300	1, 2 and 3	3400	4,700
11	9	200	1, 2, 3 and 4	3500	4,800
12	10	250	1, 2, 3 and 4	3600	4,900
13	10.5	300	1, 2, 3 and 4	3800	5,000
15 - Post Purge	9	0	All burners Off	3200	4,500
16 - Post Purge	5	0	All burners Off	2300	3,200

Outlet set point — 180°F  
 Efficiency factor — 0.85%  
 All nozzles are 5 gph with a 60 degree spray angle  
 = Reference only

**Figure 3-33. Heater stage table.**

There are four burners at the plenum side of the heater assembly. Each burner is numbered 1 through 4 for easy identification. Each assembly also has one fuel tube, a spray nozzle, and a fuel solenoid. Number 1 burner has a few more components, such as a cadmium (CAD) cell, igniter, and exciter. The heater system ignites the number 1 burner first; when a flame is established, the other burners will ignite in order. The number 1 burner is the first to ignite and the last to turn off. Mounted on top of the plenum is the air blower, which charges the plenum with air. The plenum supplies all four burners with pressurized air.

### Heater control panel

The heater control box houses the heater ECM, relays, display screen, and lights. On the front side of the panel are four lights, the ECM function keys with display screen, and two switches. The four heater lights supply status information. The function keys and the screen provide a means to interface



with the ECM. The first switch is the E-stop (emergency stop) button. The E-stop button will only shut down the heater system, not the auxiliary engine. The second switch is the power switch. *Do not* use the power switch as the primary method to activate the heater system, use the heater switch in the truck control panel. Figure 3-34 illustrates the location of components in the heater control box; refer to this figure as we cover the latch relay, undervoltage relay, and the direct current (DC)/DC converter.

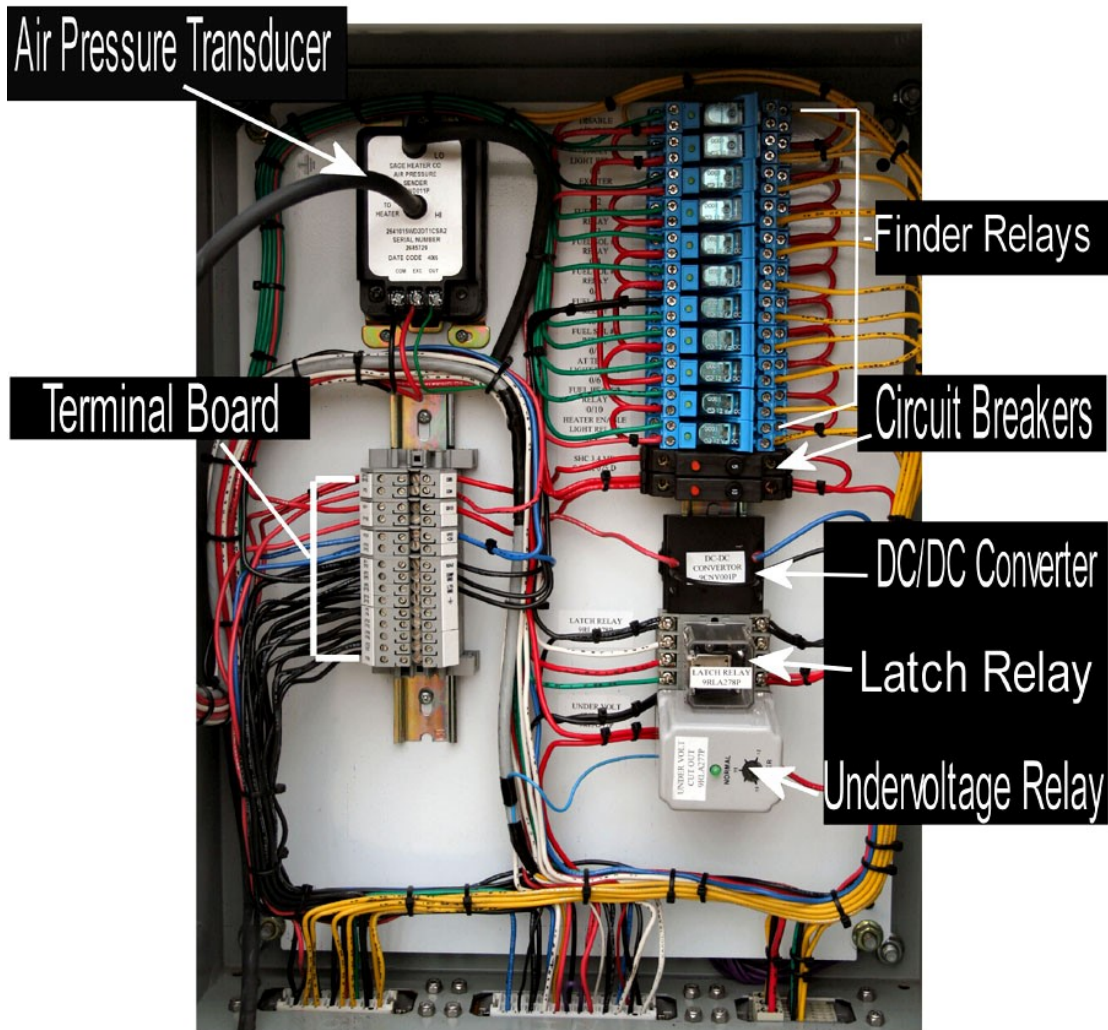


Figure 3-34. Heater components.

#### *Latch relay*

The latch relay circuit controls the air blower system. The ECM manages the post-purge cycle with the latch relay. The ECM controls the latch relay's coil ground circuit. Each time the ECM conducts the post-purge cycle it deactivates the other relays in a programmed sequence and ensures the latch relay coil is grounded for 150 seconds before deenergizing the latch coil. The next relay to cover is the undervoltage relay.

#### *Undervoltage relay*

The heater ECM can lock up and cause the heater to overheat when supply voltage falls below 10 volts. Sage Company incorporates an undervoltage relay to prevent this overheating condition. The

coil of the undervoltage relay shares the same supply voltage as the ECM. When the coil supply voltage is below 10 volts, the relay opens a set of contacts. The open contacts remove supply voltage from the fuel burner solenoids, shutting down the heater fuel system. The last component covered is the converter.

#### *Direct current/direct current converter*

The DC/DC converter does not change DC to any other form of current flow. The converter is actually a voltage conditioner. The converter receives fluctuating voltage and “conditions” it to a constant supply voltage. The converter supplies conditioned voltage to the remote temperature detectors (RTD), flow meter, and heater ECM.

#### *Inputs*

The heater system uses many inputs to manage heater operations. Each sensor or switch has a specific task to perform. All the input information allows the ECM program to manage the heater system to a target of 85 percent efficiency rate.

#### *Remote temperature detectors*

Two of the most important inputs are from the RTDs. RTD 1 measures the temperature of the deicing fluid entering the heater coils, while RTD 2 measures the temperature exiting the heater coils. The heater program uses both sensors to adjust output BTU demand. Each sensor signals the ECM with a 5-volt reference. The amount of reference signal to the ECM changes as the heater temperature increases or decreases.

#### *Flow meter*

The flow meter is mounted before the heater coil inlet and measures deicing fluid flow. On the end of the sensor is a paddle wheel. As the fluid flows past the paddle wheel, the wheel rotates, pulsing signal voltage to the ECM. The faster the paddle wheel rotates; the faster the signal pulses, indicating more fluid flow. The ECM translates the amount of pulses to determine the rate of flow.

#### *CAD cell*

The CAD sulfide flame detector is a photoconductive flame detector. Simply put, it is a light sensitive switch. This switch closes when the number 1 burner ignites. The ECM sends reference voltage to the CAD cell. The reference signal grounds at the terminal board when the CAD cell closes. The ECM recognizes a voltage drop when the switch closes and no voltage drop when the switch is open. As long as the CAD cell stays closed, the heater will continue to run.

#### *Air pressure switch*

The air pressure switch is mounted on top of the plenum next to the air blower. Like the CAD cell, the ECM sends a reference voltage to the air switch. The air switch closes when the plenum is charged with enough air. The ECM recognizes a voltage drop when the switch closes and no voltage drop when the switch is open.

#### *Air and fuel pressure transducers*

The transducers measure the amount of pressure in each system. Both transducers vary the five-volt reference signal to the ECM. The ECM changes air and fuel pressure to meet heater demands. Each sensor indicates how much the ECM altered each pressure setting.

#### *Outputs*

The heater controls the heater outlet temperature using various output voltages. Each output responds to the ECM command. To manage the output circuits, the ECM varies the amount of voltage to the control valve solenoids or provides a ground path for the relay coils.

### *Control valve solenoids*

The ECM varies the amount of voltage to the air and fuel control valve assemblies. Each assembly has a circuit card called a driver head that attaches to each solenoid. The driver head varies the amount of voltage to the electrical solenoid, which moves the hydraulic control valve. The hydraulic control valve changes the amount of hydraulic fluid flow to the air or fuel pump hydraulic motors.

### *Relays*

The ECM controls the ground circuit of each relay coil. Once the relay coil circuit is completed, the relay contacts close, providing voltage to either a light or a solenoid. The ECM uses the relays to control all four burner fuel solenoids. The fuel solenoid controls when the fuel goes to the burner fuel nozzle. This is how the ECM manages outputs to operate the heater in stages.

### *Safety devices*

Three safety devices protect the heater system:

1. Fire switch.
2. Over temperature.
3. Stack switch.

The switches are the mechanical backup systems. The ECM does not monitor the position of these switches and will not log a fault code when they are activated.

### *Fire switch*

The fire switch mounts on the actuator unit of the fire suppression system. The switch closes when the actuator is in the “cocked” position. The fire switch is connected in series with the pump switch. The heater system *will not* start until both switches (fire and pump) are closed.

### *Over temperature*

The over temperature unit consists of a thermal sensor and two switches. The unit’s thermal sensor mounts in the heater outlet piping. The two adjustable switches are the low- and high-limit:

- The *low-limit switch* is a normally closed switch. A 5-volt reference from the ECM goes to the low-limit switch. When the deicing temperature reaches 225°F, the switch opens, which means the ECM does not sense a voltage drop. The ECM shuts off the heater and begins the 150-second post-purge cycle.
- The *high-limit switch* contacts remain closed until output the deicing fluid temperature reaches 235°F. The switch provides a 12-volt power supply for the actuator relays. If the ECM fails to react to the low-limit switch, the high-limit switch opens, removing power from the actuator relays.

### *Stack switch*

The stack switch is a normally closed switch that opens when the heater exhaust temperature increases above 1,400°F. Both the high-limit and stack switches remove supply voltage from the output relays, in particular the fuel solenoid relays, which shuts down the heater. The high-limit and stack switches are the last line of defense to prevent heater damage if the ECM fails to shut down the heater system.

### *Heater fuel system*

The fuel system supplies all four burners with the correct amount of fuel pressure during the different stages of operation. Refer back to figure 3-33 to see the different fuel pressure settings for each stage.

### Heater operation

The following four cycles are part of the heater operation:

1. Five-second safety check.
2. 45-second countdown.
3. Run.
4. 150 second post-purge.

Starting the heater begins the five-second safety check. The safety check is an operational check of the input and output devices to ensure they are within working parameters. If there is a problem, in addition to logging a fault code, the ECM prevents the heater from progressing to the 45-second countdown cycle.

The 45-second countdown begins once the safety check ends. The ECM activates the air system, fuel pump, and a 45-second timer. At 15-seconds of the countdown, the ECM activates the exciter and fuel pump and adjusts the output settings to stage 14. This stage provides the correct amount of air and fuel pressure to ignite the heater.

At 0-second, the ECM activates number 1 burner fuel spray nozzle solenoid. The ECM continues to add fuel for 10 seconds or until the CAD cell closes. If the heater fails to ignite, the ECM will perform a second attempt. If both attempts fail, the ECM illuminates the fault light and begins the 150-second post-purge cycle. If the number 1 burner ignites, the ECM turns off the exciter and begins the run cycle.

During the run cycle, the heater transitions to stage 13 (refer back to figure 3-33). The heater transitions through the stages to control the output temperature as the input deicing fluid temperature increases. When the inlet and outlet deicing fluid temperatures are both at 180°F during stage 1, the heater ECM ends the run cycle and begins the 150-second post-purge.

The 150-second post-purge cycle turns off the number 1 burner fuel solenoid and the fuel pump. The ECM uses a latch relay to keep the air blower energized for 150 seconds. During the 150-second time period, the air blower slows as the post-purge cycle transitions to stages 15 and 16. Once the post-purge cycle ends, the heated deicing fluid is ready for deicing aircraft. Figure 3-35 depicts the heater operation.

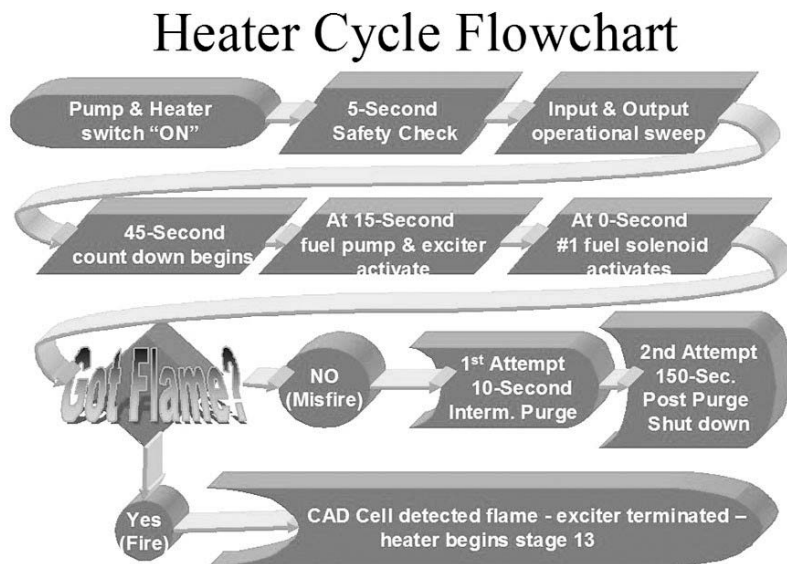


Figure 3-35. Heater cycle flowchart.

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## Self-Test Questions

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

### 211. Deicer features and fundamentals

1. What component balances an uneven load and eliminates the need for outriggers on the Global deicer?
2. What component controls the deicer auxiliary engine speed and dispensing subsystems?
3. What is the purpose of the red refill tank light in the deicer truck cab?
4. What engine protection program switches on the Deutz ECM will shut down the auxiliary engine?
5. Where is the *AirPlus!* supercharger located and how is it driven?
6. What components monitor the *AirPlus!* self-contained oil system.
7. What safety precaution should be observed when using the *AirPlus!* system?
8. Explain the need for the time delay relay in the deicer HL-level electrical circuit.
9. Under normal operation, which pump supplies hydraulic fluid to the deicer boom functions?
10. What is the purpose of the deicer deadman circuit?
11. The deicer 90-series pump supplies fluid for what systems?
12. Which deicer pump is directly attached to the auxiliary engine flywheel?

13. Name the component that both the deicer 90- and 100-series pumps share.

14. What conditions will cause the deicer fire suppression system to activate?

### **212. Deicer boom fundamentals**

1. Why is the deicer boom pedestal mounted over the rear axle?
2. What is the first deicer component the 5-series pump supplies hydraulic fluid to?
3. What solenoid on the deicer series 6 manifold must be energized for the boom functions to operate?
4. What stops boom rotation at 185 degrees in either direction?
5. What unique double-acting cylinder provides the deicer enclosed cab rotation feature?
6. What deicer component controls the amount of current flow to the functional solenoids on the Parker series 6 manifold?
7. Which electrical circuits need to work properly in order to safely operate the deicer boom functions?
8. If the deadman solenoid is *not* energized, where does hydraulic fluid flow?
9. How does the VDB determine which deicer output circuit to activate?
10. What happens when the PWM output circuit is energized?



**213. Deicer dispensing and heater system fundamentals**

1. How does the operator vary the amount of deicing fluid dispensed from the Task Force nozzle?
2. Where does deicing fluid go when the safety relief valve opens?
3. What deicing system must be in use to activate the deicing fluid inject system?
4. How can you vary the amount of anti-icing fluid dispensed from the Task Force nozzle?
5. What does the deicer heater ECM use to determine the correct BTU demand for each heater stage?
6. How many burners are at the plenum side of the deicer heater assembly?
7. What charges the deicer plenum with air?
8. Explain the function of the DC/DC converter.
9. Which RTD measures the deicing fluid *entering* the heater coils and which RTD measures the deicing fluid *exiting* the heater coils?
10. What deicer switch closes when the number 1 burner establishes a flame?
11. Which switch is mounted on top of the plenum next to the air blower and receives a reference voltage from the ECM?
12. What does the deicer ECM use to control all four burner fuel solenoids?

13. Name the deicer switches that must be closed before the heater will attempt to start.
14. If the ECM fails to shut down the heater, what deicer switches are the last line of defense?
15. What are the deicer's four heater cycles?
16. When will the deicer's ECM activate number 1 burner fuel solenoid?

---

### Answers to Self-Test Questions

#### 209

1. It uses high velocity air and vacuum to clean streets and runways.
2. 1,800 rpm for light material at 5–10 mph; 2,000–2,200 rpm for normal material at 3–5 mph; and, 2,200–2,500 rpm for heavy material at 1–3 mph.
3. It drives the blower and hydraulic pump.
4. Shuts down the auxiliary engine after 30 seconds if it overheats or loses oil pressure.
5. The blower is the heart of the air system. It produces high-pressure air and vacuum for the sweeping system.
6. Pick-up head.
7. (1) Used to adjust the height of the blast orifice off the ground.  
(2) Provides a seal on the sides of the pick-up head.  
(3) Provides a wearing surface for the pick-up head.
8. It ensures that the debris stays in the path of the pick-up head as it is being swept by the gutter brooms.
9. Remove dirt and debris from the street curbing and transfer it into the path of the pick-up head.
10. As the fluid heats up during operation, it expands and pushes out of the cap.
11. It is a vane-type pump with a built-in relief valve set at 2,500 psi and is gear-driven off the auxiliary engine.
12. It holds the gutter broom up in the stowed position.
13. Flow control valve.
14. The water system controls the amount of dust produced during sweeping operations.
15. The water pump is not working because the pump lost its prime or the tank is out of water.

#### 210

1. 175,000 pounds for aircraft and 93,000 pounds for all other towing operations.
2. Four forward and one reverse.
3. Hydraulic gerotor control unit.
4. By the vehicle's air compressor.
5. Spring applied and hydraulically released.
6. Air-over-hydraulic.
7. The trailer service brakes actuate before the vehicle's service brakes.

8. Circuit breaker mounted on the junction box.

**211**

1. Torsion bar.
2. Pump switch.
3. Illuminates when the dispensing anti-icing subsystem, deicing subsystem or the hydraulic system has a low-fluid level.
4. Engine oil pressure and coolant temperature switches.
5. Under the enclosed cab operator seat and belt driven off of a hydraulic motor.
6. An oil pressure switch, oil temperature sending unit, and a vacuum switch.
7. Do not operate the air system with individuals or debris in the air-blast radius.
8. Fluid sloshing in the tank can cause the low-level switch to momentarily close. The TD relay prevents premature shut down of the auxiliary engine.
9. 5-series pump.
10. Prevents the boom hydraulic system from activating until the operator squeezes a trigger switch on the boom joystick. This ensures the boom functions will not move if someone moves the joystick inadvertently.
11. Dispensing and heater systems.
12. The 100-series.
13. Hydraulic oil cooler.
14. When a fusible link melts or the manual release button on the front of the firebox is pressed.

**212**

1. To support the weight of the boom assembly.
2. The Parker series 6 hydraulic manifold.
3. Deadman.
4. Sliding mechanical stop.
5. Helical hydraulic rotary actuator.
6. VDB.
7. Deadman and joystick circuits.
8. Returns to the hydraulic tank.
9. By the amount of signal voltage.
10. The HI-A or HI-B red LED illuminates.

**213**

1. By varying the position of the rocker foot pedal.
2. Straight to the ground.
3. The AirPlus! system.
4. You cannot vary the amount of anti-icing fluid that is dispensed from the Task Force nozzle.
5. Various inputs and output.
6. Four.
7. The air blower.
8. The converter receives fluctuating voltage and conditions it to a constant supply voltage.
9. RTD number 1 measures the deicing fluid entering the heater coils, while RTD number 2 measures the fluid exiting the heater coils.
10. CAD cell.
11. Air pressure switch.
12. Relays.

13. Fire and pump.
14. High-limit and stack switch.
15. The 5-second safety check, 45-second countdown, run, and 150-second post-purge.
16. At the 0-second mark of the 45-second countdown.

**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.

**Do not return your answer sheet to AFCDA.**

23. (209) What supplies power to The Young Manufacturing Company (TYMCO) sweeper's hydraulic pump?
  - a. Blower.
  - b. Carrier engine.
  - c. Auxiliary engine.
  - d. Electric drive motor.
24. (209) The Young Manufacturing Company (TYMCO) sweeper utilizes a switch to
  - a. alert the driver of low water in the tank.
  - b. shut down the carrier engine if it overheats.
  - c. shut down the auxiliary engine if it overheats or loses oil pressure.
  - d. allow the carrier and auxiliary engines to start and run for 30 seconds without oil pressure.
25. (209) Which component of The Young Manufacturing Company (TYMCO) sweeper is responsible for creating *both* a vacuum and high-pressure air flow?
  - a. Blower.
  - b. Turbofan.
  - c. Supercharger.
  - d. Vacuum pump.
26. (209) The gutter brooms on The Young Manufacturing Company (TYMCO) sweeper are driven
  - a. hydraulically.
  - b. pneumatically.
  - c. by a chain and sprocket.
  - d. by a bevel gear and shaft.
27. (209) The Young Manufacturing Company (TYMCO) sweeper hydraulic system is protected from shock damage by
  - a. accumulators.
  - b. cartridge valves.
  - c. flotation springs.
  - d. rubber bumper guards.
28. (209) The Young Manufacturing Company (TYMCO) sweeper's flow control valve
  - a. adjusts the water system pressure.
  - b. adjusts the raising speed of the pick-up head.
  - c. controls the raising speed of the gutter broom.
  - d. controls the raising speed of the pick-up head and gutter brooms.
29. (209) The Young Manufacturing Company (TYMCO) sweeper's water system
  - a. blast cleans.
  - b. controls dust.
  - c. flushes streets.
  - d. washes gutters.

- 
- 
30. (210) Which is *not* a steering mode for the MB-4 towing tractor?
- Coordinated.
  - Two-wheel.
  - Oblique.
  - Cross.
31. (210) Which component limits the air produced by the MB-4 air compressor?
- Purge poppet valve.
  - Relay valve.
  - Governor.
  - Air dryer.
32. (211) What eliminates the need for outriggers on the Global deicer?
- The torsion bar.
  - Heavy-duty shocks.
  - Heavy-duty springs.
  - Rear-axle leaf springs.
33. (211) Which component limits the Global deicer speed to 4 miles per hour when the boom is out of the saddle?
- Auxiliary engine electronic control module (ECM).
  - Chassis ECM.
  - Heater ECM.
  - The operator.
34. (211) How many emergency stop switches does the Global deicer use?
- 1.
  - 2.
  - 3.
  - 4.
35. (211) Which Global deicer hydraulic pump provides fluid for the fluid dispensing and heater systems?
- 5-series.
  - 90-series.
  - 100-series.
  - Emergency.
36. (211) Which Global deicer hydraulic pump is attached directly to the auxiliary engine flywheel?
- 5-series.
  - 90-series.
  - 100-series.
  - Emergency.
37. (212) The Global deicer enclosed cab-leveling sensor signals the leveling
- solenoid when a 4 degree angle change occurs.
  - solenoid when an 8 degree angle change occurs.
  - valve driver board when a 6 degree angle change occurs.
  - valve driver board when an 8 degree angle change occurs.



38. (212) Which Global deicer boom function uses two hydraulic flow control valves to control function speed?
- a. Fly tip.
  - b. Cab rotation.
  - c. Boom rotation.
  - d. Boom elevation.
39. (213) Which valve opens to maintain the Global deicing system pressure between 180–200 pounds per square inch (psi)?
- a. Thermal relief valve.
  - b. Safety relief valve.
  - c. Pressure regulator.
  - d. Selector regulator.
40. (213) Which kind of fluid does the Global deicer fluid inject valve inject nine gallons per minute (gpm) of into the AirPlus! System?
- a. Heated anti-icing fluid.
  - b. Heated deicing fluid.
  - c. Cold anti-icing fluid.
  - d. Cold deicing fluid.
41. (213) Which Global deicing system component protects the anti-icing pump from excess pressure?
- a. Selector regulator.
  - b. Pressure regulator.
  - c. Safety relief valve.
  - d. Thermal relief valve.
42. (213) Which Global deicer heater component controls the amount of voltage to the air and fuel control valve solenoids?
- a. Driver head.
  - b. Transducer.
  - c. Switch.
  - d. Relay.

**Please read the unit menu for unit 4 and continue ➔**

## Unit 4. P-23 Fire-fighting Truck

<b>4-1. P-23 Fire-fighting Truck Systems .....</b>	<b>4-1</b>
214. General .....	4-2
215. P-23 transmission.....	4-2
216. P-23 power divider/torque converter .....	4-4
217. Electronic control system characteristics.....	4-5
218. Air and dispensing systems .....	4-8

**I**N THIS UNIT, you will learn about the A/S32P-23 crash-fire-rescue truck, commonly known as the P-23. This unit will give you a good understanding of the P-23 fire-fighting truck, its capabilities and some maintenance practices.

### 4-1. P-23 Fire-fighting Truck Systems

This section covers the P-23 fire-fighting truck systems. You must understand the fundamental systems before you can effectively maintain the truck. The P-23 systems covered in this lesson include general chassis description, the transmission, power divider/torque converter, and electrical control system. Figure 4-1 shows the exterior of the P-23 crash-fire-rescue truck. Look the figure over to get a good idea of the components that make up this important fire-fighting vehicle.

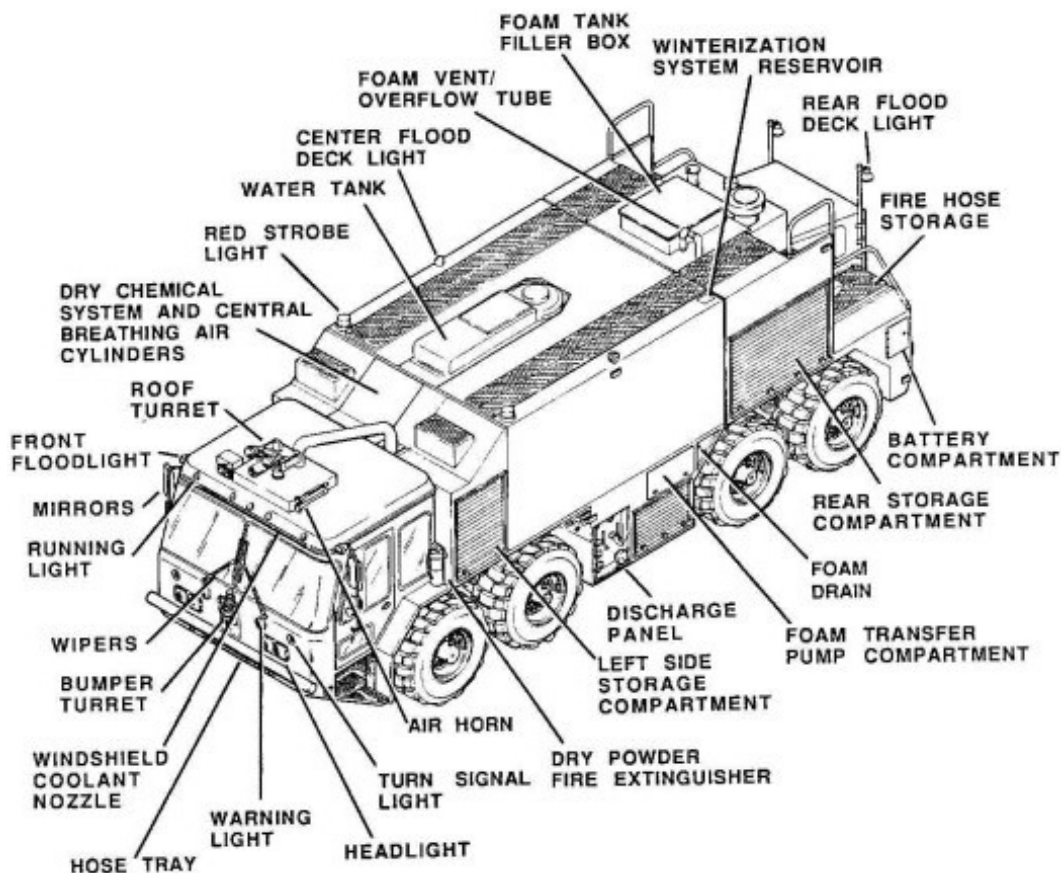


Figure 4-1. Truck exterior arrangement.

## 214. General

The P-23 is a critical fire-fighting vehicle. The design of this vehicle was carefully engineered to meet the needs of the United States military. This lesson describes the P-23 and general performance characteristics.

### Description

The P-23 has a Detroit Diesel® 8V92TA diesel engine that powers its functions. The single diesel engine powers the truck drivetrain and agent water pump. The fire-fighting systems are self-contained. This means there is no need for an outside source of extinguishing agents. The truck incorporates a 3,300-gallon capacity water tank, 500-gallon capacity stainless steel foam tank, and a 500-pound rated capacity steel dry chemical storage tank.

### Performance characteristics

The fully loaded P-23 will accelerate from zero to 50 mph in 41 seconds on level pavement. The P-23's top speed is 72 mph. It has the ability to climb a 50-percent grade without spilling fluid. The P-23 is capable of maneuvering at low speed in difficult terrain with its fire-fighting equipment operating at full capacity. Additionally, the P-23 has the stability to maintain full discharge on side slopes.

## 215. P-23 transmission

Shown in figure 4-2 are two views of the P-23 transmission. The transmission shown is an illustration of the model TD61-1172 manufactured by the Twin Disk Corporation®. The transmission is a hydraulically-actuated and electrically-controlled power shift unit providing six forward speeds and one reverse.

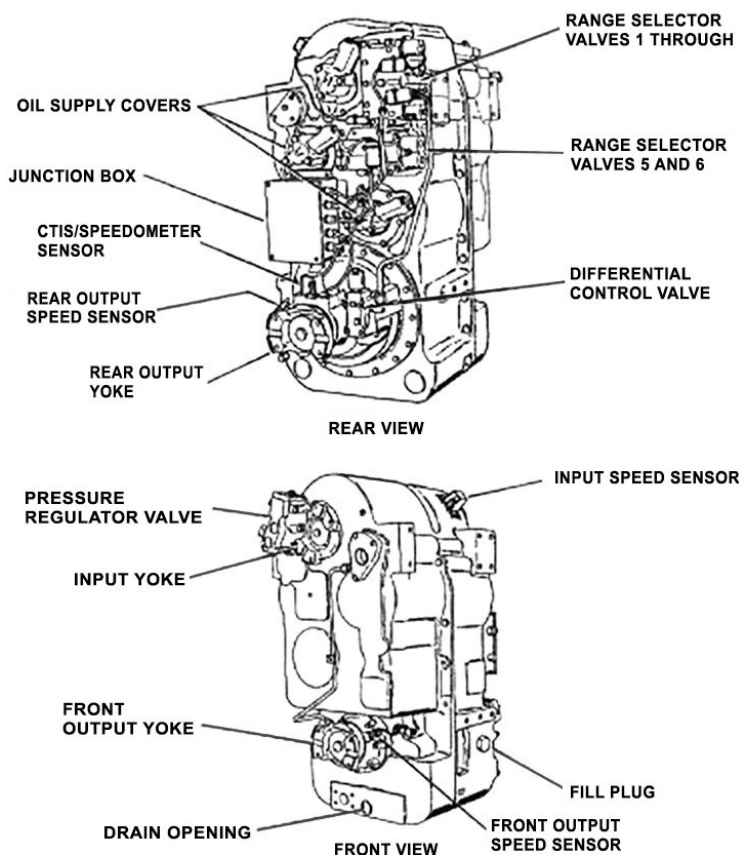


Figure 4-2. Transmission.

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functions of the transmission and the power divider (torque converter).

There are two main modes of operation:

1. Normal road mode.
2. Crash mode (modulating).

### Normal road mode

When in the D6 position, the transmission will automatically progress through gear ranges two through six in both up-shift and down-shift operation.

### Crash mode

When in crash mode, the transmission will start in first gear and automatically progress to the gear range selected.

### Lubrication

The transmission contains 28 quarts of lubricant in the sump with an overall system capacity of 120 quarts. The reason for the large oil quantity is that the

transmission also serves as the reservoir for the power divider shown in figure 4-3. Under normal conditions, the lubricant used is heat transfer oil (HTO) 30-weight. Under cold conditions, HTO 10-weight is used. To check for proper fluid level, the vehicle must be on a level surface with the engine running at idle and at operating temperature—if you do not do this, you will get a faulty reading. If you use the sight gauge on the transmission while doing a cold check, there should be about an inch of fluid visible in the sight gauge. Do not add any fluid at this time—as the fluid heats to operating temperature, it will expand.

Two gear-type pumps mounted to the power divider circulate the lubricant. The first gear-type pump delivers a maximum output of 45 gpm. A regulator valve assembly mounted on the transmission controls the main system (220 to 240 psi at 2,100 rpm) and lube pressure (35 to 45 psi). The second gear-type pump draws fluid from the sump of the power divider and returns the fluid to the transmission sump.

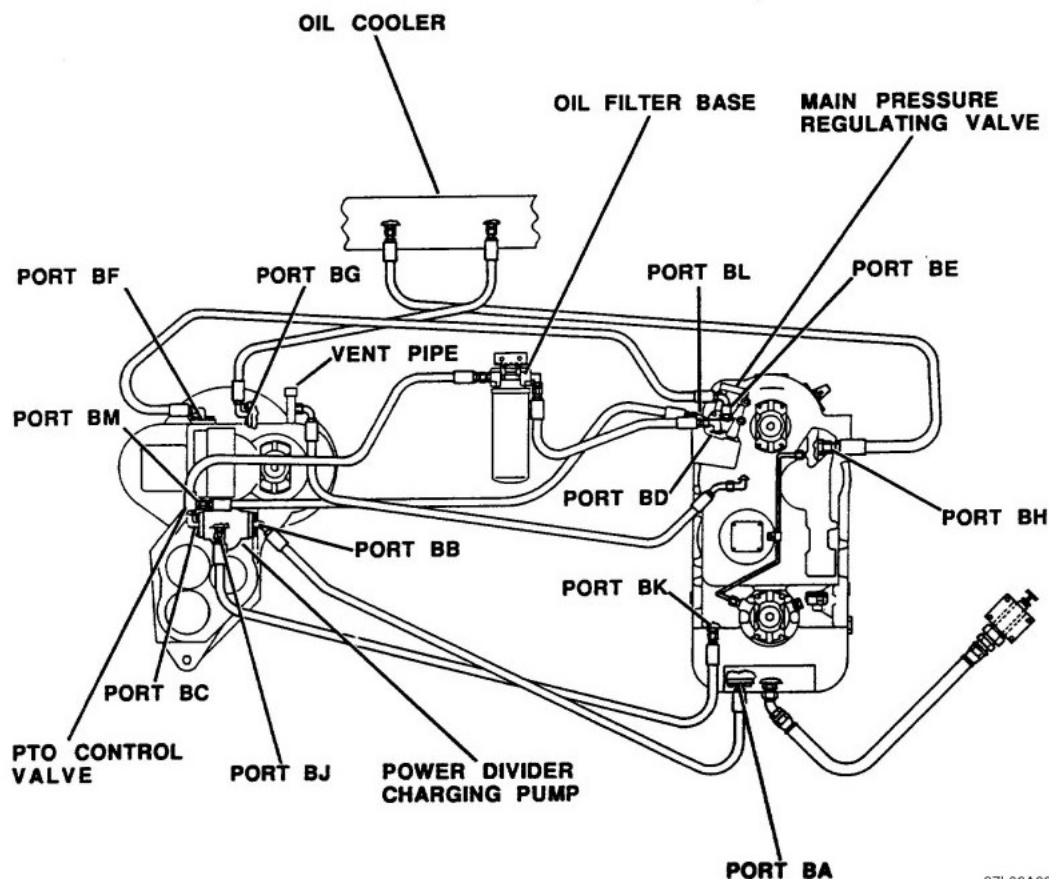


Figure 4-3. Power divider.

### Range selector valves

Six range selector valves control the application of the transmission clutches. Four of these valves are actuated by the on/off solenoids located on a single valve body and numbered 1 through 4. The remaining two valves (numbered 5 through 6) are electric modulating types contained in a single-valve body. These two valves are polarity sensitive and must be wired correctly to function correctly. If this is not done, the wrong voltage will be received and cause erratic operation (if at all) of the transmission. The reason for this is the valves work on variable voltage. If a valve is wired incorrectly, simply rewire it. Improper wiring will not damage the valves.

## 216. P-23 power divider/torque converter

The power divider/torque converter (fig. 4-4), which is mounted on the engine flywheel housing, serves to split the engine power into two separate drives:

1. Agent water pump.
2. Main drive to the transmission.

In addition, the power divider provides mounting and drive arrangements for the modulating clutch oil pump. This pump circulates oil through the power divider/torque converter and transmission (fig. 4-5) for lubrication and dissipates heat generated by the modulating clutches.

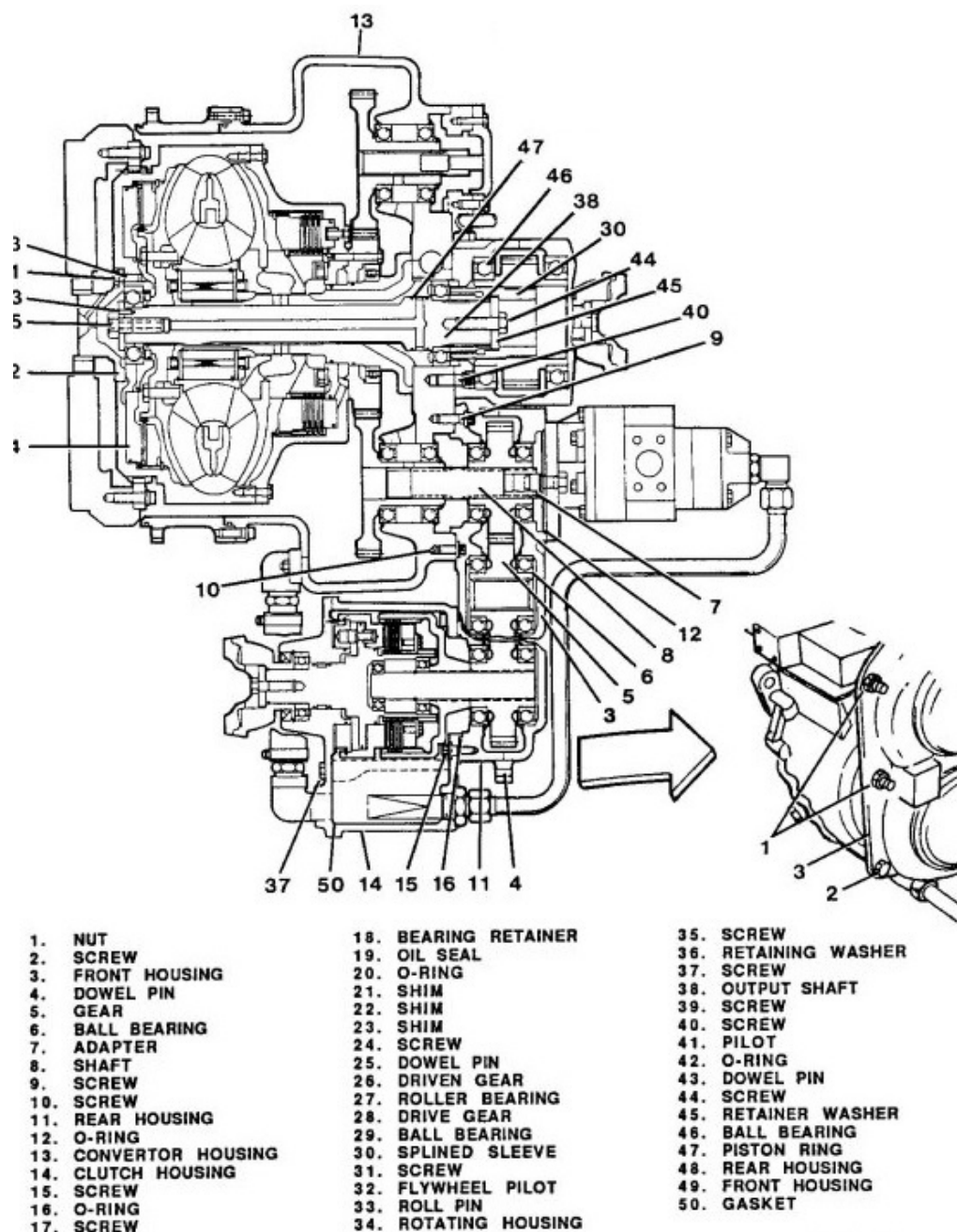


Figure 4-4. Power divider/torque converter.



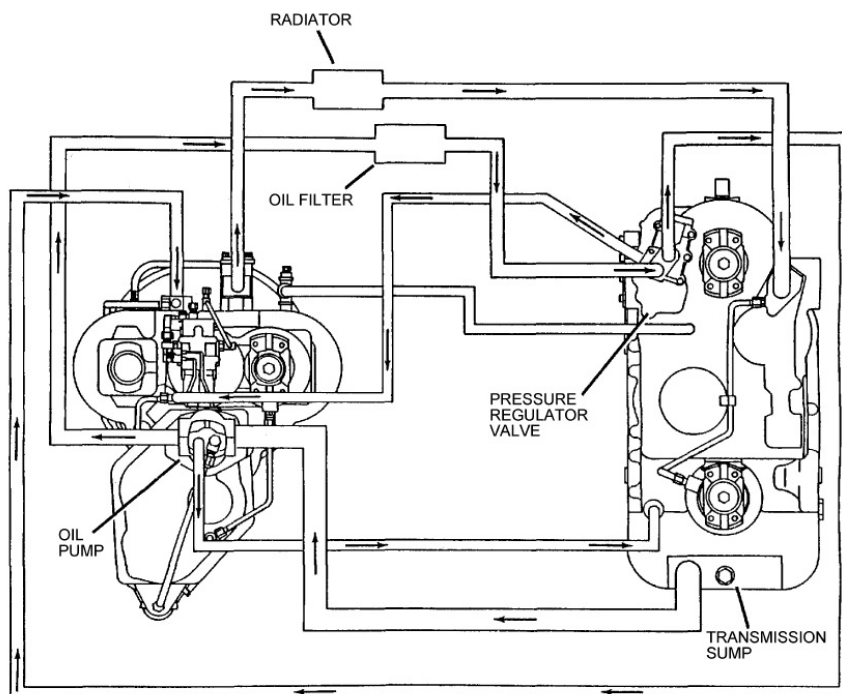


Figure 4-5. Transmission lubrication system.

#### Agent water pump drive

The agent water pump is driven by a power takeoff (PTO). It provides constant power to the pump when the engine is operating. The speed of the engine controls the agent pump speed. A separate hydraulically-actuated clutch is provided in the agent pump drive. This separate hydraulically-actuated clutch provides a means of engaging and disengaging the agent pump. An electrical switch on the instrument panel in the cab controls the engagement of the separate hydraulically actuated clutch.

#### Main drive to transmission

The modulating clutch is connected to the engine flywheel through the torque converter rotating housing. The modulating clutch controls the main drive to the transmission. Clutch modulation (controlled slippage) occurs whenever the pump clutch is engaged with the transmission in any gear. The clutch modulates to provide driveline torque and speed requirements (as necessary) to maneuver while still operating the fire-fighting system.

**NOTE:** During normal road mode, the modulating clutch is fully engaged and the PTO clutch is disengaged.

### 217. Electronic control system characteristics

The electronic control system shown in the drawing in figure 4-6 provides automatic shifting for the transmission/power divider and coordinates functions of the vehicle, power divider, and transmission. Various external components provide inputs for the control as well as the outputs for the operation of the transmission/power divider system. Different operating characteristics are obtained through the position of various switches to the control system. In the event of a failure of the electronic control system in the normal road mode, transferring connectors P3 and P4 from the control unit enclosure to the manual override enclosure can achieve manual operation. There are two enclosures; both are located in the cab of the vehicle under the left-hand side of the dash.

Manual operation allows the transmission to operate in reverse, neutral, and third gear when placing the shift controller in the D6 position. The electronic control system components and functions are described as follows.

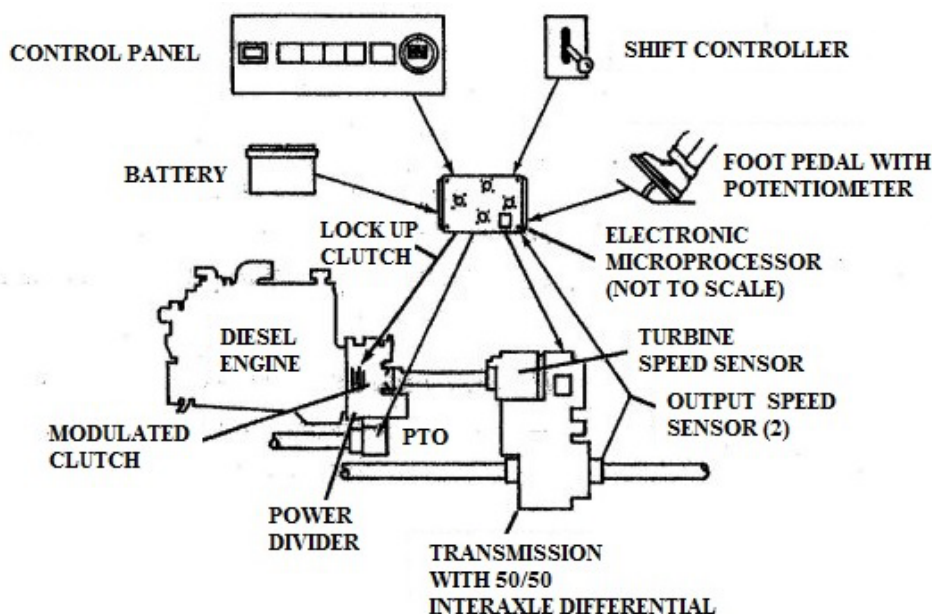


Figure 4-6. Electronic control system.

### Controller

This is a microprocessor-based unit (computer) with 12 VDC inputs.

### Range selector

The range selector selects forward ranges, neutral, and reverse. When the selector lever is in the neutral position, the transmission will always be in neutral. This is ensured by both the computer neutral and redundant neutral (which is an open switch in the selector causing neutral disconnect that physically removes power from the transmission solenoids 1 to 4 and electric modulating valves 5 and 6). Three switches in the range selector, labeled D6, D4, and D3 on the electronic control system, are used to select one of the four available positions. When selecting a particular range, a switch for the specific position is closed. When first range is selected, both the D4 and D3 close. All forward range switches are open in neutral and reverse.

### Manual override

Figure 4-7 shows the manual override unit. The manual override feature allows operation of the vehicle with limited capability if the electronic control fails to operate. Reverse, neutral, or third forward is selected through movement of the selector lever. Manual override is entered by disconnecting the P3 and P4 wiring harness from the electronic control and connecting the corresponding connectors to the manual override enclosure at the appropriately labeled connectors, J3 and J4. This is covered in greater detail in the trouble-shooting section.

### Forward manual override

When selecting D6 range, the D6 contacts are closed. The D6 contacts are open in all other forward ranges. In manual override, the D6 contacts energize the third range.



### *Reverse manual override*

When selecting reverse range, the reverse contacts are closed. The reverse contacts are open in all forward ranges and neutral. In manual override, the reverse contacts energize reverse range.

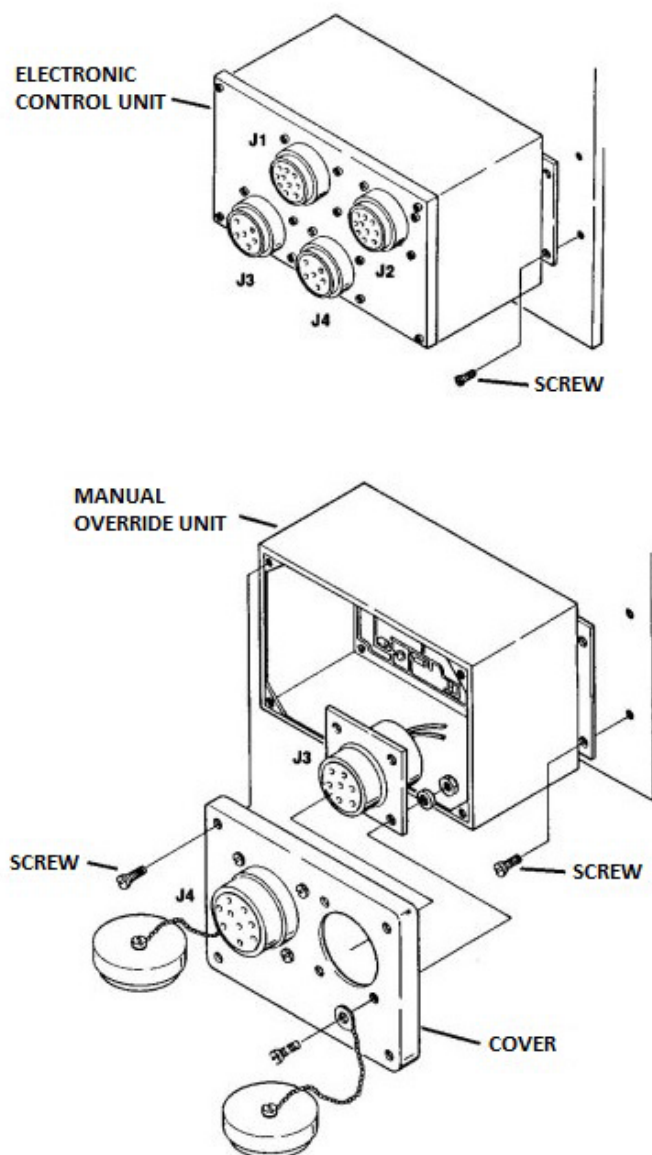


Figure 4-7. Control units.

### **Pump mode switch**

The pump mode switch controls a normally open ground circuit. When the truck is in road operation, the switch is open. When the switch is selected, the completed ground circuit signals the controller to enter pump mode operations.

### **Stationary select switch**

When in the stationary mode, the stationary select switch is open. This action interrupts the current path to all of the six transmission solenoids. The stationary disconnect switch is wired in series with the neutral disconnect switch.

### **Diagnostic test switch and connector**

This is a separate connector that leaves the test port normally open for the operating mode, but is used to connect a normally closed push-button switch to the test port to signal diagnostic test when closed.

**NOTE:** Do not put the diagnostic test switch in the test mode while operating the vehicle in the normal road mode. The reason is the transmission runs a constant diagnostic while the vehicle is operating, which could cause significant transmission damage.

### **Turbine speed sensor**

Mounted on top of the transmission housing is the turbine speed sensor. It senses torque converter output speed for engagement of the lockup clutch. The power divider output speed is also compared with the transmission output speed to determine engagement of the differential lock and for the protection for the clutch in first gear range.

### **Transmission speed sensors**

Two separate speed sensors read transmission output speed. The rear output speed sensor located at the rear output yoke of the transmission is identified as #1 and the front output speed sensor located at the front output yoke is identified as #2. The electronic control system compares the transmission output speed with the output speed of the power divider to determine engagement of the differential lock clutch in the first gear range. The electronic control system monitors both output speed sensors. There are two sensors in case of a failure of one of the output speed sensors. Additionally, there is one speed sensor that reads the transmission input speed. This sensor is located at the top of the transmission.

### **Accelerator potentiometer**

The accelerator potentiometer senses accelerator pedal position to enable the control unit to select shift speeds and the clutch engagement sequence in the road mode. The potentiometer also senses accelerator pedal position for control of the modulating clutch engagement during pump mode operation.

### **Display**

An LCD indicates transmission range during the normal mode of operation. Additionally, the LCD provides status codes in both the operational and diagnostic modes.

### **Solenoids and electric modulating valves**

Solenoids S1, S2, S3, S4, SD, and SP and electric modulating valves M5, M6 ML, and MI are used for controlling clutch engagement. The solenoids are on/off devices that energize when supply voltage is applied. When a solenoid is energized, oil at the main pressure of 220 to 240 psi at 2,100 rpm is supplied to engage a particular clutch pressure. The resistance of a 12 VDC solenoid varies from 8 to 16 ohms depending on the temperature. These solenoids are not polarity sensitive.

The electric modulating valves vary the pressure to the clutch by varying current through the coil of the solenoid. As the current increases, the pressure will increase. The current will vary between 0 and 1.0 amps. The resistance of the coil varies from 5 to 8 ohms depending on temperature. The modulating valves are polarity sensitive. If the polarity is reversed, the voltage will change, but the pressure will remain at zero. Reverse polarity does not damage the valve.

## **218. Air and dispensing systems**

The P-23 dispensing system is very similar to other fire-fighting vehicles. At the same time, it has some systems that are vehicle specific and very different from what you have serviced in the past. In this lesson, we look at many old familiar components and some that are newer than what you have seen previously.

Figure 4-8 is a diagram of the P-23 agent piping system. The system consists of the following components:

- Fiberglass water tank—3,300 gallon.
- Stainless steel foam tank—500 gallon.
- System piping.
- Agent water pump.
- Water pressure regulator system.
- Foam proportioning system.
- Control system and instruments.

The tanks are located in the body section of the vehicle. A PTO from the power divider/torque converter drives the agent pump. The agent pump pumps the water and foam through the system to the discharge outlets. A multimetering valve automatically and uniformly proportions water and foam concentrate selectively for the roof turret, bumper turret, and handline nozzles through fixed orifices. This design allows the truck to operate and perform its function without interruption. This can be done while the truck is moving in either direction, standing still, or maneuvering in difficult terrain.

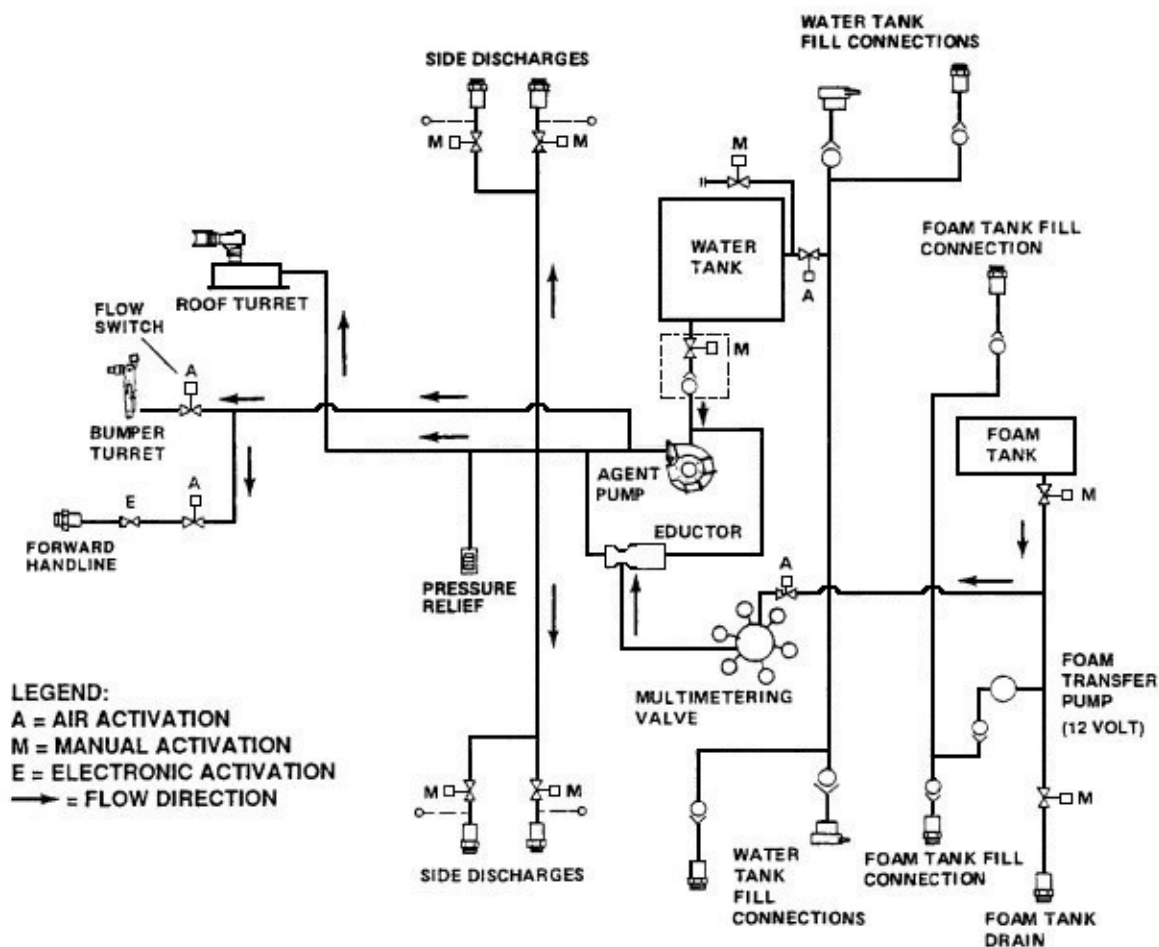


Figure 4-8. Agent piping.

Figure 4-9 shows the agent air system. As you can see, pump pressure is controlled by agent pressure in the piping, electrical components, air components, and mechanical means. All of these must work

together to maintain proper system operation. You put the vehicle in the pump mode by placing the pump switch in the ON position. When you do this, you complete a ground for the conversion relay from the transmission control module. At the same time, the PTO is energized to engage the agent pump and the throttle solenoid is energized to increase the engine rpm. As the water pressure increases in the piping, it closes a 20-psi pressure switch. This switch will take the vehicle out of pump mode if the water pressure drops below 20 psi. You need to adjust the manual air pressure regulator on the console between the driver seat and the turret operator to establish the desired system pressure. The pressure transducer and the electronic pressure regulator (EPR) will then work together to maintain the set pressure. The pressure transducer, located in the roof turret piping behind the left hand discharge panel, senses pump pressure and converts it to electrical voltage. The pressure transducer then sends the electrical voltage to the EPR, also known as a *pizo* valve. The EPR is located inside the shift tower console. The EPR receives this voltage and provides counter air pressure to the pump throttle cylinder to adjust engine rpm to maintain desired pump pressure.

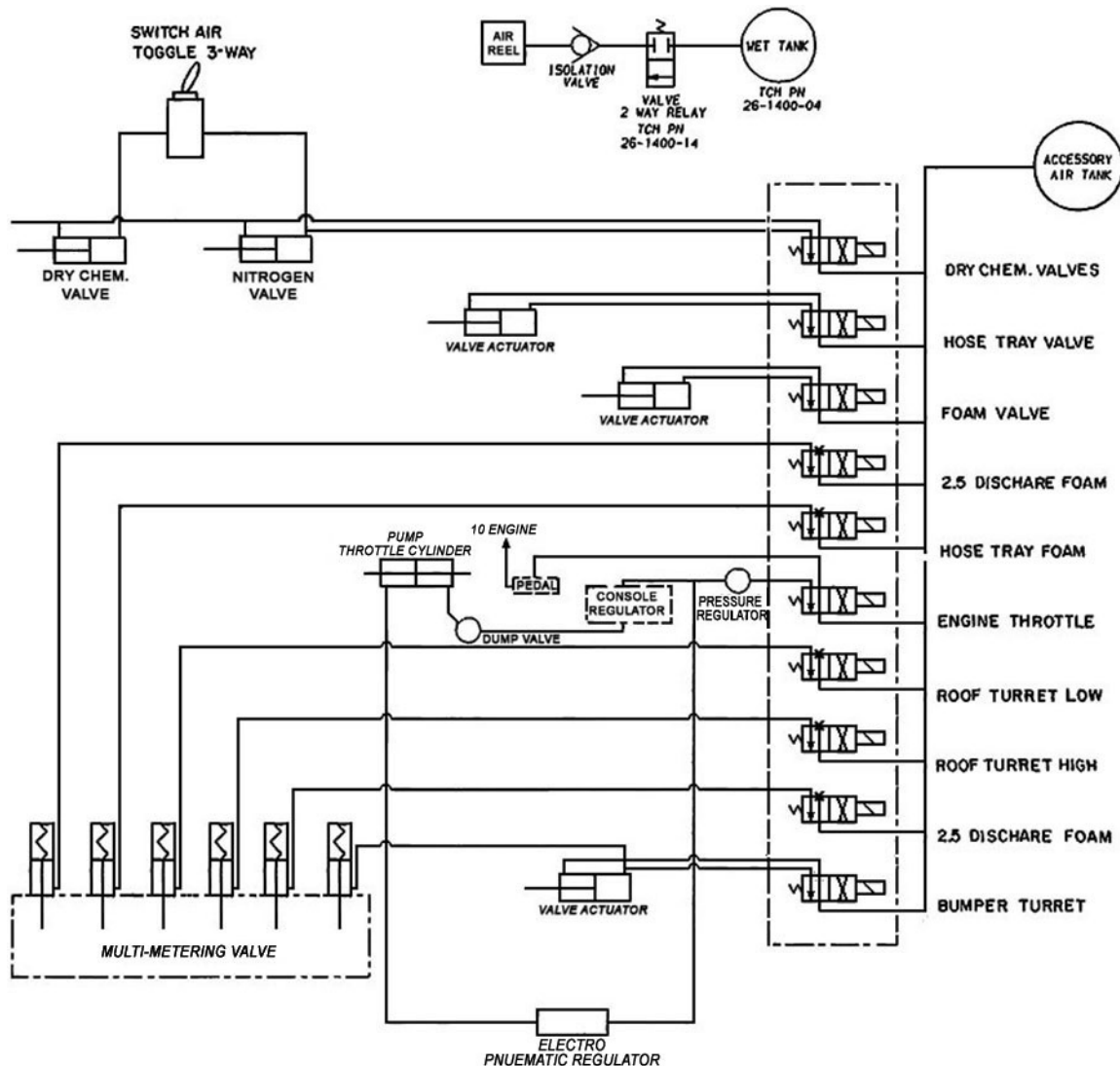


Figure 4-9. Agent air system.

## Turrets

Turrets are two of the water discharge points on the P-23. The P-23 has a roof turret and a bumper turret to discharge water. Akron Brass® and Feecon® are the two manufactures that currently provide turrets for the P-23. Akron Brass is the most commonly used roof turret used on the P-23.

### Roof turret

The roof turret of the P-23 is a single barrel, nonaspirating, constant flow, variable stream nozzle located on the roof of the cab. Early models of the P-23 are equipped with Feecon roof turrets; the later models are equipped with Akron Brass roof turrets. Both roof turrets have a discharge rate of 750 gpm in low flow and 1,500 gpm in high flow. The discharge pressure of the Akron Brass is 180 psi. The Feecon turret has a discharge pressure of 200 psi.

The turret travel limits, discharge patterns, and roof turret control handles differ in the Feecon and Akron Brass applications. Figure 4-10 shows the travel limits for the Feecon. Figure 4-11 illustrates the Feecon turret control handle. Figure 4-12 shows the Akron Brass travel limits and discharge patterns, while figure 4-13 shows the control handle.

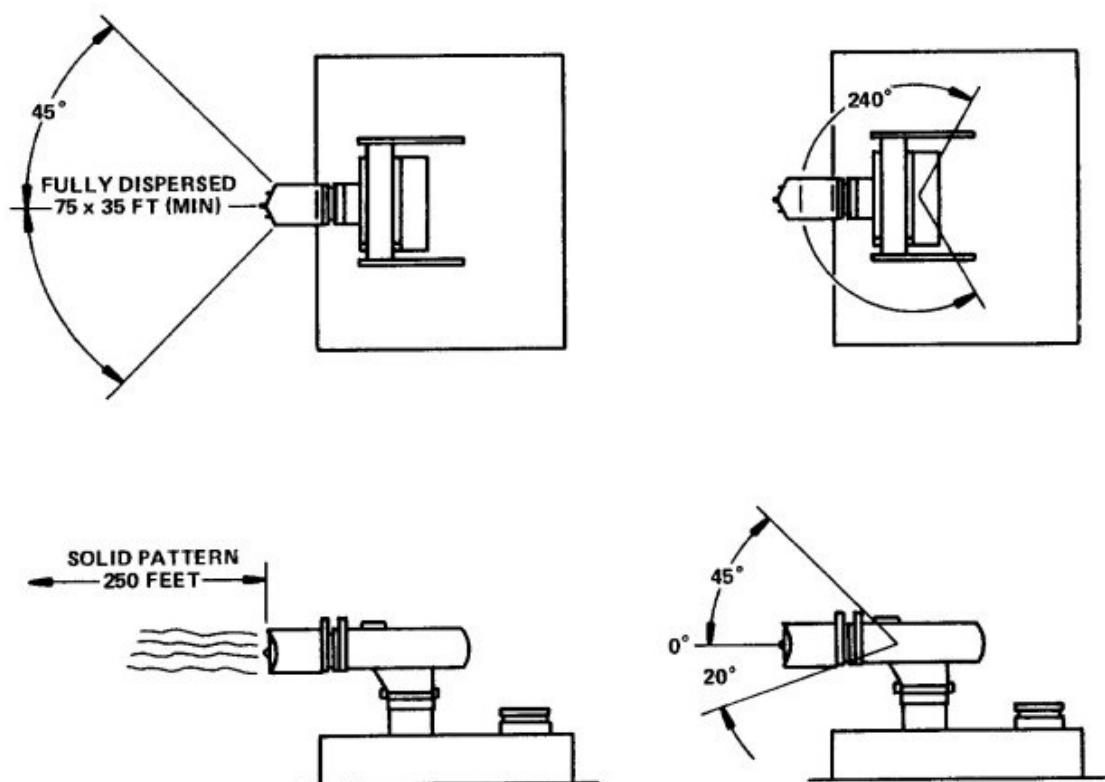


Figure 4-10. Feecon roof turret travel limits.

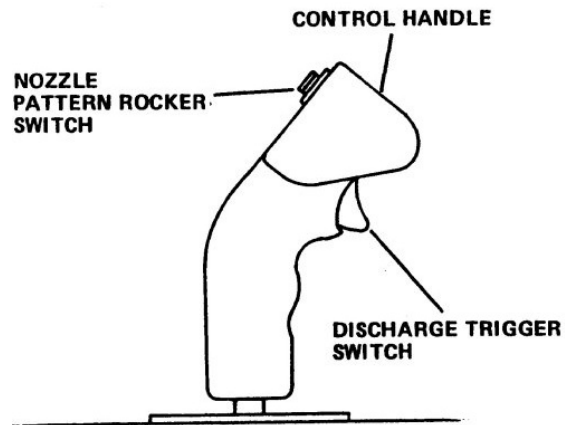


Figure 4-11. Feecon roof turret control handle.

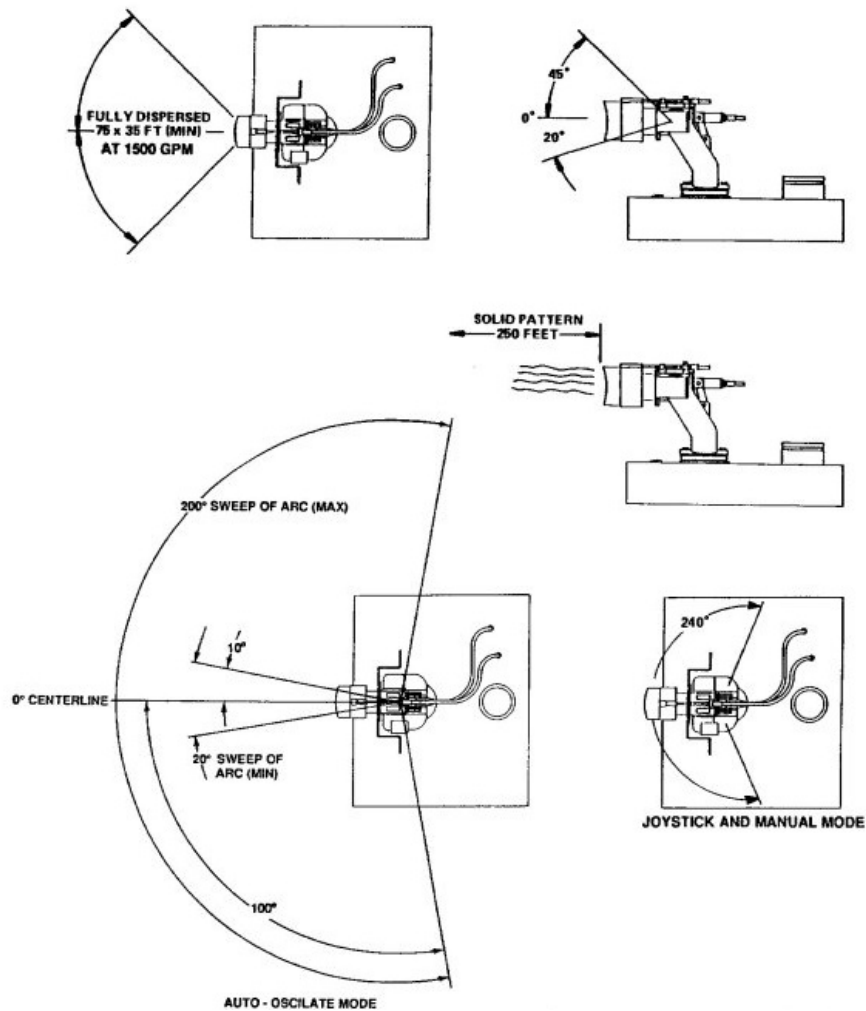


Figure 4-12. Akron Brass roof travel limits.



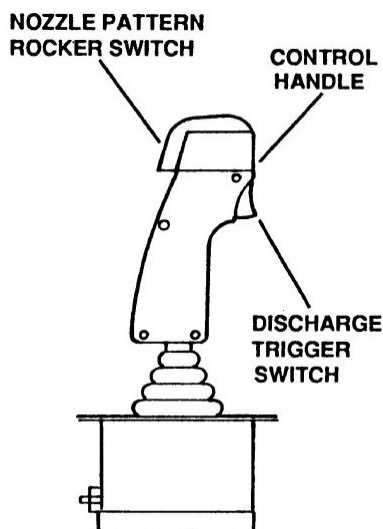


Figure 4-13. Akron Brass roof turret control handle.

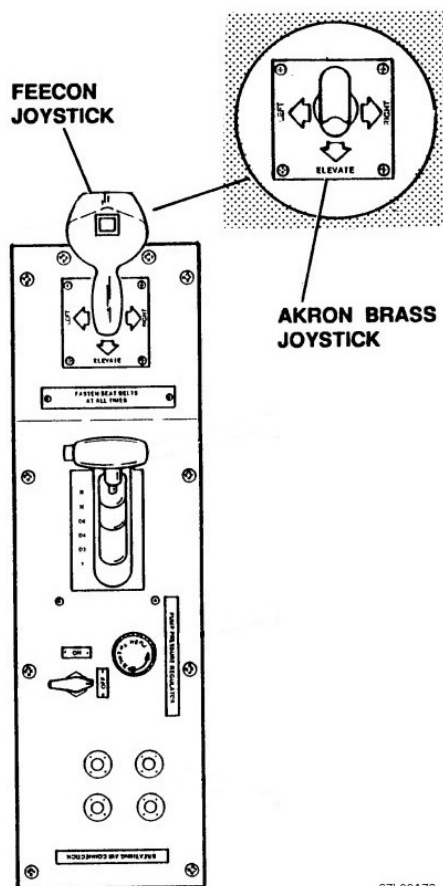


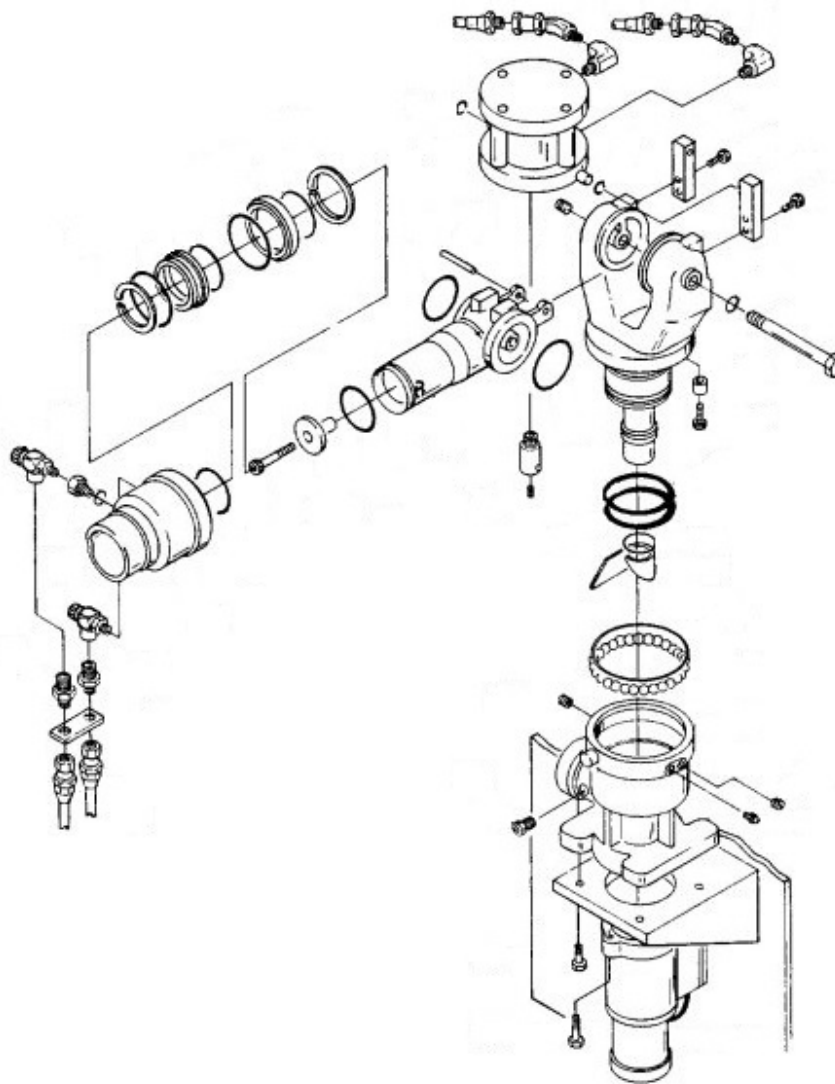
Figure 4-14. Center console.

Both types of roof turrets have three modes of operation—auto-oscillating, electronic joystick, and manual. The center console and the two types of joysticks are shown in figure 4-14. The location of the joystick is between the driver seat and the turret operator. Electronic operation is the same for both turrets. As you saw in figures 4-11 and 4-13, both control handles are a pistol-grip-type with an index finger-operated button to open and close the turret discharge valve. A thumb-operated rocker switch on the joystick provides variable pattern control so you can change from solid stream to disperse or vice versa.

In the event of electrical or air system failure, the turrets can be positioned manually using the mechanical handle stored next to the turret operators seat. The manual controls for pattern control and discharge are located on the roof panel.

### *Bumper turret*

The bumper turret is a single-barrel, nonaspirating, constant flow, variable stream nozzle mounted in the center front face of the cab. Figure 4-15 shows an exploded view of the turret. This turret has a discharge rate of 250 gpm at 200 psi. It has a minimum straight stream capability of 150 feet and a minimum disperse pattern of 75 by 35 feet. The bumper turret may be elevated to achieve these distances.



**Figure 4-15. Bumper turret.**

The bumper turret has two modes of operation—auto-oscillation and joystick. Unlike the roof turret, the bumper turret has no manual operation capability. The joystick controls all turret functions. Figure 4-16 shows an exploded view of the joystick.

Figure 4-17 is a panel view of the joystick. As you would expect, the joystick allows directional movement of the turret. It also allows for pattern selection using a rocker switch mounted on the top of the joystick. Using the button switch, located at the front of the joystick, controls agent discharge. When pressed, the button switch allows the agent to discharge. Releasing the button will stop the agent discharge. (The button switch functions like an interrupt switch.)

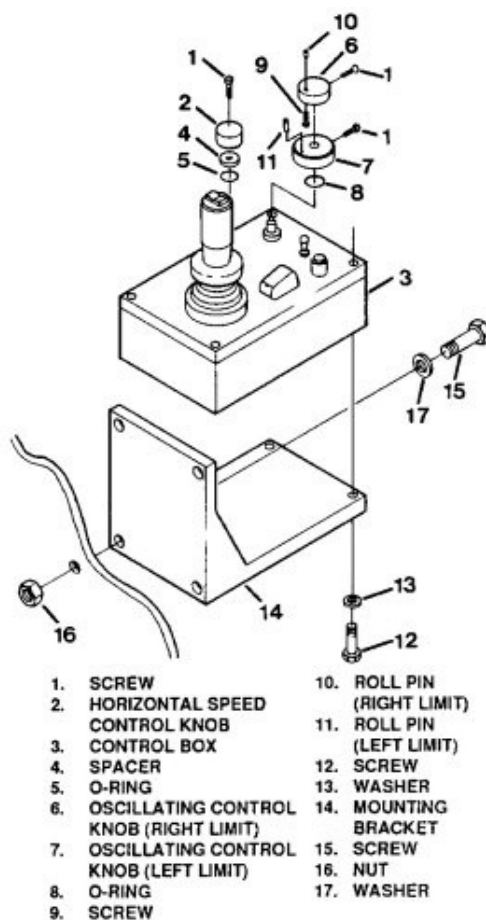


Figure 4-16. Bumper turret controls.

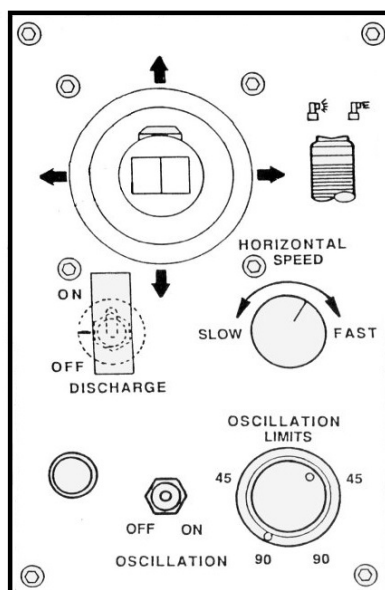


Figure 4-17. Bumper turret control box.

As with the roof turret, the bumper turret has travel limits and specific discharge patterns. Figure 4-18 shows these patterns.

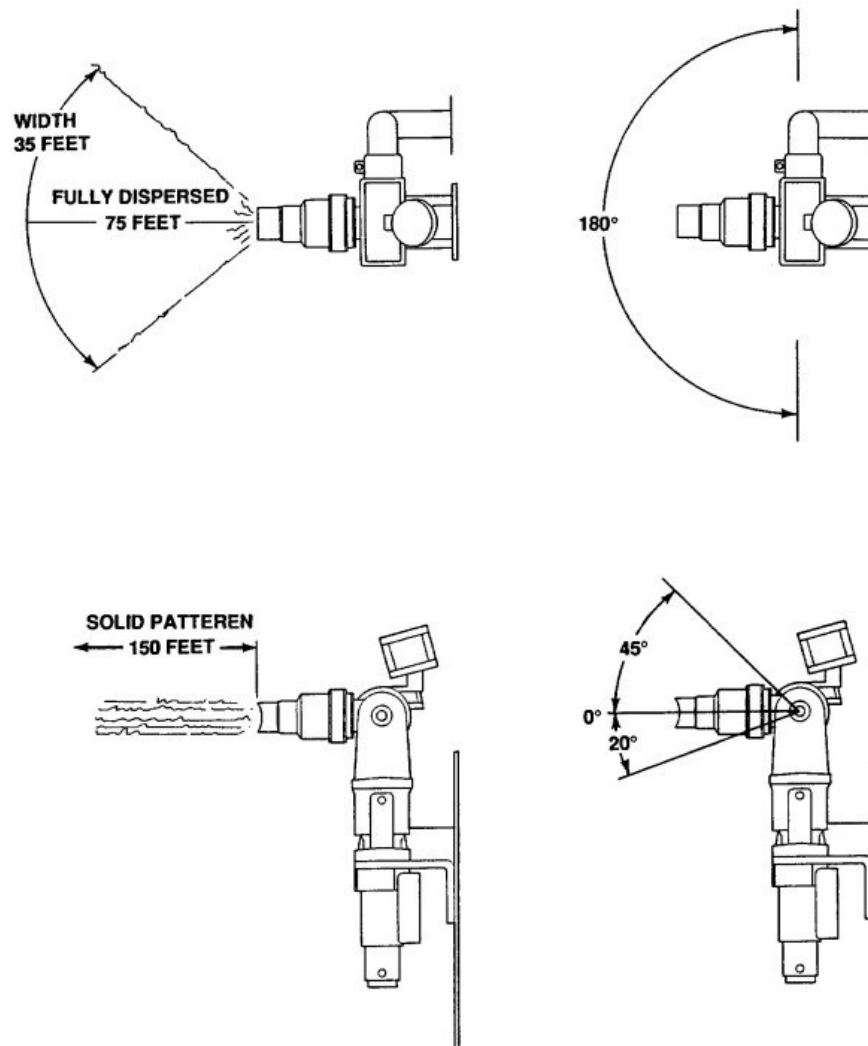


Figure 4-18. Travel limits.

### Forward hose compartment

The forward hose compartment handline (fig. 4-19) is stowed in a slide-out hose tray at the front of the cab. The handline connects to the piping and receives its agent supply from the bumper turret discharge system. Agent is supplied to the handline nozzle when the hose tray is pulled out and either of the two front hose charge switches (on the emergency system control panel in the cab or at the front of the cab) is placed in the ON position. The hose required for the hose tray is 200 feet of 1.75-inch diameter.

This hose is not a basic issue item supplied with the vehicle; instead, the using organization must furnish this hose. When using the forward hose tray, remove all of the hose from the compartment before charging the hose. This requirement is for obvious reasons; imagine 150 feet of collapsed hose suddenly and rapidly filling with agent. The possible injuries the handline operator might sustain and the type of damage that would occur to the vehicle could indeed be disastrous. To prevent accidental discharge, a dual indicator alerts the driver in the event the hose tray is not fully closed, or if the

discharge valve is open prior to pulling out the hose tray. The reason for this is that a lever-actuated interlock switch prevents system operation when the hose tray is closed.

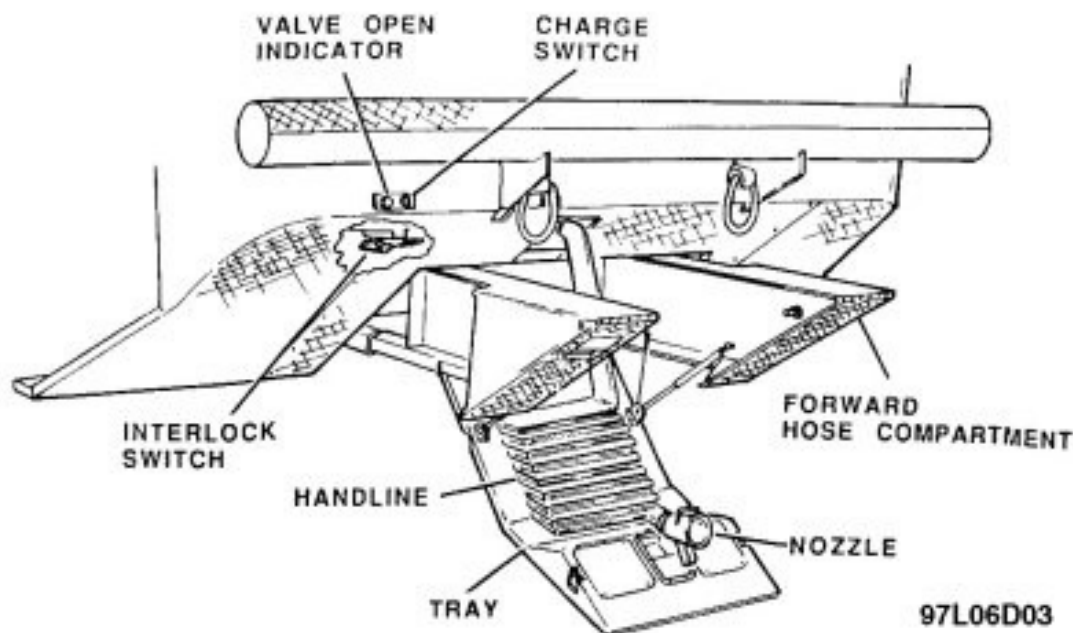


Figure 4-19. Forward hose compartment.

Additional system components include the discharge (ball) valve, air-operated valve actuating cylinder, and a flow switch. The flow switch will prevent the multimetering valve from injecting foam into the system when the volume of water discharged is too low for efficient foam dispersal.

### Foam proportioning system

The P-23 foam proportioning system uses a multimetering manifold. The multimetering manifold uses six ports (or orifices) to induct foam into the system. The output port used depends on which discharges are in operation. The following is a list of possible discharges:

1. One for the bumper turret.
2. One for the handline.
3. Two for the roof turret (one high discharge, one low discharge rate).
4. Two for the side discharge (one for each side).

As more discharges open in the foam mode, more foam is introduced into the system to maintain the correct percentage of foam for fire-fighting operations.

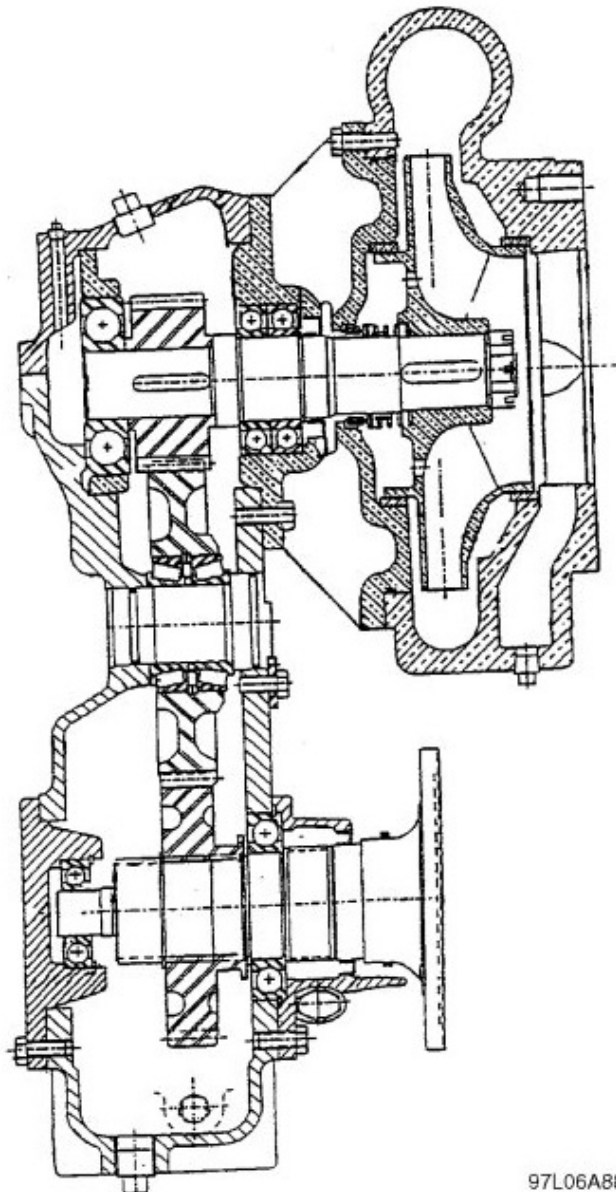
The foam proportioning system is called “around the pump.” In this type of system, foam passes from the foam tank through the multimetering valve (manifold), and is introduced into the system at a single eductor located in the water bypass loop. Water then suction draws foam into the system, then through the water pump to the discharge outlets. This type of system will accurately discharge metered foam through fixed orifices at a rate of no less than 2.8 percent and no more than 3.5 percent. You can convert the system to discharge 3 or 6 percent foam ratios by simply changing the internal metering plate. The vehicle comes with the 3 percent plate installed and the 6 percent plate is shipped along with the vehicle.

Part of the foam proportioning system is the foam transfer system. This system allows the operator to transfer foam in one of three ways:

1. Fill the foam tank with agent from a bulk source.
2. Transfer foam from the foam tank to a storage tank.
3. From one source to another external source by opening the appropriate valves.

The foam tank fill operation (as well as the transfer operations) can be done from either side of the vehicle. The foam transfer pump, rated at a maximum of 75 gpm, is a gear-type pump.

The agent pump of the P-23 is a Hale® Model 60 FCG, single-stage, centrifugal pump capable of delivering 2,000 gpm at 2,100 rpm. Shown in figure 4-20 is a cutaway view of the pump. The internal workings of the pump are the same as the pump on the P-19 fire truck. If you have a good understanding of that pump, this one is no different.



97L06A88

Figure 4-20. Agent pump.

For Official Use Only

Figures 4-21 and 4-22 are exploded views showing the components of the agent pump. The agent pump has a single impeller (single stage), which draws the water from the water tank; when the agent pump is engaged the pump sends agent out into the piping under pressure. Pressed into the pump head and the volute are wear rings, which provide a labyrinth seal for the impeller. The tolerances are very close (.002 to .010 of an inch), between the wear rings and the impeller, to prevent any aeration of the water, which could cause surges in the dispensing system and abnormal pressure readings. If the wear rings are worn, it is easier and more cost efficient to replace the wear rings than either the pump head, or the volute, or both. To provide a seal, the pump uses a mechanical seal. This type of seal has no leak rate. If there is any agent leaking from the pump around the pump shaft, you must replace the seal (there are no adjustments). Installed into the pump housing is a thermal relief valve, which is set at 320 psi/170 °F. The relief valve protects the system against over pressurization and excess heat generated if the pump is deadheaded (pump engaged not discharging) for any length of time.

**NOTE:** Deadheading the system to adjust the pressure is all right since it takes only a very short time.

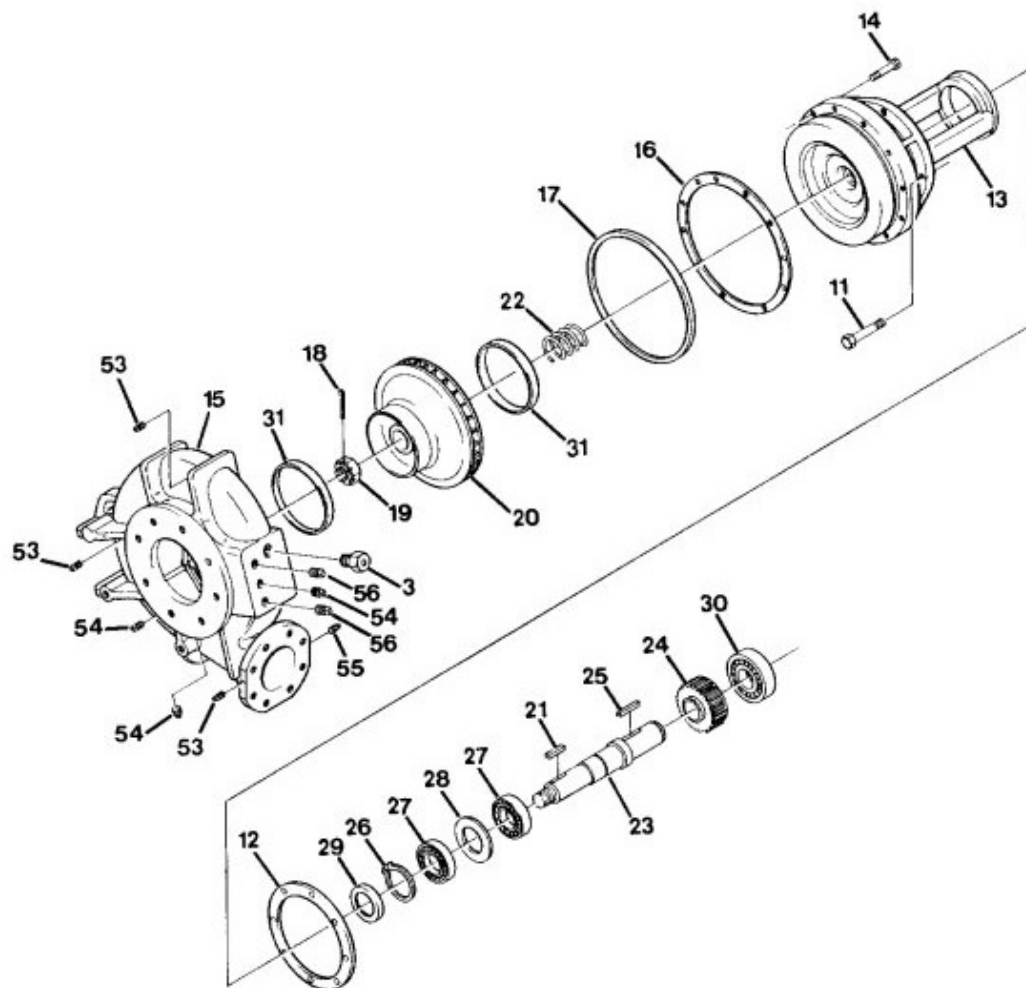


Figure 4-21. Agent pump components.



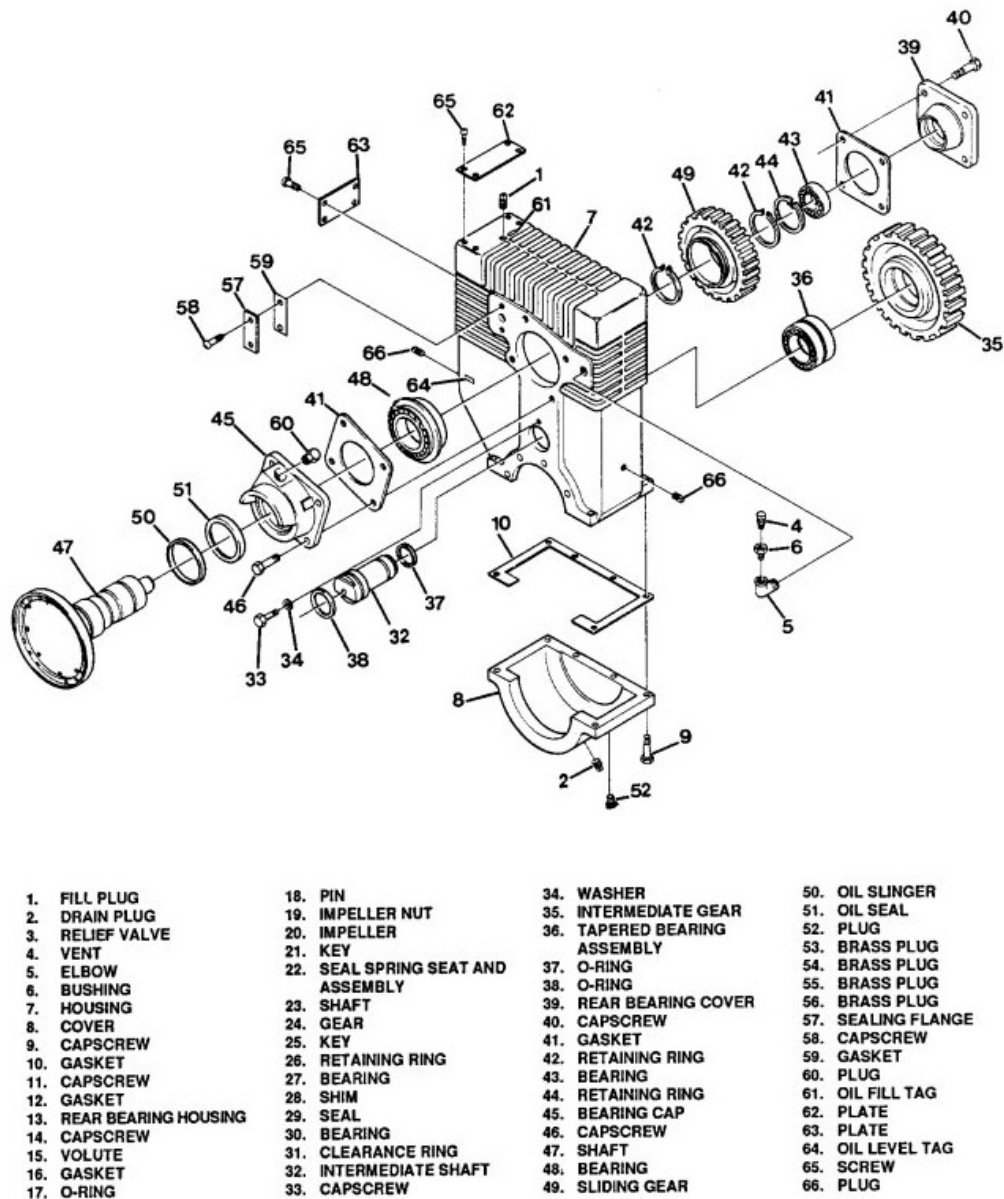


Figure 4-22. Agent pump components (cont'd).

### Dry chemical system

The P-23 has a dry chemical system that is completely separate from the water and foam fire-fighting systems. Shown in figure 4-23 is a drawing of the dry chemical system and its components. The dry chemical system can be used at any time. This system does not require the engine or water pump to be running. The system discharges potassium bicarbonate fire-extinguishing agent. As you can see in figure 4-24, the system consists of the following:

1. A 500-pound-rated steel dry chemical storage tank located in the forward body section of the truck.
2. A 300-cubic foot capacity expellant (nitrogen) cylinder stored in a side compartment.
3. 150 feet of 1-inch hose on a hose reel located in the rear section of the right side hose reel compartment.

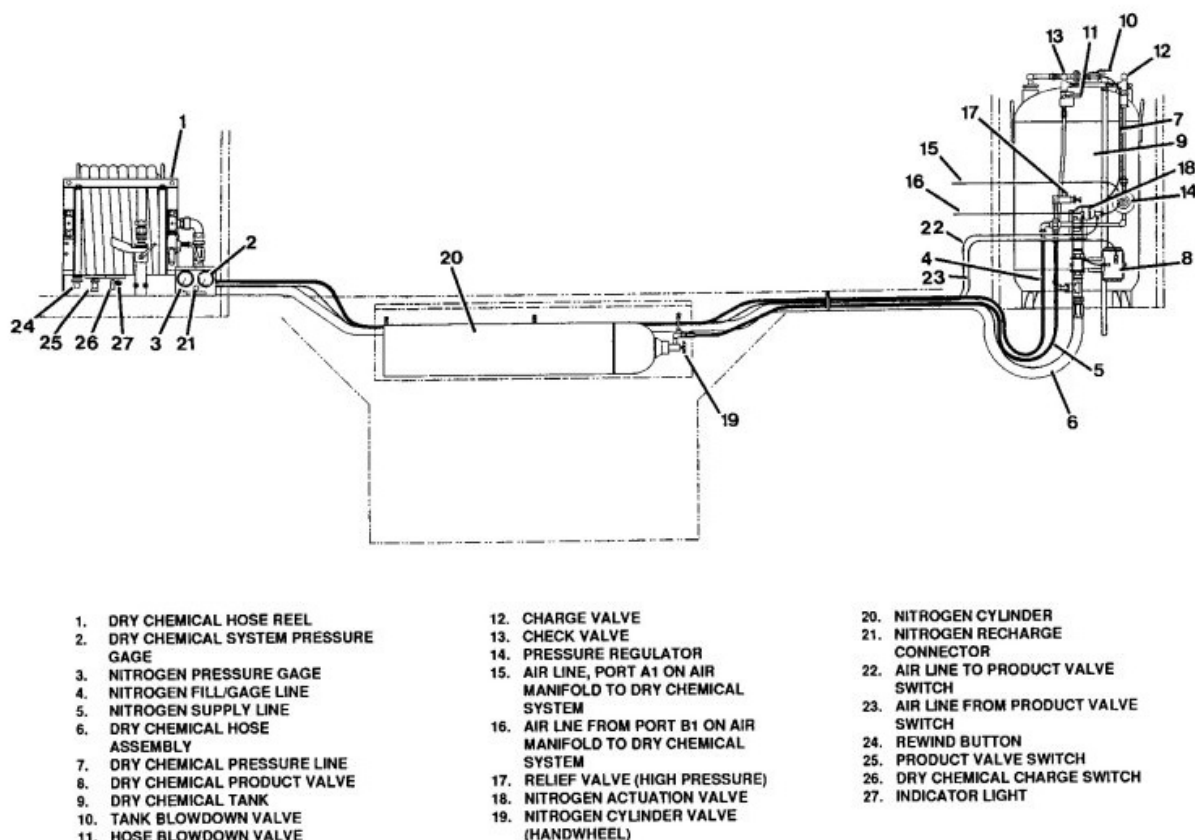


Figure 4-23. Dry chemical system.

Additionally the dry chemical system incorporates a pressure regulator, various control valves and associated plumbing. Any time you perform any type of maintenance on the system use extreme caution, since part of the system has very high pressure. The maximum pressure for the nitrogen tank is 2,400 psi at 70°F. Should the pressure drop below 1,750 psi, the cylinder should be serviced or replaced.

**WARNING:** Dropping a charged cylinder may cause *injury* or *death*. For this reason, any time you remove or install the nitrogen tank, you must install the shipping cap.

To prevent over pressurization, the system uses a high-pressure relief. The relief valve is set at 3,300 psi. A pressure regulator drops the high-pressure nitrogen to a system pressure of 220 to 240 psi. This is the normal operating pressure for the system. The regulator has an internal relief set at 400 psi to prevent damage.

The nitrogen actuation valve controls the nitrogen actuation to the pressure regulator. The actuation valve is a normally closed valve controlled by the nitrogen charge switch on the hose reel or in the cab. Once the pressure regulator reduces nitrogen pressure, nitrogen passes through a check valve, which prevents dry chemical agent from entering the pressure regulator. From the check valve, the nitrogen flows through the normally open charge valve (manually operated) into the dry chemical tank through two tubes. This action fluidizes the dry chemical agent (it is still in a dry chemical state) for use. From the dry chemical tank, flow is down to the air-operated dry-chemical product valve. Once the valve energizes by the activation of the dry chemical switch on the hose reel, the chemical agent enters the dry chemical hose and flows to the dry chemical nozzle, rated at 5.5 to 7 pounds/second.

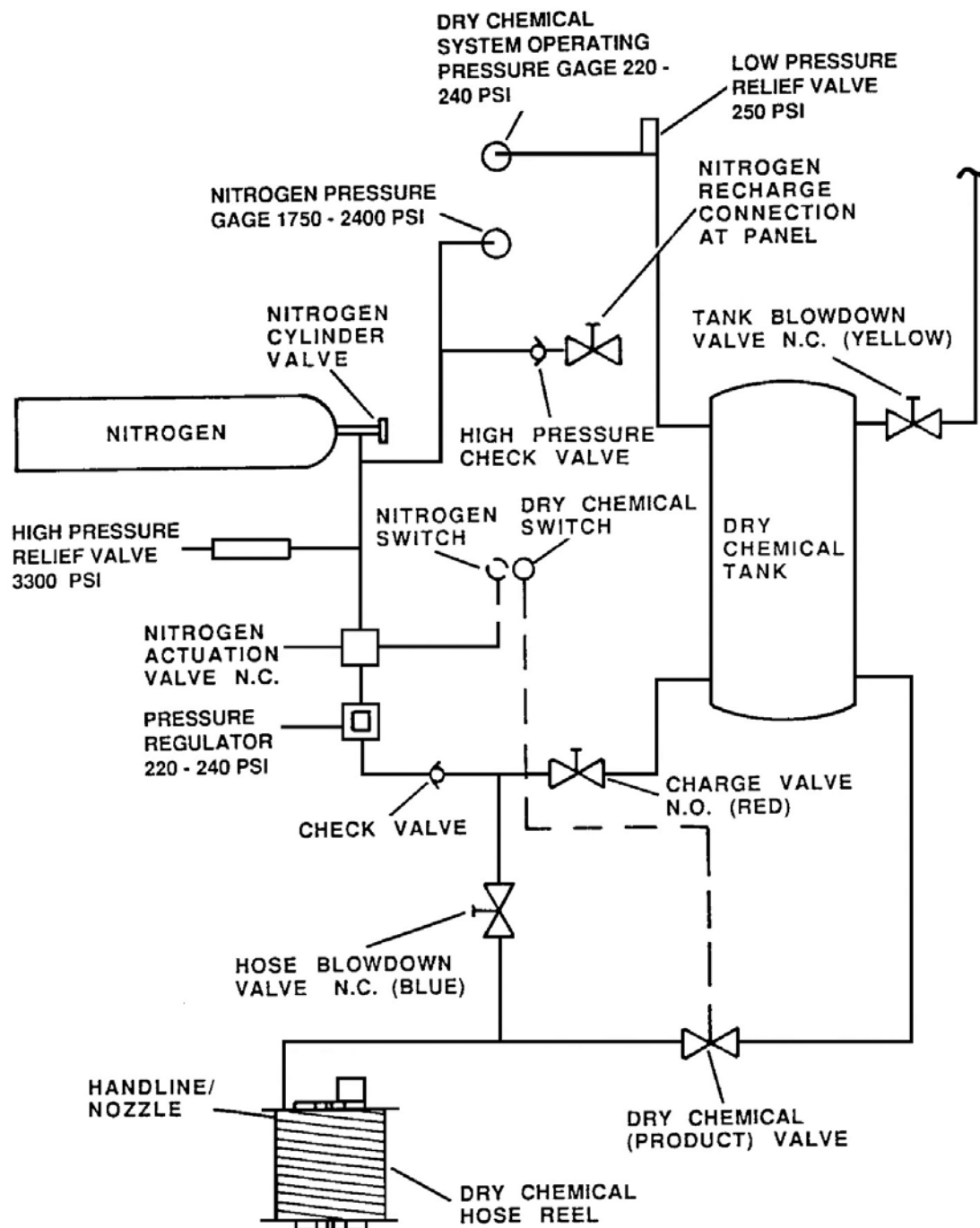


Figure 4-24. Dry chemical system schematic.

## Self-Test Questions

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

### 214. General

1. What type of engine does the P-23 have?
2. What is the capacity of the P-23 fire-fighting tanks?
3. How fast will a fully loaded P-23 accelerate on level pavement?
4. What is the top speed on the P-23?
5. What percent grade can the P-23 climb?

### 215. P-23 transmission

1. What type of transmission does the P-23 have?
2. What does the electronic control unit do?
3. What are the two main modes of transmission operation?
4. What gear ranges will the transmission automatically progress through in the D6 position?
5. What gear does the transmission start when in crash mode?
6. What are the lubrication capacities of the transmission?
7. What type of lubricants does the transmission use under normal and cold weather conditions?

8. How many and what type of pumps circulate oil to lubricate the power divider?

**216. P-23 power divider/torque converter**

1. Where is the power divider/torque converter mounted?
2. What are the two separate drives of the power divider?
3. What pump circulates oil through the power divider/torque converter and transmission?
4. What controls the agent water pump speed?
5. The modulating clutch connects to which housing?
6. What is meant by the term *modulating*?
7. When is the modulating clutch fully engaged?

**217. Electronic control system characteristics**

1. What is the voltage input for the controller?
2. What ensures transmission is in neutral?
3. How is redundant neutral maintained?
4. How many switches are in the range selector?
5. When are all the forward switches open?

6. What is the purpose for the manual override?
7. What must you do to enter manual override?
8. When is the pump mode switch open?
9. Where is the turbine speed sensor located?
10. Where are the transmission speed sensors located?
11. What is the reason for having two transmission output speed sensors?
12. What does the accelerator potentiometer do?
13. What two functions does the display perform?
14. What is the resistance of the 12 VDC solenoids?
15. What will cause a variance in the resistance of the solenoids?
16. What happens if the polarity is reversed on the modulating valve?
17. What damage will be caused by reversing the polarity on the modulating valve?

**218. Air and dispensing systems**

1. What is the capacity of the P-23 foam tank?

2. What is used to drive the agent pump?
3. What is used to meter the foam?
4. What happens when you place the pump switch in the ON position?
5. What is the setting for the pressure switch that takes the vehicle out of pump mode?
6. Where is the pressure transducer located?
7. What is another name for the EPR?
8. Where is the EPR located?
9. What type of roof turret does the P-23 have?
10. What is the discharge pressure of the Akron Brass roof turret?
11. What is the discharge pressure of the Feecon roof turret?
12. What are the modes of operation for the roof turrets?
13. Where is the joystick control for the roof turret located?
14. How can the turrets be positioned in the event of an electrical failure?
15. What is the discharge rate of the bumper turret?



16. What is the minimum straight stream capability of the bumper turret?
17. What is the forward hose compartment piping connected to?
18. How many feet of hose are required for the hose tray?
19. What precaution must you take before charging the forward compartment hose?
20. What is the purpose of the forward hose compartment flow switch?
21. How many ports does the forward hose compartment multimetering manifold have?
22. The P-23 is equipped with what type foam proportioning system?
23. What is the agent flow rate of the foam proportioning system?
24. What type of pump is the foam transfer pump?
25. What is the maximum rate of the foam transfer pump?
26. What type of pump is the agent pump?
27. What are the gpm and rpm ratings of the agent pump?
28. What is the purpose of the agent pump's wear rings?

29. What are the tolerances of the agent pump's wear ring to the impeller?
30. What type of seal does the agent pump have?
31. What are the pressure and temperature settings of the agent pump's thermal relief valve?
32. What is meant by *deadheading* the pump?
33. What agent does the dry chemical system use?
34. What is the capacity of the dry chemical system?
35. What type of expellant does the dry chemical system use?
36. What is the maximum pressure of the nitrogen tank at 70 °F?
37. What is the internal relief valve setting of the pressure regulator of the dry chemical system?
38. What is the rating of the dry chemical nozzle?

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### Answers to Self-Test Questions

#### 214

1. Detroit Diesel 8V92TA diesel engine.
2. 3,300-gallon capacity water tank, 500-gallon foam tank, and 500-pound dry chemical storage tank.
3. 0 to 50 mph in 41 seconds.
4. 72 mph.
5. 50-percent grade.

#### 215

1. Hydraulically-actuated and electrically-controlled power shift unit.

2. Provides automatic shifting and coordinates the functions of the transmission and the power divider/torque converter.
3. Normal and crash mode.
4. Two through six in both up-shift and down-shift operation.
5. In crash mode, the transmission will start in first gear and automatically progress to the gear range selected.
6. 28 quarts of lubricant in the sump with an overall system capacity of 120 quarts.
7. HTO 30-weight under normal conditions and HTO 10-weight under cold conditions.
8. Two gear-type pumps.

**216**

1. On the engine flywheel housing.
2. Agent water pump and main drive to transmission.
3. Modulating clutch oil pump.
4. Speed of the engine.
5. Torque converter rotating housing.
6. Controlled slippage.
7. During normal road mode operation.

**217**

1. 12 VDC.
2. Computer neutral and redundant neutral.
3. An open switch in the selector causes a neutral disconnect which physically removes power from the transmission solenoids 1 to 4 and electric modulating valves 5 and 6.
4. Three switches (D6, D4, and D3).
5. In neutral and reverse.
6. Allows for the vehicle to be operated with limited capability if the electronic control fails to operate.
7. Disconnect the P3 and P4 wiring harness from the electronic control and connect them to the manual override enclosure connectors J3 and J4.
8. When the truck is in road operation.
9. Top of transmission housing.
10. The rear transmission output speed sensor #1 is located on the transmission toward the front of the vehicle and the front transmission output speed sensor #2 is located on the transmission toward the rear of vehicle.
11. In the event of a failure of one of the output speed sensors.
12. Senses the pedal position of the accelerator pedal to enable the control select shift speeds and clutch engagement sequence in road mode. The potentiometer also senses accelerator pedal position for control of the modulating clutch engagement during pump mode operation.
13. Provides gear range and status codes in operational and diagnostic mode.
14. Varies between 8 to 16 ohms.
15. Temperature.
16. The voltage will change, but the pressure will remain at zero.
17. None.

**218**

1. 500 gallons.
2. PTO from the power divider/torque converter.
3. Fixed orifices in multimetering manifold.
4. Completes a ground for the conversion relay from the transmission control module.
5. 20 psi.

6. In the roof turret piping behind the left hand discharge panel.
7. Pizo valve.
8. Inside the shift tower console.
9. Single barrel, nonaspirating, constant flow, variable stream nozzle type.
10. 180 psi.
11. 200 psi.
12. Auto-oscillating, electronic joystick, and manual.
13. On the console between the driver seat and turret operator.
14. The turrets can be positioned manually using the mechanical handle stored next to the turret operator's seat.
15. 250 gpm at 200 psi.
16. 150 feet.
17. Bumper turret piping.
18. 200 feet of 1.75-inch diameter hose.
19. Remove all the hose from the compartment.
20. Prevent the multimetering valve from injecting foam into the system when the volume of water being discharged is too low.
21. Six.
22. Around the pump.
23. 2.8 to 3.5 percent.
24. Gear.
25. 75 gpm.
26. Single-stage, centrifugal.
27. 2,000 gpm at 2,100 rpm.
28. Provide a labyrinth seal.
29. .002 to .010 of an inch.
30. Mechanical.
31. 320 psi/170°F.
32. Pump is engaged, but not dispensing.
33. Potassium bicarbonate.
34. 500 pounds.
35. Nitrogen.
36. 2,400 psi.
37. 400 psi.
38. 5.5 to 7 pounds/second.

**Do the unit review exercises before going to the next unit.**

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## Unit Review Exercises

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

**Do not return your answer sheet to AFCDA.**

43. (214) What kind of engine is on the P-23 fire truck?
- a. Gas.
  - b. Diesel.
  - c. Bio fuel.
  - d. Propane.
44. (215) While stopped, you enter the transmission into crash mode. In this situation, the P-23 fire truck's transmission will *start* in the
- a. D6 gear range.
  - b. first gear range.
  - c. second gear range.
  - d. third gear range.
45. (216) The P-23 fire truck's power divider/torque converter is connected to the agent water pump drive by the
- a. power takeoff.
  - b. snap over center clutch.
  - c. wet-type modulation clutch.
  - d. multidisk, dry-type clutch.
46. (216) Which P-23 fire truck driveline component connects the transmission to the engine flywheel?
- a. Torque converter.
  - b. Modulation clutch.
  - c. Torque converter through the power divider.
  - d. Modulating clutch through the torque converter.
47. (216) The P-23 fire truck power divider modulation clutch is fully engaged and the power take off (PTO) clutch is disengaged during
- a. normal road mode of operation.
  - b. stationary mode of operation.
  - c. structural mode of operation.
  - d. crash mode of operation.
48. (217) Where are the manual override electrical connectors for the P-23 fire truck's transmission control unit located?
- a. On the transmission.
  - b. Inside the transmission shift tower.
  - c. Underneath the left hand side of the dash.
  - d. On the power divider/torque converter.

49. (218) In gallons, what is the capacity of the water tank on the P-23 fire truck's dispensing system?
- a. 1,800.
  - b. 2,400.
  - c. 3,100.
  - d. 3,300.
50. (218) From where does the P-23 fire truck's handline nozzle receive its agent supply?
- a. The bumper turret system.
  - b. The left-hand discharge system.
  - c. The right-hand discharge system.
  - d. The roof turret discharge system.

**Please read the unit menu for unit 5 and continue ➔**

## Unit 5. P-34 Rapid Intervention Vehicle and P-19 Fire-fighting Truck

<b>5-1. Rapid Intervention Vehicle Fundamentals .....</b>	<b>5-1</b>
219. Dispensing system .....	5-1
220. Electrical system.....	5-8
221. Air system.....	5-16
<b>5-2. P-34 Rapid Intervention Vehicle Maintenance .....</b>	<b>5-18</b>
222. Dispensing system troubleshooting .....	5-18
<b>5-3. P-19 Fire-fighting Truck Systems .....</b>	<b>5-20</b>
223. P-19 drivetrain .....	5-21
224. P-19 dispensing system.....	5-24
225. P-19 electrical system .....	5-33
226. P-19 winterization system.....	5-33
227. P-19 air system.....	5-36
<b>5-4. P-19 Fire-fighting Truck Maintenance .....</b>	<b>5-44</b>
228. Troubleshooting the P-19 power divider.....	5-44
229. Troubleshooting the P-19 dispensing system.....	5-47
230. P-19 turret system maintenance .....	5-50

**T**HE P-34 RAPID INTERVENTION VEHICLE (RIV) is capable of being deployed to fire scenes much faster than larger fire trucks, while providing the same or better fire-fighting capabilities. The fire-fighting unit is mounted on a Ford® F-550 Super Duty chassis. It uses ultra-high pressure (UHP), which has been found to increase fire protection effectiveness over conventional methods. UHP dispenses smaller water droplets, dispersing water over a larger area and making more surface contact with less water usage.

As implied by the name aircraft crash and structural fire-fighting truck, the A/S32P-19 (commonly called the P-19) is an extremely important vehicle. Fire-fighters use the P-19 in dire circumstances. As you would expect, the design, manufacture, service, and maintenance of the P-19 requires the utmost care and attention. After all, there is no doubt, an aircraft crash involving fire can be a terrifying experience for those involved and is often a life or death situation. Your job as a specialized vehicle maintenance journeyman carries great responsibility. How well you do your job may well decide the success or failure of fire-fighting operations at your base.

### 5-1. Rapid Intervention Vehicle Fundamentals

The RIV is designed to extinguish fires associated with airfield and flightline operations, such as aircraft, aircraft fuel, and weapon system fires. This section will cover the fundamentals, repair, and adjustment of the dispensing and electrical systems on the Pierce Manufacturing RIV. It will also cover the air system of the Kovatch® RIV.

#### 219. Dispensing system

The main purpose of the RIV lies within the dispensing system. Maintaining the dispensing system to ensure proper function is imperative to successfully supporting flightline operations.



**Water tank**

The water tank has a 400-gallon capacity. It is constructed using a high-impact copolymer, non-corrosive, stress relieved thermoplastic, ultraviolet stabilized for maximum protection. The tank incorporates a manual fill tower with a 4-inch combination vent/overflow pipe. The fill tower is constructed of polypropylene and is large enough to provide filling by means of a conventional 2½-inch hose nozzle. The tower is located near the center of the tank to minimize water surge during vehicle operation. The tower has a removable polypropylene screen and a polypropylene hinged cover. The vent/overflow pipe runs through the tank and exits through the floor of the tank behind the rear axle. The water tank can be filled through either the water tank filler dome at the top of the tank or through a 2½-inch direct tank fill hose connection on the driver side of the vehicle.

**Foam tank**

The foam tank has a 56-gallon capacity. It is constructed of the same non-corrosive material as the water tank. The foam tank fill hose connection and fill valve are located on the driver side of the vehicle inside the lower pump compartment.

**Foam pump**

The foam pump is a hydraulically driven, self-priming, piston-type foam transfer pump. It is capable of drawing foam liquid concentrate at flow rates up to 10 gpm directly through the pump and loading connection.

**Agent pump**

The agent delivery fire pump is capable of delivering 60 to 100 gpm of water/foam solution at pressures between 1100 and 1500 psi at the bumper turret and 15 gpm between 1100 and 1500 psi at the UHP handline nozzles. This pump is equipped with a low-pressure switch in the pump discharge to shut down pump operation in the event of a loss of discharge pressure. The agent pump is capable of providing agent to both the bumper turret and handlines simultaneously. The agent pump is capable of pump and roll operation, independent of vehicle speed, with simultaneous operation of the bumper turret and both handlines.

**Bumper turret**

The agent delivery bumper turret is able to deliver UHP water/foam solution at rates from 1100 to 1500 psi at 60 gpm. The bumper turret is controlled by a speed proportion controlled joystick (both horizontal and vertical motion). The bumper turret is capable of automatic oscillation, with an adjustable range of up to 80 degrees each side of center. It is capable of horizontal movement with a range of up to 90 degrees each side of center. The bumper turret has an up and down range from 75 degrees up and 30 degrees down.

**Handlines**

The P-34 RIV is equipped with two 200-foot, UHP handlines with a minimum rating of 1500 psi. The handlines are equipped with a constant flow 1500 psi rated pistol grip shutoff-type nozzles, capable of both fog and straight stream patterns. The handlines are capable of discharging 1100 to 1500 psi of water/foam solution at 15 gpm. They are capable of reaching a distance of 65 feet. Each handline is stored on a reel, one on each side of the vehicle. They can be wound by an electrical switch at the side of each hose reel, or manually using a crank.

**Structural pump panel**

The structural pump panel (fig. 5-1) provides controls and indicators for various pump and foam system components. It is located on the driver side of the vehicle.

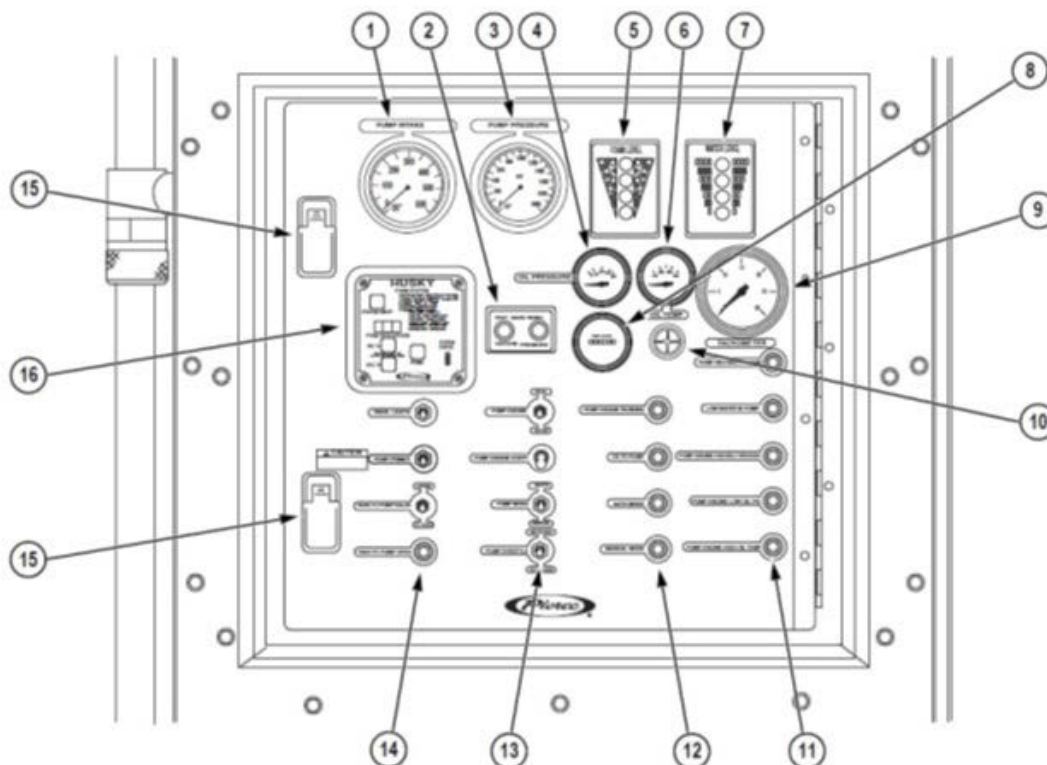


Figure 5-1. Structural pump panel.

**1. PUMP INTAKE GAUGE.** Displays the pressure in psi of the incoming water at the pump intake.

**2. TEST GAUGE PANEL.** Allows gauges to connect to the system to test system vacuum and pressure.

**3. PUMP PRESSURE GAUGE.** Displays the pressure of the pump output in psi.

**4. OIL PRESSURE GAUGE.** Displays the pump drive engine oil pressure in psi while the engine is running.

**5. FOAM LEVEL INDICATOR.** The electronic foam level gauge displays the level of foam concentrate in the onboard storage tank. LED lights indicate the foam concentrate level as follows:

**Full** = Four LEDs on.

**7/8** = Three LEDs on.

**5/8** = Two LEDs on, third LED flashing.

**1/2** = Two LEDs on.

**3/8** = One LED on, second LED flashing.

**1/4** = One LED on.

**1/8** = One LED flashing.

**Empty** = All four LEDs flashing.

**6. OIL TEMPERATURE GAUGE.** Displays the pump drive engine oil temperature while the engine is running.

**7. WATER LEVEL INDICATOR.** The electronic water level gauge displays the water level in the onboard storage tank. LED lights indicate the water level as follows:

**Full** = Four LEDs on.

**7/8** = Three LEDs on.

**5/8** = Two LEDs on, third LED flashing.

**1/2** = Two LEDs on.

**3/8** = One LED on, second LED flashing.

**1/4** = One LED on.

**1/8** = One LED flashing.

**Empty** = All four LEDs flashing.

**8. HOURMETER.** Displays the number of hours the pump has operated.

**9. TACHOMETER.** Displays the engine speed in rpm.

**10. AUDIBLE ALARM.** The alarm sounds whenever a warning condition occurs to alert the operator of a possible dangerous condition.

**11. WARNING LIGHT BANK.** Includes various warning lights

**12. INDICATOR LIGHT BANK.** Includes various status indicator lights.

**13. SWITCH BANK 2.** Includes switches that control various pump functions.

**14. SWITCH BANK 1.** Includes switches that control various pump functions.

**15. ACCESS PANEL LATCHES.** When released, the pump panel can be opened, allowing access to various pump and foam system components.

**16. HUSKY FOAM SYSTEM CONTROL PANEL.** The foam system control panel is the interface with the foam system. The control panel contains the following controls, indicators, and information displays:

**A. SYSTEM ON/OFF BUTTON**—Press to activate or deactivate the foam system.

**B. FOAM PERCENTAGE DISPLAY**—Displays the current percentage of foam concentrate being introduced.

**C. INCREASE BUTTON**—Press to increase the percentage of foam concentrate.

**D. DECREASE BUTTON**—Press to decrease the percentage of foam concentrate.

**E. PRIME BUTTON**—Press to prime the foam system.

**F. SYSTEM STATUS LED DISPLAY**—Displays the status of the foam system using colored LEDs:

**Solid Green**—System on.

**Solid Red**—Valve position error.

**Solid Yellow**—Priming system.

**Flashing Green**—Injecting foam.

**Flashing Red**—Low tank level.

**Flashing Yellow**—Refilling tank.

### Switch banks 1 and 2

Figure 5-2 is a closer image of switch banks 1 and 2, along with a list of their components and functions.

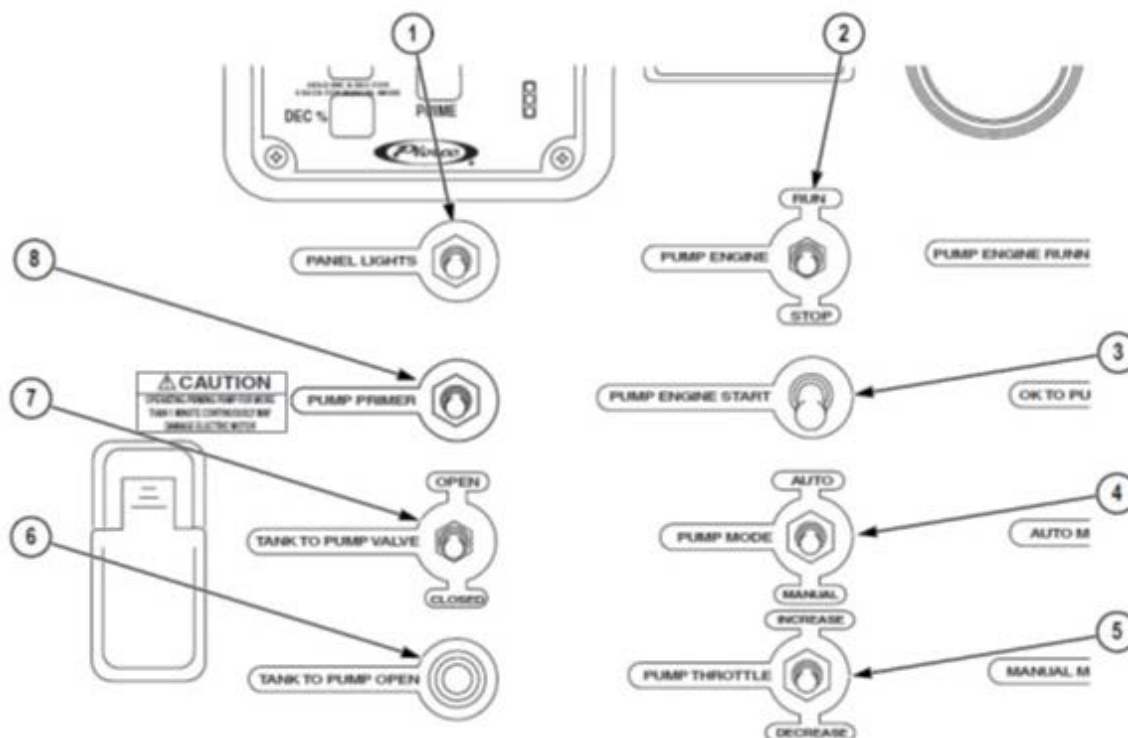


Figure 5-2. Switch banks 1 and 2.

**1. PANEL LIGHTS SWITCH.** The panel lights switch is a two-position toggle switch. Move the toggle up to turn the panel lights to the ON position. Move the toggle down to turn the lights OFF. Release the toggle to allow the switch to return to the home position.

**2. PUMP ENGINE RUN/STOP SWITCH.** The pump engine run/stop switch is a two-position momentary toggle switch. Move the toggle up to place in the run mode. Move the toggle down to place in the stop mode.

**3. PUMP ENGINE START SWITCH.** The start pump engine switch is a two-position, momentary toggle switch. When the conditions for starting the pump engine are met, move the toggle up and hold until the pump engine starts, and then release the switch.

**4. PUMP MANUAL/AUTO MODE SWITCH.** The pump auto/manual mode switch is a two-position momentary toggle switch. Move the toggle up to place the pump in the auto mode. Move the toggle down to place the pump in the manual mode. In either case, a light turns on to indicate the mode selected.

**5. PUMP THROTTLE INCREASE/DECREASE SWITCH.** The pump throttle increase/decrease switch is a three-position momentary toggle switch. Move the toggle up to increase the pump engine speed. Move the toggle down to decrease the pump engine speed. Release the switch to allow the switch to return to the home position.

**6. TANK TO PUMP OPEN INDICATOR LIGHT.** When illuminated, indicates the tank to pump valve is open.

**7. TANK TO PUMP VALVE OPEN/CLOSE SWITCH.** The tank to pump valve switch is a two-position momentary toggle switch. Move the toggle up to open the tank to pump valve. Move the toggle down to close the valve. Release the toggle to allow the switch to return to the home position.

**8. PUMP PRIMER SWITCH.** The pump primer switch is a two-position momentary toggle switch. Move the toggle up to engage the pump primer. Release the toggle to turn the primer OFF.

**CAUTION:** Do not operate the pump primer continuously for more than *one minute*. Doing so may damage the electric motor.

### Indicator and warning light banks

Figure 5-3 is a closer image of the indicator and warning light banks, along with a list of their components and functions.

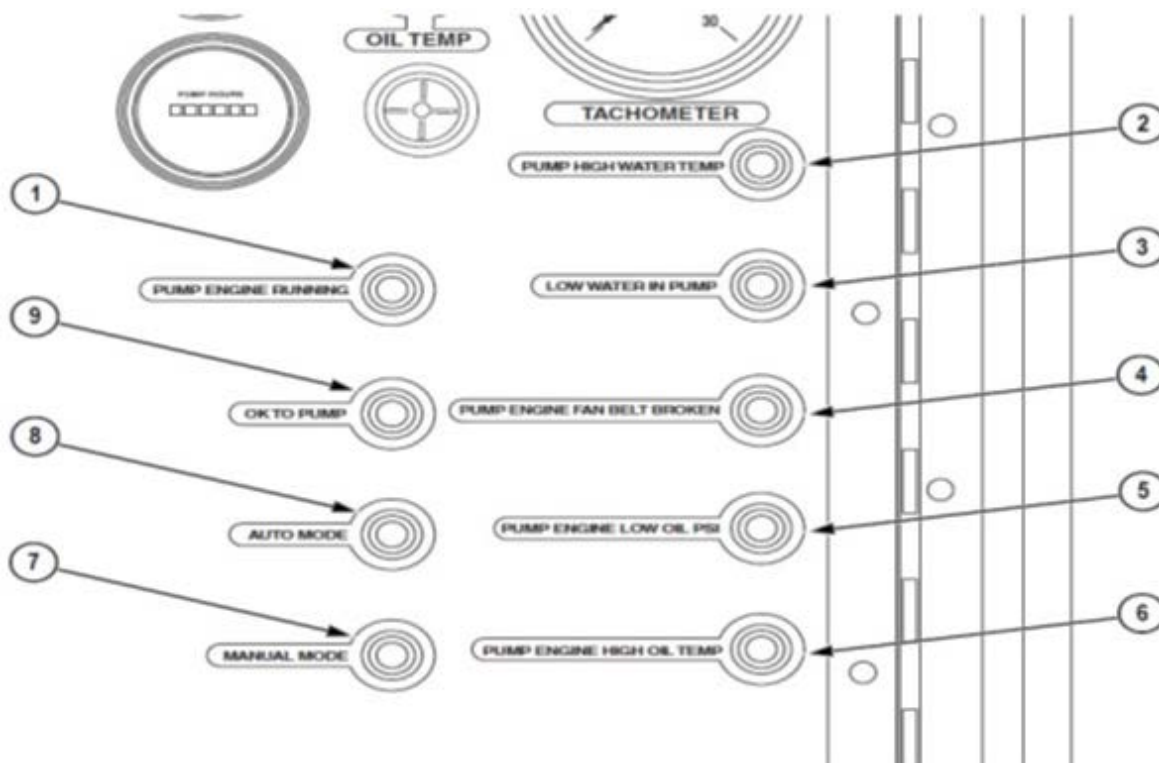


Figure 5-3. Indicator light and warning light banks.

**1. PUMP ENGINE RUNNING INDICATOR LIGHT.** When illuminated, indicates the pump drive engine is operating.

**2. PUMP HIGH WATER TEMPERATURE WARNING LIGHT.** When illuminated, indicates the water temperature within the pump has reached maximum safe operating temperature of 140 °F. When this occurs, the pump overheat valve opens, dumping water on the ground, allowing cooler water to enter the pump. If additional cooling is required, open additional discharges.

**3. LOW WATER IN PUMP WARNING LIGHT.** When illuminated, indicates the water level in pump has dropped below the safe operating level. Pumping operations should be stopped to prevent damage to the pump. The light illuminates (solid) until 100 psi is established. Once the pressure exceeds 100 psi, the light goes out. Upon initial start, the operator has 30 seconds to achieve 100 psi. If the pressure drops below 100 psi during operations, the light begins to flash. If the pressure is not

raised above 100 psi within 15 seconds, the engine automatically shuts down to prevent damage to the pump.

**4. PUMP ENGINE FAN BELT BROKEN WARNING LIGHT.** When illuminated, indicates cooling fan belt is broken. Pumping operations should stop to prevent damage to the pump and engine.

**5. PUMP ENGINE LOW OIL PRESSURE WARNING LIGHT.** When illuminated, indicates the pump engine oil pressure has dropped below the safe operating level. Pumping operations should stop and shut off the engine immediately to prevent engine damage.

**6. PUMP ENGINE HIGH OIL TEMPERATURE WARNING LIGHT.** When illuminated, indicates the pump engine oil temperature is above the safe operating limits. Pumping operations should stop and shut off the engine immediately to prevent engine damage.

**7. MANUAL MODE INDICATOR LIGHT.** When illuminated, indicates Manual mode has been engaged.

**8. AUTO MODE INDICATOR LIGHT.** When illuminated, indicates Auto mode has been engaged.

**9. OK TO PUMP INDICATOR LIGHT.** When illuminated, indicates conditions have been met to allow pump operation.

#### Lower pump compartment

The lower pump compartment (fig. 5-4) is located on the driver side of the vehicle, below the structural pump panel. The following is a breakdown of the components within the lower pump compartment and their functions.

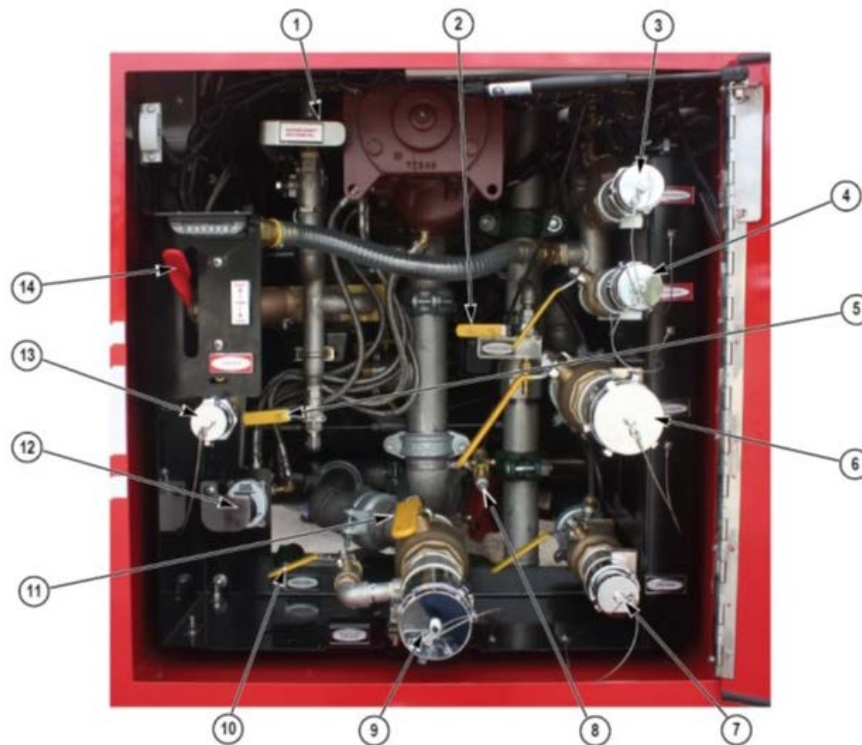


Figure 5-4. Lower pump compartment.

**1. FOAM INJECT/FOAM FILL LEVER.** Pull the lever out to place the foam system in the foam fill mode. Push the lever in to place the foam system in the inject mode.

**2. MANIFOLD DRAIN.** Move the lever 1/4 turn counterclockwise to open the valve and drain water from the manifold or relieve trapped pressure in the manifold.

**3. FOAM TANK FILL INLET.** A 1 1/2 inch inlet allows the foam tank to be refilled from an external source through an external hose at flow rates of up to 7.5 gpm. The fill line incorporates a check valve and an easily removable strainer. The strainer is used to help prevent any debris from entering the foam tank.

**4. FOAM DRAIN OUTLET AND VALVE.** A 1 1/2 inch outlet allows the foam tank to drain into storage containers. A 1/4-turn valve controls the outlet.

**5. FOAM PUMP DISCHARGE DRAIN VALVE.** A 1/4-turn valve allows the foam discharge side of the foam pump to drain and aid when bleeding air from the foam system.

**6. DIRECT TANK FILL INLET AND VALVE.** A 2 1/2 inch inlet allows the water tank to be filled during pumping operations. A 1/4-turn valve controls the inlet.

**7. TANK DRAIN OUTLET AND VALVE.** A 1 1/2 inch outlet allows the water tank to be drained. A 1/4-turn valve controls the tank drain.

**8. AIR BLOW-OUT FITTING AND VALVE.** Allows the connection of a compressed air source to blow water out of the water piping system.

**9. DRIVER'S SIDE AUXILIARY INLET AND VALVE.** A 2 1/2-inch inlet connection to allow connection to a hydrant, or for truck-to-truck transfer. A 1/4-turn valve controls the inlet.

**10. FRONT TURRET VALVE.** A 1/4-turn valve drains turret plumbing.

**11. AUXILIARY INLET DRAIN VALVE.** A 1/4-turn valve allows the auxiliary inlet to drain.

**12. PUMP DRAIN.** Pull to drain the pump after pumping operations are complete. Push to close the pump drain.

**13. FOAM INLET.** A 1-inch inlet connection allows foam concentrate to be drawn from an external source, using a supplied hose.

**14. FOAM TANK/DRAFT SELECTOR LEVER.** Move the lever up to draw foam concentrate from an external source (draft). Move the lever to the lower position to draw foam concentrate from the foam tank.

## **220. Electrical system**

The electrical system is a 12 VDC system powered by two batteries, wired in parallel, located under the hood of the vehicle.

### **Battery switch**

Figure 5-5 shows the layout of the battery switch, battery status indicator, and 110 VAC connection port. These items are located on the front driver side of the vehicle.





Figure 5-5. Battery switch, battery status indicator, and 110 VAC connection port.

**1. BATTERY SWITCH.** The battery switch disconnects electrical power to the rear engine to prevent battery discharge while the vehicle is not in use. Rotate the switch clockwise to provide battery power to the engine, and rotate the knob counterclockwise to disconnect battery power.

**2. BATTERY STATUS INDICATOR.** Displays the battery's level of charge.

**3. 110 VAC, 20 AMP, 1 Ø, 60 HERTZ (Hz), SHORELINE CONNECTION.** Provides 110 VAC, 60 Hz, auto-eject receptacle to provide electrical power to the battery charger/conditioner and engine block heater.

### Cab control console

The cab control console (fig. 5-6) is located between the driver and front passenger seats to provide access from either side of the truck. The following are illustrations of the console and details of each component's function.

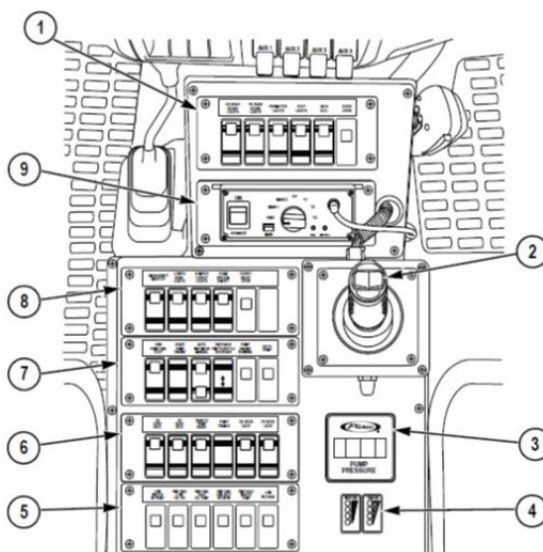


Figure 5-6. Cab control console.

1. **SWITCH BANK.** Houses various lighting controls, high-idle switch, and door open warning light (fig. 5-7).
2. **BUMPER TURRET JOYSTICK.** Controls the operation of the bumper turret functions.
3. **PUMP PRESSURE DISPLAY.** Displays the pump output pressure on a digital display.
4. **LEVEL INDICATOR BANK.** Houses indicators for water and foam tank levels.
5. **WARNING LIGHT BANK.** Houses warning lights that monitor the status of various pump systems (fig. 5-10).
6. **SWITCH BANK 4.** Houses various fire-fighting controls and indicator lights (fig. 5-10).
7. **SWITCH BANK 3.** Houses various fire-fighting controls and indicator lights (fig. 5-9).
8. **SWITCH BANK 2.** Houses various fire-fighting controls and indicator lights (fig. 5-8).
9. **ELECTRONIC SIREN.** Controls the operation of the electronic siren.

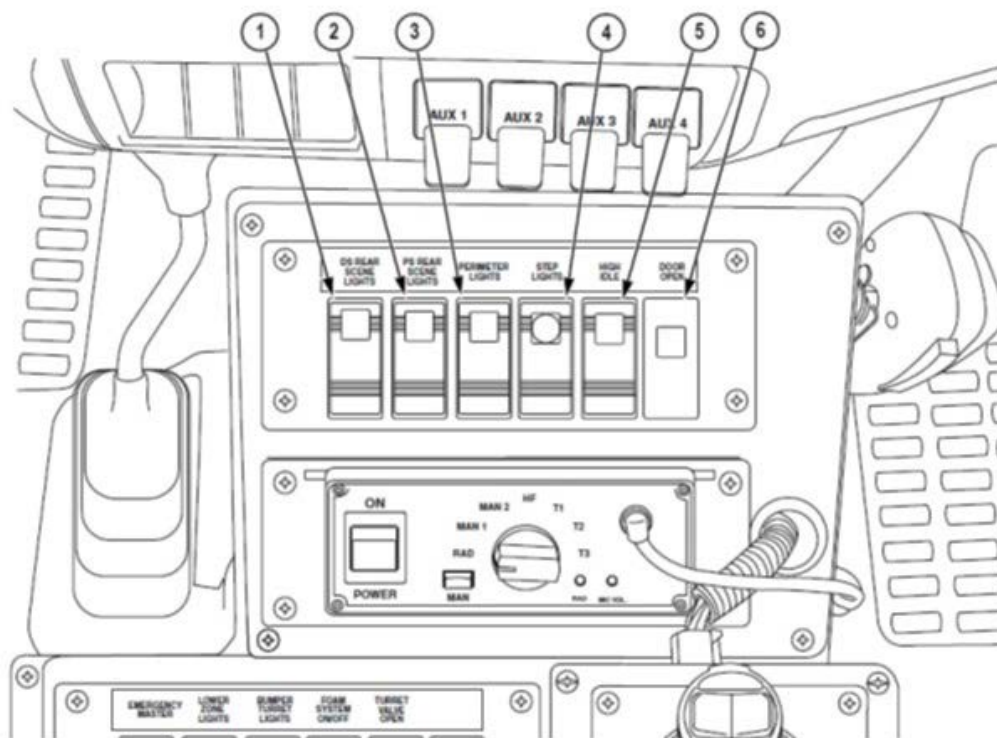


Figure 5-7. Switch bank.

1. **DRIVER'S SIDE SCENE LIGHTS SWITCH (with indicator light).** The driver's side scene lights switch is a two-position rocker switch. Press on the top of the switch to turn on the scene lights; the indicator light will turn on. Press the bottom of the switch to turn off the scene lights.
2. **PASSENGER'S SIDE SCENE LIGHTS SWITCH (with indicator light).** The passenger's side scene lights switch is a two-position rocker switch. Press on the top of the switch to turn on the scene lights; the indicator light will turn on. Press the bottom of the switch to turn off the scene lights.

**3. PERIMETER LIGHTS SWITCH (with indicator light).** The perimeter lights switch is two-position rocker switch. Press on the top of the switch to turn on the perimeter lights; the indicator light will turn on. Press the bottom of the switch to turn off the perimeter lights.

**4. STEP LIGHTS SWITCH (with indicator light).** The step lights switch is a two-position momentary rocker switch. Press on the top of the switch to turn on the step lights; the indicator light will turn on. Press the bottom of the switch to turn off the step lights.

**5. HIGH-IDLE SWITCH (with indicator light).** The high-idle switch is a two-position momentary rocker switch. The first switch position is the default switch position. The second switch position activates and deactivates the high idle function when pressed and released. The high-idle switch can be activated only with the vehicle transmission in neutral and the parking brake engaged.

**6. DOOR OPEN INDICATOR LIGHT.** The warning light illuminates whenever a compartment door is open, when the parking brake is released, or the transmission is in any position other than park.

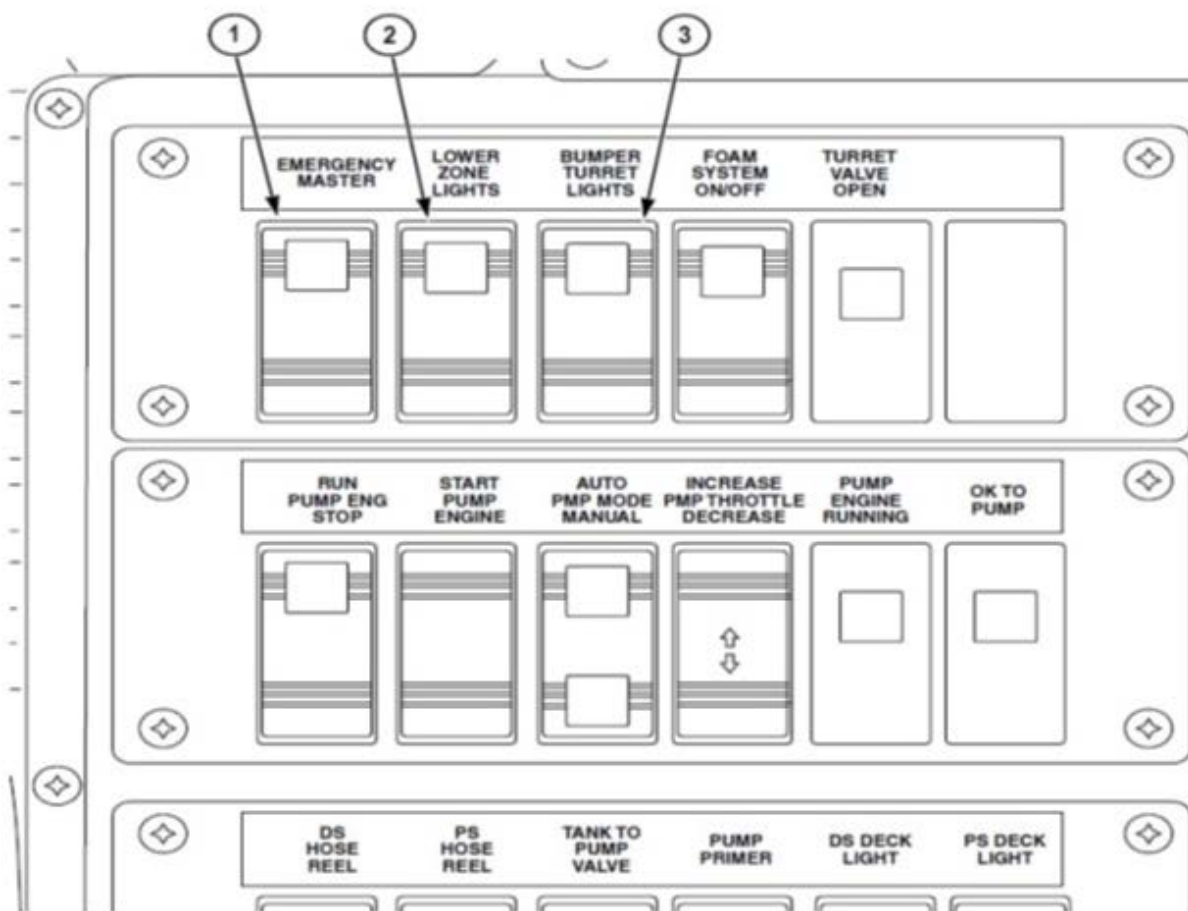


Figure 5-8. Switch bank 2.

**1. EMERGENCY MASTER SWITCH (with indicator light).** The emergency master switch is a two-position rocker switch. Press the top of the switch to allow operation of the warning lights and

sirens; the indicator light will turn on. Press the bottom of the switch to turn off all active warning lights and sirens.

**2. LOWER ZONE LIGHTS SWITCH (with indicator light).** The lower zone lights switch is a two-position rocker switch. Press the top of the switch to turn the lower zone lights on; the indicator light will turn on. Press the bottom of the switch to turn off the lights.

**3. BUMPER TURRET LIGHTS SWITCH (with indicator light).** The bumper turret lights switch is a two-position rocker switch. Press the top of the switch to turn the bumper turret lights on; the indicator light will turn on. Press the bottom of the switch to turn off the bumper turret lights.

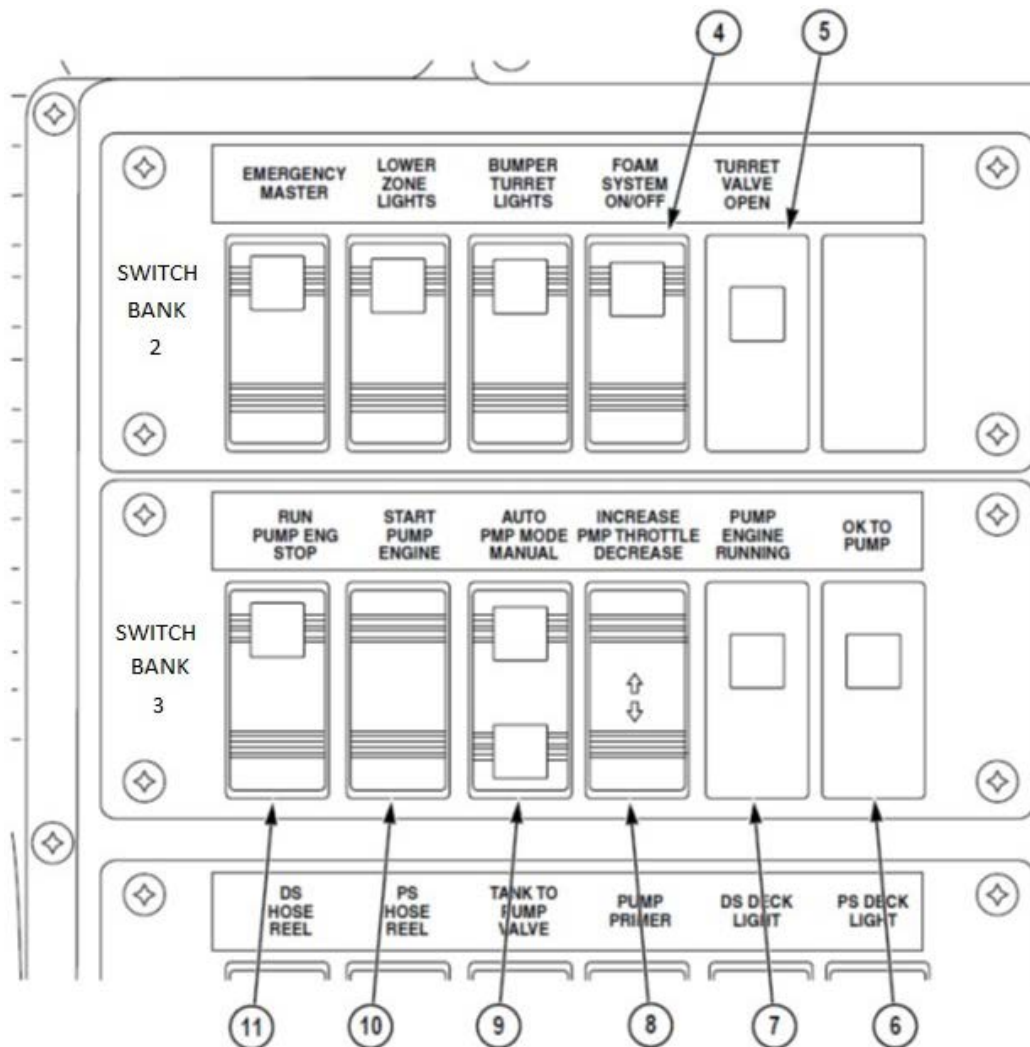


Figure 5-9. Switch banks 2 and 3.

**4. FOAM SYSTEM ON/OFF SWITCH (with indicator light).** The foam system on/off switch is a two-position momentary rocker switch. Press the top of the switch to turn the foam system on; the indicator light will turn on. Press the bottom of the switch to turn off the foam system.

**5. TURRET VALVE OPEN INDICATOR LIGHT.** When illuminated, indicates that the turret valve is open.

**6. OK TO PUMP INDICATOR LIGHT.** When illuminated, indicates that conditions have been met to allow the pump to be started.

**7. PUMP ENGINE RUNNING INDICATOR LIGHT.** When illuminated, indicates that the pump drive engine is running.

**8. PUMP THROTTLE INCREASE/DECREASE SWITCH.** The pump throttle increase/decrease switch is a two-position momentary rocker switch. Press the top of the switch to increase the pump engine speed. Press the bottom of the switch to decrease the pump engine speed.

**9. PUMP MODE AUTO/MANUAL SWITCH (with indicator lights).** The pump auto/manual mode switch is a two-position momentary rocker switch. Press the top of the switch to place the pump in the Auto mode (crash); the Auto mode indicator light will turn on. Press the bottom of the switch to place the pump in the Manual mode; the Manual mode indicator light will turn on.

**10. START PUMP ENGINE SWITCH.** The start pump engine switch is a two-position, momentary rocker switch. With the conditions for starting the pump engine met, press and hold the top of the switch until the pump engine starts, and then release the switch.

**11. PUMP ENGINE RUN/STOP SWITCH (with indicator light).** The pump engine run/stop switch is a two-position rocker switch. Press the top of the switch to enable the pump engine; the indicator light will turn on. Press the bottom of the switch to shut off the pump engine.

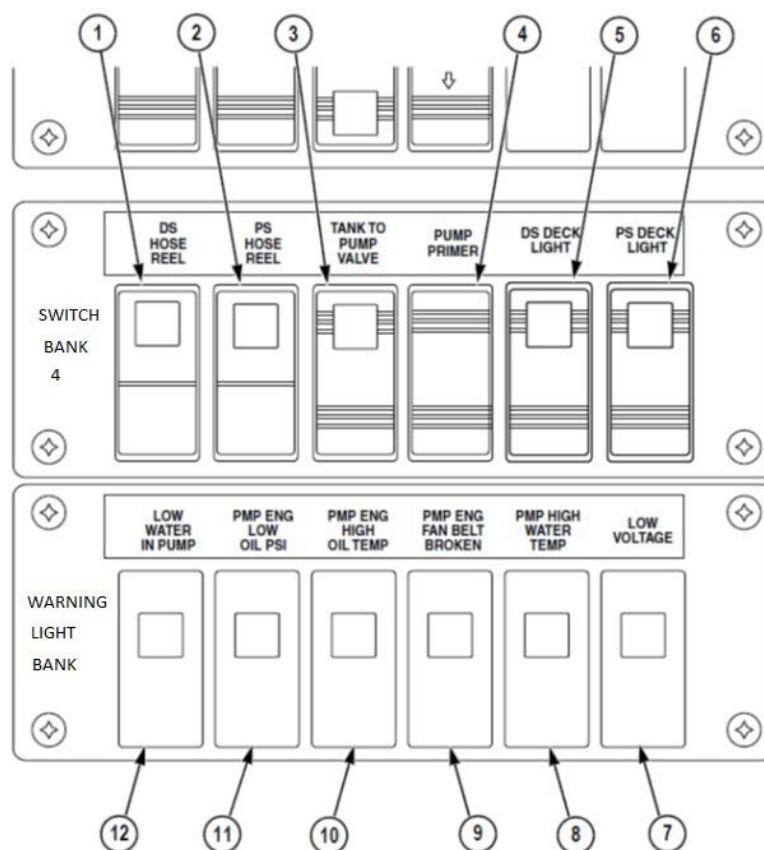


Figure 5-10. Switch bank 4 and warning light bank.

**1. DRIVER'S SIDE HOSE REEL SWITCH (with indicator light).** The driver's side hose reel switch is a two-position rocker switch. Press the top of the switch to enable fire-fighting agent to flow

to the hose reel; the indicator light will turn on. Press the bottom of the switch to shut off the hose reel.

**2. PASSENGER'S SIDE HOSE REEL SWITCH (with indicator light).** The passenger's side hose reel switch is a two-position rocker switch. Press the top of the switch to enable fire-fighting agent to flow to the hose reel; the indicator light will turn on. Press the bottom of the switch to shut off the hose reel.

**3. TANK TO PUMP VALVE SWITCH (with indicator light).** The tank to pump valve switch is a two-position momentary rocker switch. Press the top of the switch to open the tank to pump valve; the indicator light will turn on. Press the bottom of the switch to close the valve.

**4. PUMP PRIMER.** The pump primer switch is a momentary rocker switch. Press and hold the top of the switch to prime the pump. Release the switch to stop.

**5. DRIVER'S SIDE DECK LIGHT SWITCH (with indicator light).** The driver's side deck light switch is a two-position rocker switch. Press the top of the switch to turn the driver's side deck light on; the indicator light will turn on. Press the bottom of the switch to turn off the light.

**6. PASSENGER'S SIDE DECK LIGHT SWITCH (with indicator light).** The passenger's side deck light switch is a two-position rocker switch. Press the top of the switch to turn the passenger's side deck light on; the indicator light will turn on. Press the bottom of the switch to turn off the light.

**7. LOW VOLTAGE WARNING LIGHT.** When illuminated, indicated the chassis voltage has dropped below the operating voltage.

**8. PUMP HIGH WATER TEMPERATURE WARNING LIGHT.** When illuminated, indicates the water temperature within the pump has reached that maximum safe operating temperature of 140°F. When this occurs, the pump overheat valve opens, dumping water on the ground, allowing cooler water to enter the pump. If additional cooling is required, open additional discharges.

**9. PUMP ENGINE FAN BELT BROKEN WARNING LIGHT.** When illuminated, indicates the cooling fan belt has broken. Pumping operations should be stopped and the engine shut off to prevent damage to the pump engine.

**10. PUMP ENGINE HIGH OIL TEMPERATURE WARNING LIGHT.** When illuminated, indicates the pump engine oil temperature is above the safe operating limits. If practical, remove load on pump engine and reduce engine speed to idle with the engine fan operating. This may help alleviate the overheat condition.

**11. PUMP ENGINE LOW OIL PRESSURE WARNING LIGHT.** When illuminated, indicates the pump engine oil pressure has dropped below the safe operating level. Pumping operations should be stopped and the engine shut off immediately to prevent engine damage.

**12. LOW WATER IN PUMP WARNING LIGHT.** When illuminated, indicates the water level in the pump has dropped below the safe operating level. Pumping operations should be stopped immediately to prevent pump damage. The light will illuminate (solid) until 100 psi is established. Once the pressure exceeds 100 psi, the light will go out. Upon initial start, the operator has 30 seconds to achieve 100 psi. If the pressure drops below 100 psi during operations, the light will begin to flash. If the pressure is not raised above 100 psi in 15 seconds, the engine will automatically shut down to prevent damage to the pump.



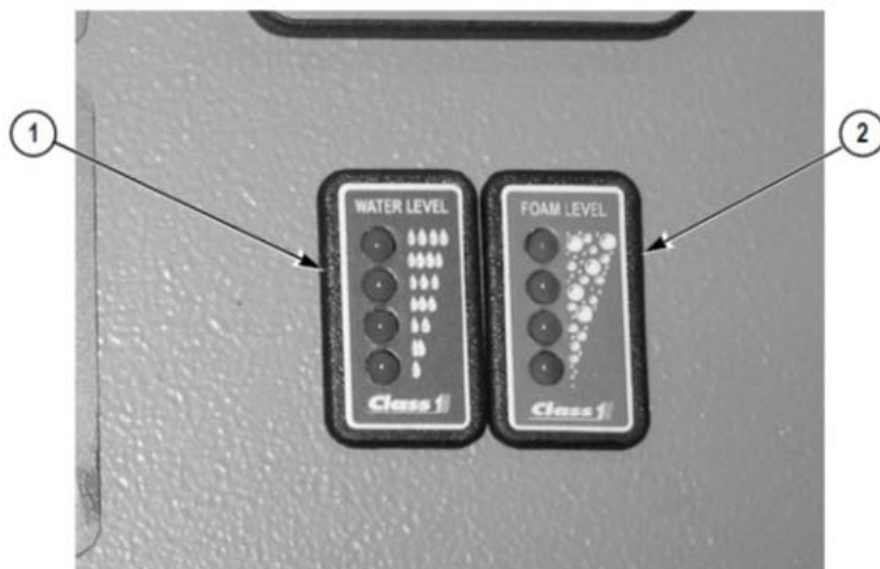


Figure 5-11. Water and foam level indicators.

**1. WATER LEVEL INDICATOR.** The electronic water level indicator (fig. 5-11) displays the water level in the onboard storage tank. LED lights indicate the water level as follows:

**Full** = Four LEDs on.

**7/8** = Three LEDs on.

**5/8** = Two LEDs on, third LED flashing.

**1/2** = Two LEDs on.

**3/8** = One LED on, second LED flashing.

**1/4** = One LED on.

**1/8** = One LED flashing.

**Empty** = All four LEDs flashing.

**2. FOAM LEVEL INDICATOR.** The electronic foam level indicator displays the level of foam concentrate in the onboard storage tank. LED lights indicate the foam concentrate level as follows:

**Full** = Four LEDs on.

**7/8** = Three LEDs on.

**5/8** = Two LEDs on, third LED flashing.

**1/2** = Two LEDs on.

**3/8** = One LED on, second LED flashing.

**1/4** = One LED on.

**1/8** = One LED flashing.

**Empty** = All four LEDs flashing.



### DO NOT MOVE APPARATUS light

Mounted on the interior roof of the cab between the driver and front passenger seats, this flashing red indicator light, accompanied by a tone alarm, is activated whenever the parking brake is released *and* any device is opened or deployed which would create a hazard or would be likely to cause damage if the apparatus is moved. Operators must be aware of this light in order to avoid damage to components.

### 221. Air system

The Kovatch RIV dispensing air system is simple and consists of an electric air compressor and an air tank. The air is used to operate the valves that control water flow to the driver side hose reel, the passenger side hose reel, and the bumper turret. The system is regulated to 120 psi.

#### Other air system components

Attached to the bottom of the air tank is an air drain valve, which must be drained after every use of the system to remove air, moisture, and debris from the system.

The air system has a filter located under the air tank to remove contaminants from the system. Filter change frequency depends on operation frequency and field conditions. If it used in a dusty environment, it is recommended the filter be replaced at least once a month.

The air compressor is equipped with an automatic reset thermal protector, and can automatically restart after the thermal protector resets. *Always* cut off the power source when the thermal protector activates.

#### Air system troubleshooting

Below is a list of malfunctions, possible causes, and suggested remedies for repairing the Kovatch air system:

MALFUNCTION	POSSIBLE CAUSE	SUGGESTED REMEDY
Tank pressure drops when compressor is off.	1. Opened drain valve. 2. Leaking check valve. 3. Loose connections.	1. Tighten valve. 2. Replace check valve. 3. Tighten and check connections with soapy water.
Compressor runs continuously and airflow lower than normal.	Clogged filter element.	Replace air filter element.
Excessive moisture in discharge.	Water in air tank.	Drain air tank, change air filter if needed.
Compressor will not run.	1. Blown fuse. 2. Motor overheated. 3. Faulty pressure switch.	1. Disconnect compressor from power source, replace fuse (refer to manual). 2. Allow compressor to cool for 30 minutes to allow thermal overload switch to reset. 3. Replace pressure switch.
Thermal overload protector cuts out repeatedly.	1. Lack of proper ventilation or ambient temperature is too high. 2. Compressor valves failed.	1. Move compressor to a well-ventilated area with lower ambient temperature. 2. Repair or replace compressor.

## Self-Test Questions

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

### 219. Dispensing system

1. What is the capacity of the water tank?
2. What type of pump is the foam transfer pump?
3. How much UHP water/foam solution is the agent delivery bumper turret capable of delivering?
4. When all four LEDs are flashing on the foam level indicator, what is indicated?
5. How long should you limit continuous operation of the pump primer in order to prevent damage to the electric motor?
6. What is the maximum safe operating temperature for the water system?
7. Where is the lower pump compartment located?

### 220. Electrical system

1. The 110 VAC shoreline connection provides electrical power for what?
2. What conditions must be met before the high idle switch can be activated?
3. What would cause the DO NOT MOVE APPARATUS light in the cab to illuminate?

### 221. Air system

1. What are the components of the RIV air system?

2. If used in a dusty environment, how often should the RIV air system filter be replaced?
3. What should you *always* do when the air compressor thermal protector becomes activated?
4. If the compressor will not turn due to an overheated motor, what action should you take?

## **5-2. P-34 Rapid Intervention Vehicle Maintenance**

Now that you are familiar with the RIV's functions and capabilities, let's take a look at some common troubleshooting steps for the dispensing system. Keep in mind that these steps highlight only a few malfunctions that may occur, but they can give you good reference points to build upon.

### **222. Dispensing system troubleshooting**

In the following table is a list of malfunctions, possible causes, and suggested remedies for repairing the dispensing system; use this table to help troubleshoot problems.

Use this following table to help troubleshoot problems:

MALFUNCTION	POSSIBLE CAUSE	SUGGESTED REMEDY
Pump fails or loses prime.	1. Air leaks in system. 2. Obstructions in intake strainer.	1. Ensure connections are tight, repair or replace defective parts. 2. Remove dirt and foreign matter from intake strainer.
Insufficient water flow at full throttle.	1. Insufficient engine power. 2. Discharge relief valve not at correct setting. 3. Damaged or worn pump.	1. Complete necessary engine repairs. 2. Adjust relief valve in accordance with proper manual. 3. Repair or replace pump.
System pressure not relieved properly.	1. Sticky pilot valve. 2. Plugged tube lines.	1. Disassemble and clean. Replace noticeably worn parts. 2. Disconnect lines and inspect.
Delay in system pressure relief.	Plugged line or filter.	Clean lines and filter.

It is important to keep in mind that the water pump seal packing is designed to drip slightly during operation. This is to cool and lubricate the packing. It is desirable to adjust the packing housing to maintain a leakage rate of 10 to 120 drops per minute when operating at a discharge pressure of 150 psi. Pump packing adjustment procedures are as follows:

1. Engage pump per appropriate operating instructions. Operate the pump at the capacity shown on the serial plate for 10 minutes. Operate the pump in VOLUME position.
2. Observe leakage. Normal leakage is 10 – 120 drops per minute.
3. If drip rate is considered high, disengage per instructions, stop the engine, and tighten the packing gland nuts no more than 1/6 turn at a time to avoid over-tightening. Tighten gland nuts equally to ensure adjustment occurs evenly.

## Self-Test Questions

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

### 222. Dispensing system troubleshooting

1. List three possible causes for insufficient water flow at full throttle.
2. Why is the water pump seal packing designed to drip?
3. When performing a pump packing adjustment, how long must the pump operate prior to observing leakage?

### 5-3. P-19 Fire-fighting Truck Systems

This section covers the P-19 fire-fighting truck systems. You must understand the fundamental systems of the P-19 before you can effectively maintain the truck. The fundamental P-19 truck systems and maintenance covered in this lesson include the drivetrain, dispensing system, electrical system, winterization system, and air system. The first lesson you will cover is the P-19 drivetrain.

This unit references the P-19, P-19A, and P-19B model fire trucks. Although the trucks are similar, there are slight differences. For example, the basic P-19 is for use on aircraft crashes or fires only. The P-19A is a United States Marine Corps (USMC) variant, which has both aircraft and structure fire-fighting capabilities. The P-19B is a USAF truck variant used for aircraft crash and structure fires. Figure 5-12 shows the P-19A and P-19B.

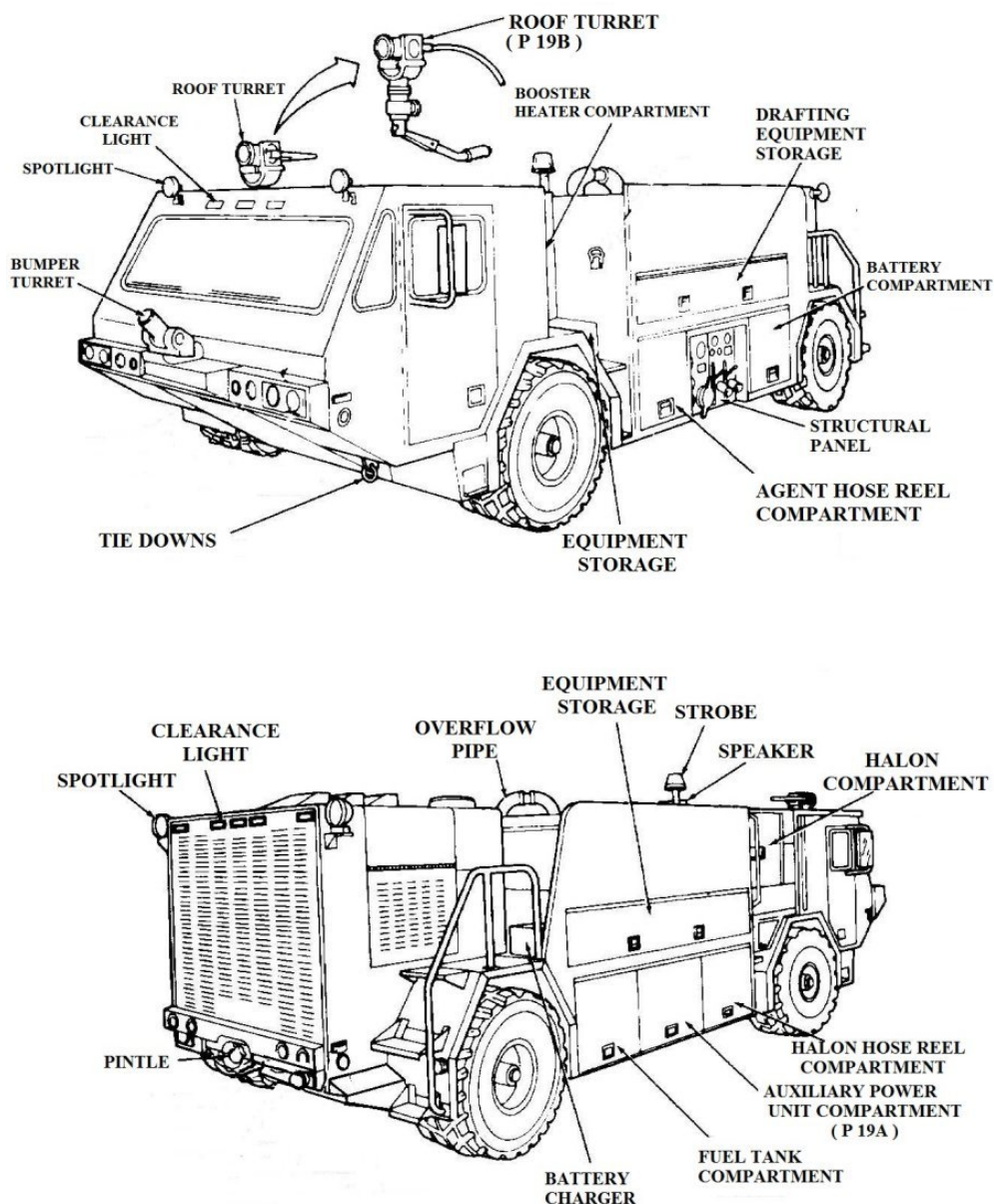


Figure 5-12. Truck exterior arrangement (P-19A and P-19B).

## 223. P-19 drivetrain

The P-19 drivetrain is unique in that the drivetrain actually starts with the engine at the rear of the truck. You will study performance characteristics and information about each drivetrain component.

### Performance characteristics

The P-19 has a diesel engine powered, all-wheel drive chassis. The P-19, fully loaded, will accelerate from a standing start to 50 mph in 25 seconds on level pavement. The P-19's top speed is 65 mph, which allows for quick response to an emergency. Additionally, the P-19 is capable of maneuvering at low speed in difficult terrain with its fire equipment operating at full discharge. The truck can ascend and descend a 60-percent grade and negotiate an 18-inch wall.

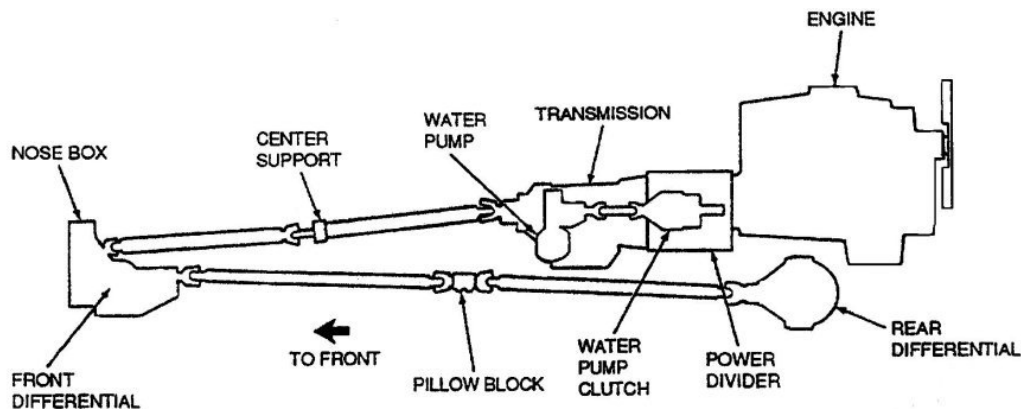


Figure 5-13. Drivetrain.

### Engine

Refer to figure 5-13 to identify the location of drivetrain components. As with all powered vehicles, you must have power. The power comes from an in-line, six-cylinder, four-cycle diesel engine manufactured by Cummins®. This engine is equipped with a turbocharger and an aftercooler for smooth, powerful operation. The engine provides power to drive the transmission and the fire-fighting system simultaneously. To divide the engine power between these two drives, the P-19 uses a power divider.

### Power divider

The power divider is mounted on the flywheel housing between the engine and transmission (fig. 5-14). Not only does the power divider provide a drive to the transmission, it also provides a means to drive the dispensing system water pump. A modulating clutch, located inside the power divider, provides the means to drive the transmission. A water pump clutch wing, attached to the power divider, houses the dispensing system's water pump clutch. The water pump clutch is in constant mesh with the engine through a series of gears starting at the input side of the modulating clutch.

### Modulating clutch

The modulating clutch provides the operator a safe way to operate the dispensing system at full engine speed, while driving the truck.

Located inside the power divider, the 13½-inch wet-type modulating clutch is a spring applied, air released clutch. When in Road mode (normal driving) the modulating clutch is applied, allowing full engine power to the transmission. When placing the agent selector valve in the WATER or FOAM position and the discharge valve is open, air pressure at a minimum of 90 psi activates the modulating clutch release air chamber. This air pressure overcomes the clutch spring pressure and disengages the modulating clutch; thus breaking the power flow to the transmission.

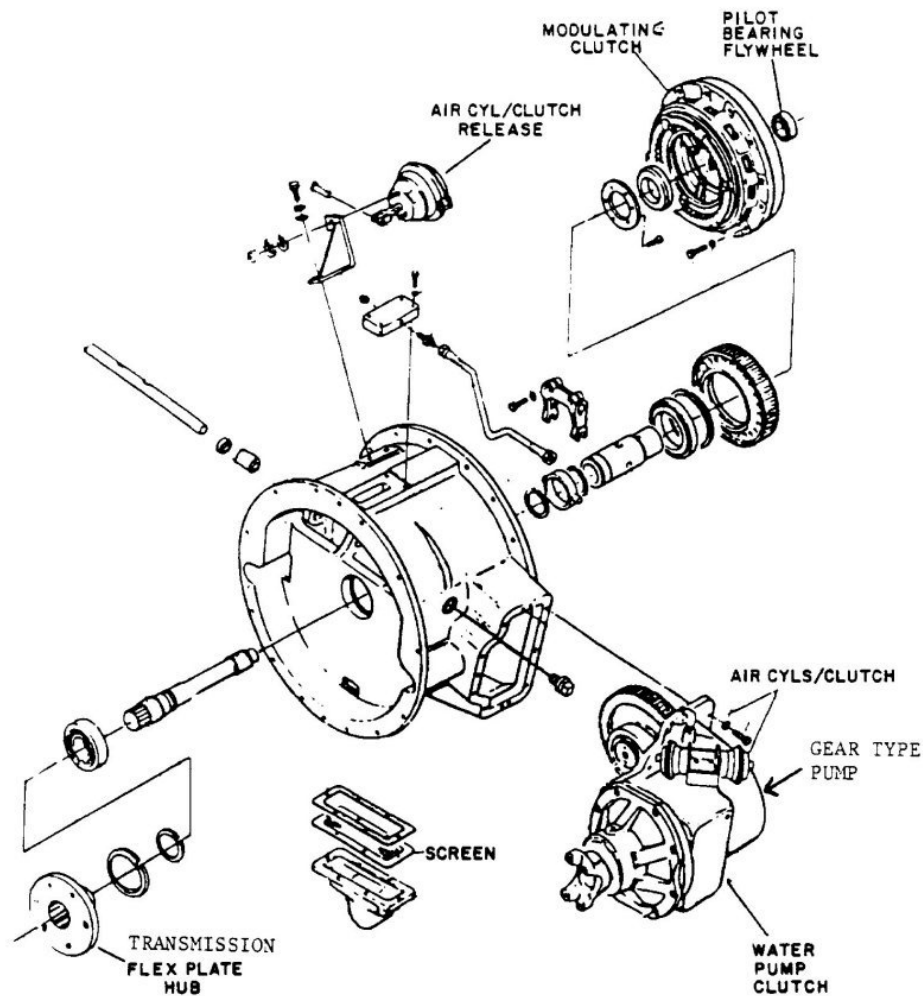


Figure 5-14. Power divider.

Modulation (operator-controlled slippage) occurs when the transmission is in gear and an operator slowly depresses the accelerator pedal while discharging agent. Depressing the accelerator pedal controls air pressure bleed-off from the modulating clutch release air chamber through the R-7 modulating valve. This allows clutch spring pressure to gradually overcome the air pressure and apply the clutch. The modulating clutch allows an operator to maneuver the vehicle while continuously pumping water or foam.

#### **Water pump clutch**

The water pump clutch is a dry-type, snap-overcenter clutch. The water pump clutch engages and disengages by air pressure. The input side of the water pump clutch is in constant mesh with the engine. When an operator places the agent selector valve lever in the WATER or FOAM position, air pressure (minimum of 90 psi) activates the water pump clutch air chamber causing the clutch to engage. Power from the engine is now available to the water pump, through the power divider.



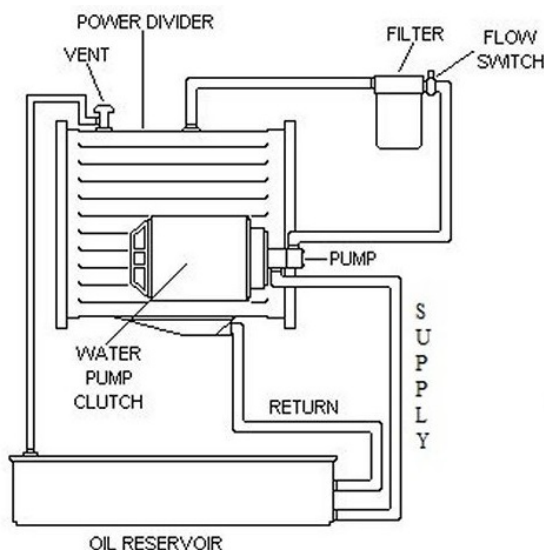


Figure 5-15. Power divider hydraulic system.

### **Power divider lubrication system**

Figure 5-15 shows the power divider hydraulic system. A reservoir, located behind the battery compartment, supplies the system with 10-weight oil. The oil flows from the reservoir to a gear-type pump mounted to the rear of the water pump clutch wing. The gear-type pump lubricates the modulating clutch, center output shaft, and all of the gears within the power divider assembly. The gear-type pump sends the oil to a normally closed flow switch that opens at 2 gpm of flow or 4 to 10 psi. This flow switch controls the power divider low oil light on the dash. After passing through the flow switch, the oil passes through a filter before going to the power divider. The flow switch and filter assembly are located in the engine compartment to the rear of the engine. Once 10-weight oil enters the power divider, it lubricates internal components through drilled passages. While in the power divider, the gears and modulating clutch will “splash lubricate” themselves as the oil passes through. The oil then returns under gravity to the sump (bottom of the power divider). In the sump of the power divider, there is a filter screen to collect large debris before the oil returns to the reservoir.

### **Transmission**

The P-19 transmission provides five speeds forward and one reverse. The transmission shifts into and out of first range manually by the operator. The remaining ranges automatically upshift and downshift. An integral torque converter transmits power from the power divider to the transmission gearing. From the transmission, power leaves through driveline components into the nose box.

### **Nose box**

Mounted on the front of the front axle is the nose box. The nose box functions like a transfer case to transmit torque downward to the front axles. Here it drives both the front axles and a drive-through shaft for the rear axle. The nose box features an interaxle differential and locking clutch to allow for different axle speeds and the ability to lock both axles together.

### **Front and rear axles**

The full-floating front and rear axles utilize a controlled traction feature. This provides better traction in soft terrain or slippery conditions. The controlled traction feature consists of a clutch pack. This clutch pack applies when an operator engages the differential lock switch. When *engaged*, the controlled traction differential limits the differential action between the two-axle shafts. When *disengaged*, you restore full differential capability for normal steering control, under normal road

conditions. The controlled traction differential only limits differential action. It does not lock the differential.

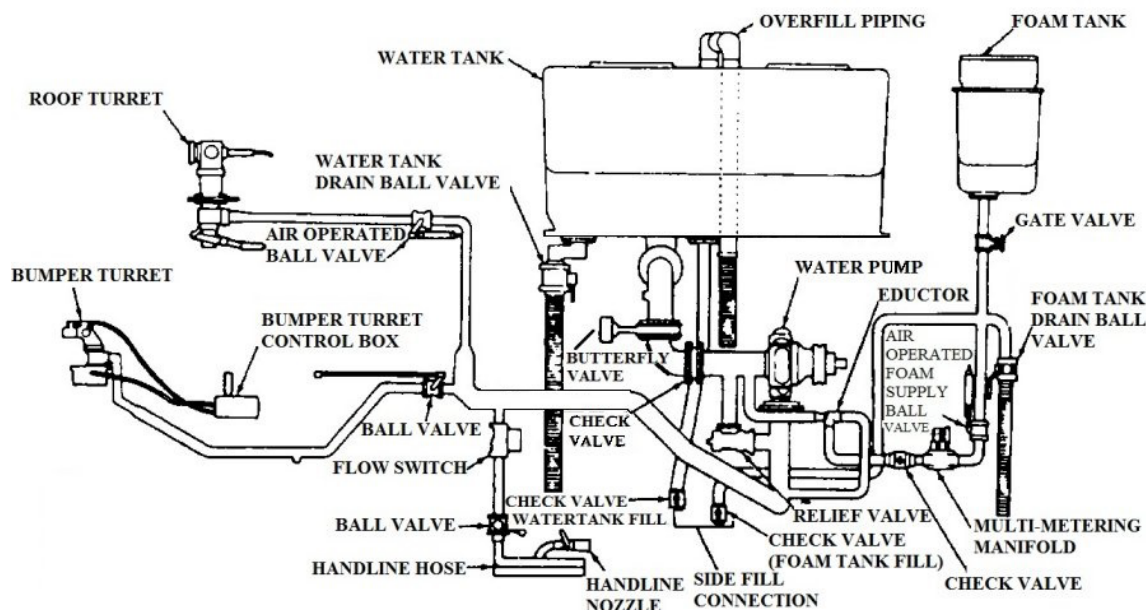


Figure 5-16. P-19 fire-fighting dispensing system.

## 224. P-19 dispensing system

Figure 5-16 shows the P-19 dispensing system. This dispensing system is self-sufficient and capable of selectively delivering either water or a mixture of water and foam (called agent) from all discharge points. The components covered in this lesson are the water and foam tanks, system piping, foam proportioning system, agent selection valve, water and priming pumps, and the pressure and pilot relief valves. Additionally, the roof turret, bumper turret, and the handline reel assembly are covered.

### Water tank

The water tank on the P-19 is made of fiberglass and has a capacity of 1,000 gallons. A three-point, pivot-mounted subframe supports the tank and relieves twisting forces on the assembly during off-highway operation. The water tank has full section baffles for unrestricted water passage and access to any portion of the tank for cleaning and inspection. You can fill the water tank using the top hatches or bottom fill connections. The bottom fill parts have standard hose connections. A one-way check valve located in the bottom fill piping prevents water from spilling out. On the cab dash are tank water level and foam tank level gauges.

**CAUTION:** Before filling the tank from overhead, verify all drain valves are closed and the strainer basket is in place and clean. Also, when filling the water tank from a hydrant or another water source, be sure to open the water tank's top fill hatch while pressure filling from the side of the truck or damage can result.

### Foam tank

The foam tank is made of fiberglass and has a capacity of 130 gallons. It is located directly behind the water tank. Operators can fill the foam tank from bulk supply by a hose connected to a transfer pump. However, filling the foam tank usually takes place from the top. The foam tank filler box contains a strainer screen and incorporates four can-piercing knives to expedite pouring from the foam containers.

### System piping

The dispensing system uses piping to carry water and foam to each discharge point. All piping in contact with water or foam is stainless steel, bronze, or brass. In some areas, the system piping has flexible hose, due to movement between parts. To maintain a set operating pressure in the system piping, the system uses a pressure relief valve with a bypass pipe. Located within the system piping is the foam proportioning system.

### Foam proportioning system

The proportioning system includes a multimetering manifold and eductor. Figure 5-17 illustrates these two components. The multimetering manifold delivers foam concentrate into the water system at the correct percentage for the roof turret, bumper turret, or handline operation. The multimetering manifold delivers foam concentrate using three orifices controlled by air valves. The manifold comes equipped with two interchangeable orifice plates capable of delivering 3 or 6 percent foam concentrate. When either the turrets or the handline discharge valves opens, the pertinent air valve opens and allows the correct percentage of foam to flow (fig. 5-18). The foam flows through the orifice opening within the manifold and out to the eductor. At the eductor, the foam and water are mixed. Then, the mixture flows to the water pump. This type of proportioning system produces a high degree of accuracy at all foam discharge rates. You can manually override each orifice, if an air cylinder fails to operate, to provide necessary foam concentrate to various discharge points.

**NOTE:** When a replacement multimetering manifold is ordered, replacement manifolds may come with six cylinder valves. However, only three of these cylinder valves are used.

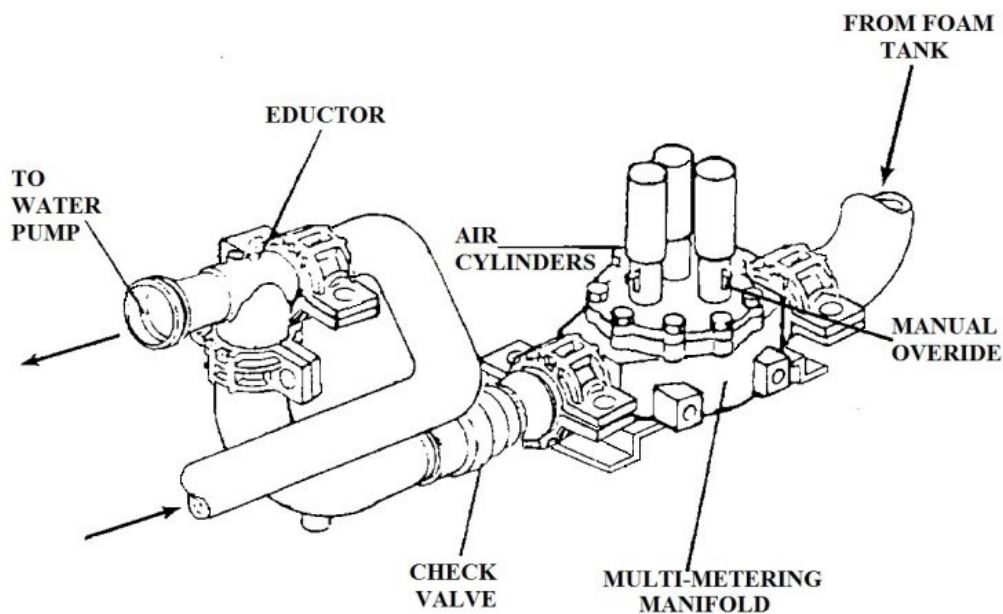
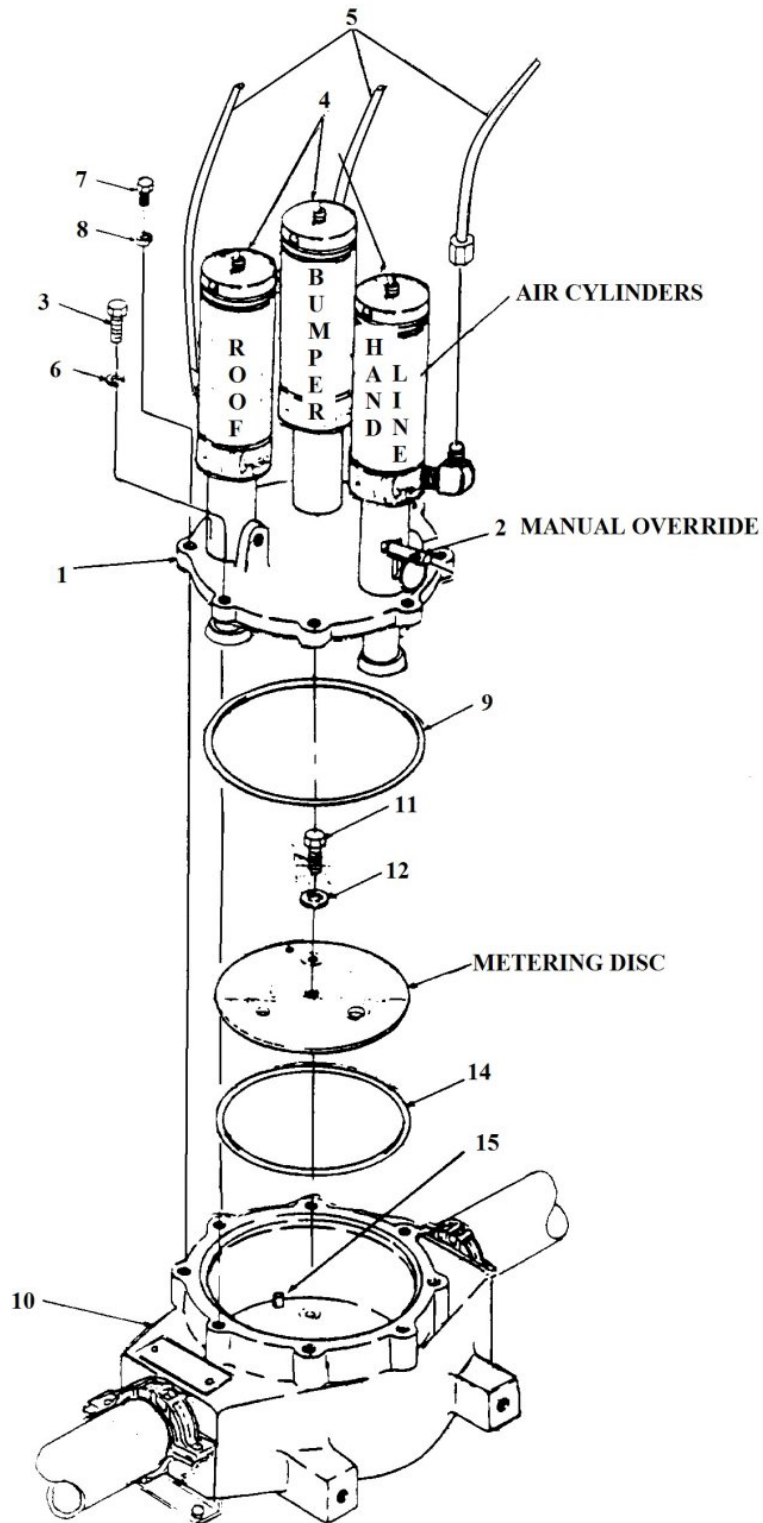


Figure 5-17. Foam proportioning system.



**FOAM METERING MANIFOLD**

Figure 5-18. Foam metering manifold.

### Agent selection valve

Mounted on the right-hand side of the dash is the agent selection valve. Operators use this valve to select the agent, either foam or water. When operating the vehicle in Crash mode, the engine speed must be at idle before shifting the agent selection valve. Engaging the valve at engine speeds above idle has a detrimental effect on the life of clutches, drivelines, and pumps. However, you can switch the agent selection valve from the water position to the foam position when the engine is at 2,100 rpm, because the pump is already engaged and dispensing agent.

### Water pump

Figure 5-19 is an illustration of the P-19 water pump. All variants use a single stage, centrifugal type pump. The P-19 and P-19B (USAF variants) utilize a Waterous® water pump, which is rated at 1000 gpm, while the P-19A (USMC variant) has a Hale® water pump with a rating of 950 gpm. Both pumps operate at 240 psi at 2100 rpm. The power divider provides the direct drive arrangements to engage the water pump, through the water pump clutch. An oil supply, in the pump bearing housing, provides water pump lubrication. The water pump engages whenever the agent selection valve on the dash is in the WATER or FOAM position.

**WARNING!** Remember, engaging the agent selector valve in either WATER or FOAM position at engine speeds above idle has a detrimental effect on the life of clutches, drivetrain components, and pumps.

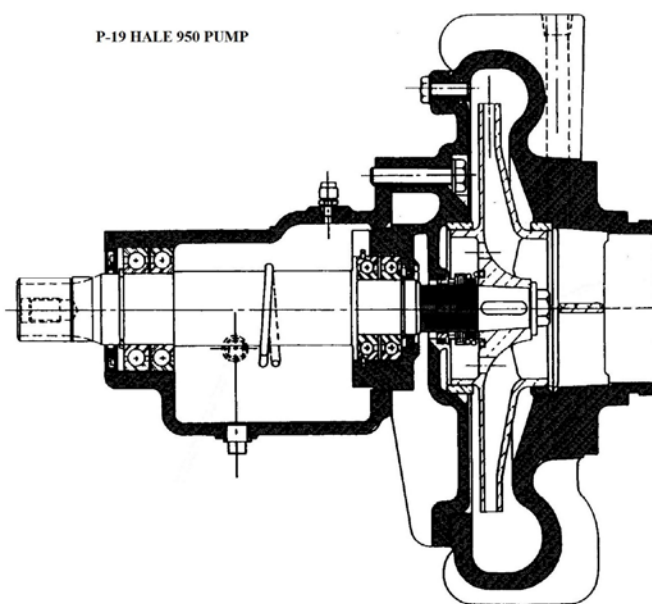


Figure 5-19. P-19 water pump.

### Water priming pump

The P-19A/B model trucks use a priming pump because the centrifugal-type pump cannot create its own vacuum. Because the water pump is unable to create a vacuum, you *must* prime the water pump when operating the pump from a draft. The priming pump system, shown in figure 5-20, uses water to displace air in the suction lines and portions of the pump.

Priming *is not* required for pumping from a hydrant or in a relay (one pump to another). In this situation, inlet water pressure is high enough to force air out of the suction lines and pump. A discharge line must be open to permit the air to escape. If you temporarily stop pumping, and no air enters the pump, re-priming is not necessary.

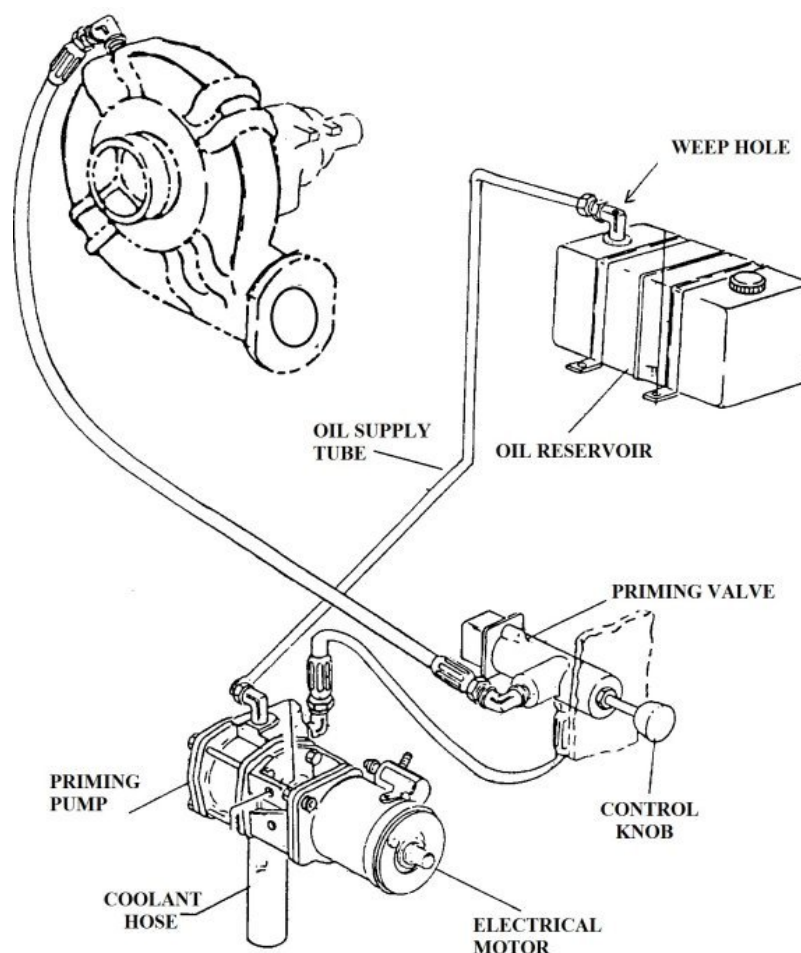


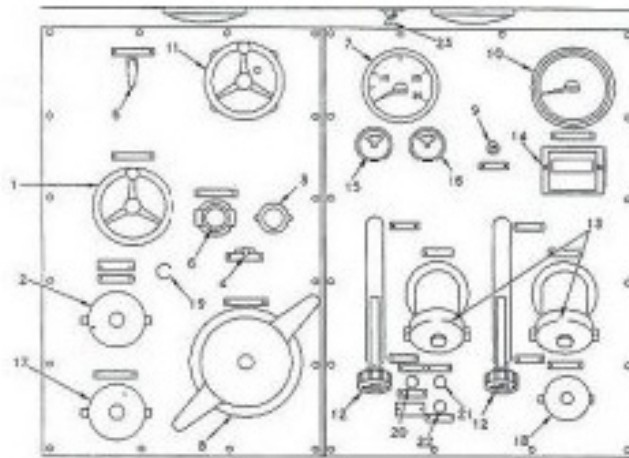
Figure 5-20. Priming pump system.

The priming pump gets its initial seal from oil. The oil reservoir is located in the battery compartment. Attached to the reservoir is an oil supply line that runs to the priming pump. This line has a brass fitting at the reservoir with a small weep hole on top. You must ensure this weep hole stays free of any obstructions; otherwise, the oil and water may premix and not be able to provide a proper seal for the priming pump. An electric motor (similar to a starting motor) drives the priming pump. The priming control is on the structural panel (fig. 5-21). Hearing a definite change in sound of the priming pump, and checking the water pump pressure gauge on the structural panel, indicates when priming is complete. In addition, when priming is complete, water-oil mixture flows from the priming pump discharge line underneath the vehicle.

### Pressure relief valve

The pressure relief valve is located in the piping, on the outlet side of the water pump (fig. 5-22). The pressure relief valve operates in crash and structural mode. The pilot relief valve controls the operation of the pressure relief valve. In the crash mode of operation, the pressure-relief valve bypasses excess agent pressure back to the water pump. Equal pressure on both ends of the pressure-relief-valve piston holds the dispensing system pressure steady while dispensing. When you shut a turret off, the system pressure increases. Because of system pressure increase, the pilot-relief valve bleeds off pressure from behind the pressure-relief valve piston. This allows the pressure-relief valve to open and bypass the excess water pressure back to the water pump.





- |  |  |
|--|--|
| 1. Water tank shut off valve hand wheel  | 2. 2.5 inch water suction connection   |
| 3. Priming pump control knob             | 4. Waterpump engage/disengage valve    |
| 5. Relief valve ( crash/structural )     | 6. Engine throttle control knob        |
| 7. Engine tachometer                     | 8. 5 inch water suction connection     |
| 9. Structural panel control switch       | 10. Waterpressure gage                 |
| 11. Relief valve hand wheel              | 12. Discharge levers                   |
| 13. 2.5 inch water discharge connections | 14. Digital flow meter                 |
| 15. Engine oil pressure guage            | 16. Engine water discharge connections |
| 17. Water fill connection                | 18. Foam fill connection               |
| 19. Suction inlet valve                  | 20. Water drain                        |
| 21. Foam drain                           | 22. Water drain                        |
| 23. Panel light switch                   |  |

Figure 5-21. Structural panel.

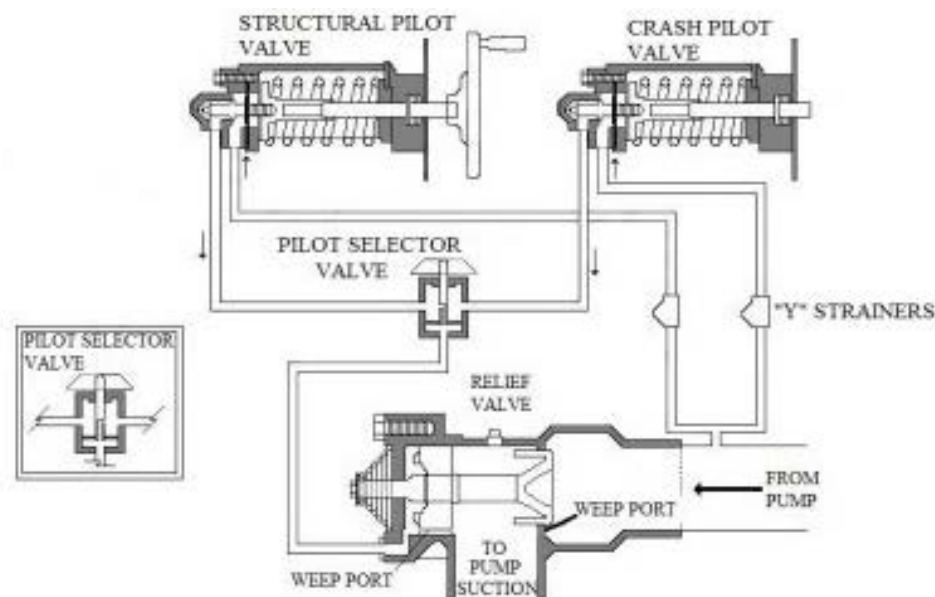


Figure 5-22. Relief valve/pilot valve assembly.



### Pilot relief valve

The P-19 has only one pilot valve, while the P-19A/B has two valves that operate on both crash and structural modes. The pilot relief valve is located in the piping on the outlet side of the water pump. The valve adjusts to maintain system pressure at 240 psi at all times in crash mode, the pilot valve for structural mode is set by the fire-fighters. To increase the system pressure, turn the valve adjustment clockwise. This increases the spring pressure within the pilot relief valve. Turning the valve adjustment counterclockwise decreases system pressure.

**NOTE:** When adjusting the relief valves in the dispensing system, always reference the applicable technical order.

### Roof turret

The roof turret, shown in figure 5-23, is a remote, manual-type turret. The roof turret is a nonaspirating, single-barrel turret, with an air-operated discharge valve. The discharge capacity of the roof turret is 500 gpm at approximately 225-psi discharge pressure at the pump. The driver, or an individual sitting in the cab below the turret, operates the roof turret. A single control handle provides directional control of turret movement in the horizontal and vertical planes. The position of the control handle corresponds to the position of the turret. Pressing a button on the grip end of the directional control handle activates the air-operated turret discharge valve. To stop discharge, press the button again. For the turret discharge valve to operate, the electric toggle switch, located on the ceiling, must be in the ON position. The pattern control lever is located to the right of the turret control column on the interior ceiling. Figure 5-24 shows the roof turret travel limits and discharge patterns.

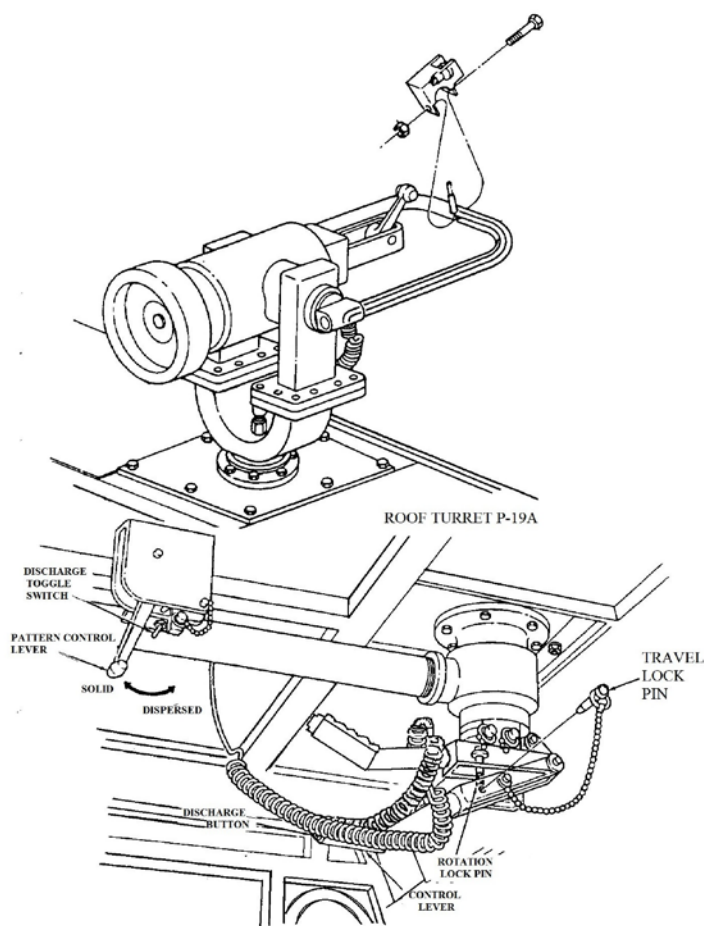


Figure 5-23. Roof turret (P-19 and P-19B).

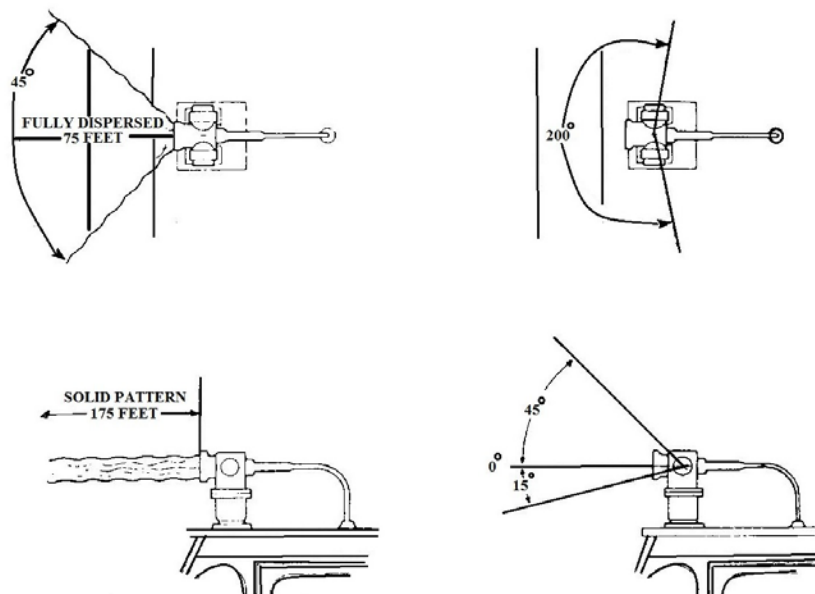


Figure 5-24. Roof turret travel limits.

### Bumper turret

Located above the front bumper, in the center, is the bumper turret. The design of the bumper turret allows discharge of water or foam at a rate of 250 gpm at 240 psi. The bumper turret is similar in construction to the roof turret. The bumper turret is a single-nozzle, non-aspirating, constant flow and variable-stream type turret. Directional control is electric over air, operated in both horizontal rotation and elevation. All bumper turret air operational controls are beneath the bumper turret, and all electrical controls are inside the turret control box on the center console. Pattern control is by a control cable and is variable from straight stream to a fully dispersed pattern. The bumper turret discharge valve is operated from within the cab. Figure 5-25 shows the bumper turret's travel limits and discharge pattern.

**NOTE:** You must elevate the bumper turret to achieve distance.

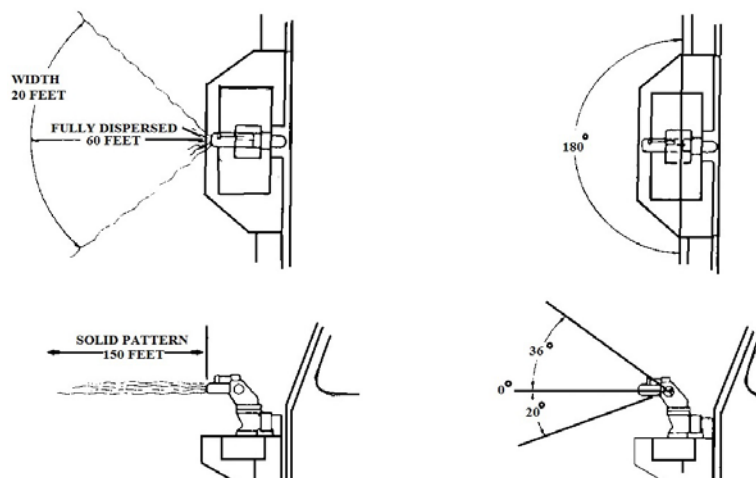


Figure 5-25. Bumper turret travel limits.

### Handline hose reel assembly

The handline installed on the hose reel is a hard hose. The P-19 uses this type of hose because it can be pressurized on the hose reel without damaging the reel assembly. As figure 5-26 shows, the handline is on a hose reel assembly in the left front compartment. The handline is 100 feet of 1-inch hose, with a pump discharge pressure of 60 gpm at 100 psi. Operators can wind the hose on the reel electrically or manually. Before you rewind the handline, use the blowdown valve to remove any remaining water or foam/water from the hose. This prevents freezing during cold weather conditions and reduces the weight of the hose to take the strain off the electric rewind motor during use. The pistol grip nozzle is nonaspirating, with an infinitely variable pattern ranging from straight stream to a fully dispersed pattern.

**NOTE:** Reconfiguration of the handline hose reel assembly is a field-level option to permit the removal of the hose reel and hard hose for substitution with 150 feet of 1 to 3-¼ inch preconnected soft hose. Refer to the appropriate technical order for this reconfiguration.

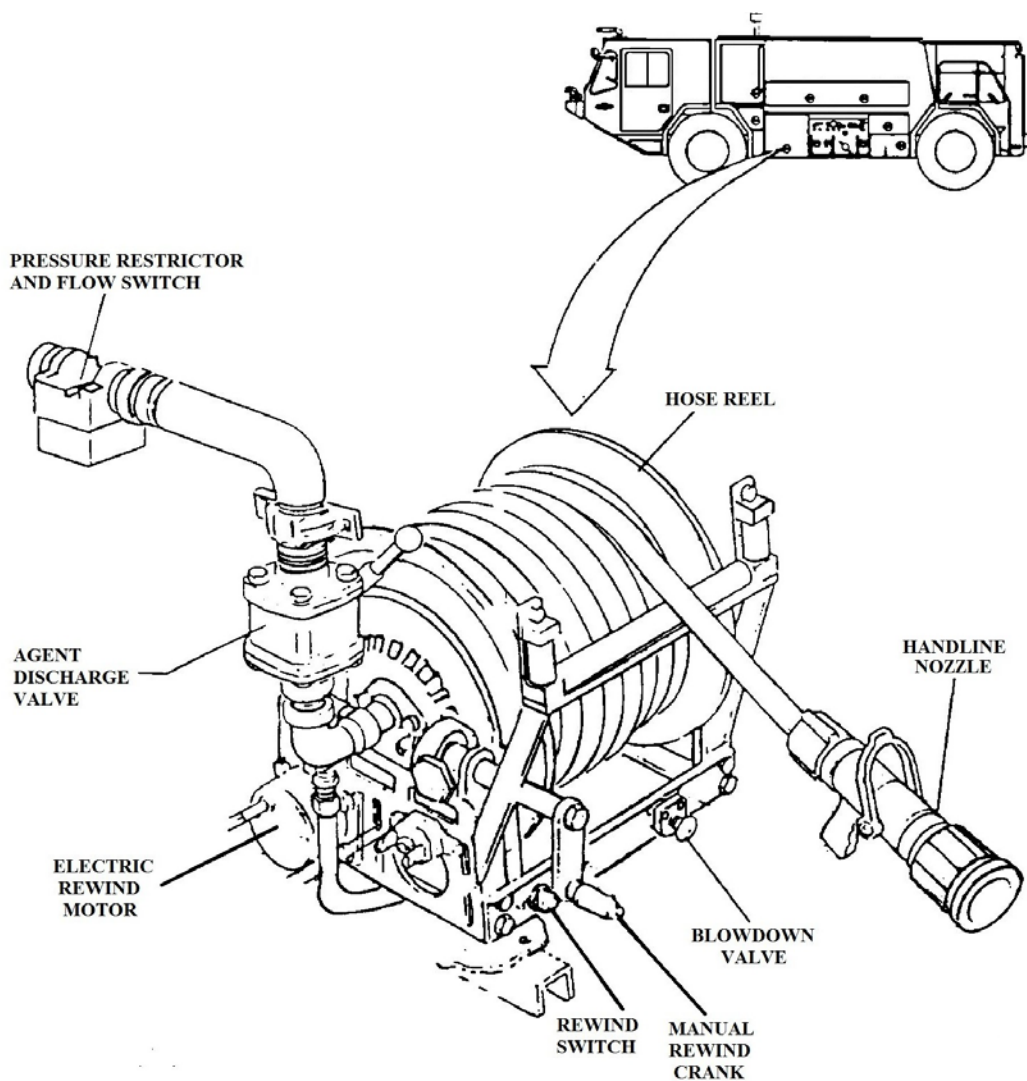


Figure 5-26. Handline hose reel assembly.

## 225. P-19 electrical system

This lesson provides general information about the P-19 electrical system. Always reference the technical order before troubleshooting electrical system components and use standard automotive electrical theories.

### Electrical system (general)

The P-19 utilizes a 24-volt electrical system. A 100-amp alternator supplies the current to maintain the truck's two 24-volt batteries. Automatic reset type circuit breakers protect most major circuits. A master solenoid is located on the left frame rail in the center of the truck. When the master switch on the cab dash is in the OFF position, the master solenoid disconnects power from all vehicle electrical systems *except* the winterization system.

Two types of external power receptacles are located at the rear of the vehicle. The first type is a 24 VDC plug-in receptacle. The receptacle will accept power from an auxiliary power source for jump-starting. The second receptacle is a 110VAC receptacle used to supply power to the battery charger and vehicle electrical system when the engine is not operating.

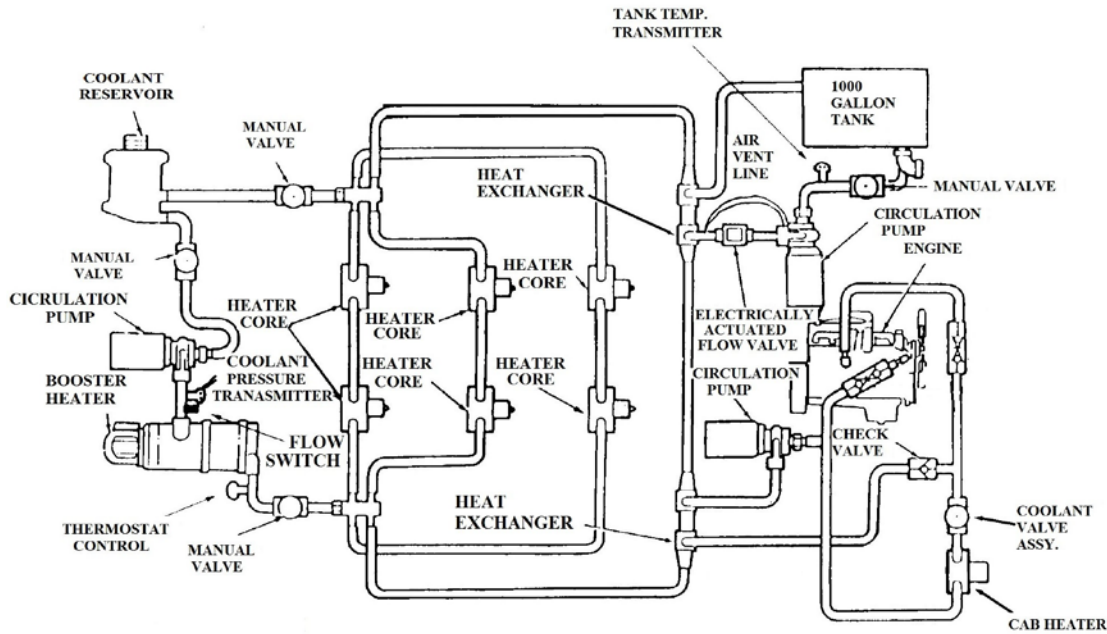
**SAFETY CAUTION:** Always disconnect batteries before replacing electrical parts. *Disconnect* the negative cable before disconnecting the positive cable. When reconnecting, *connect* the positive cable before connecting the negative cable.

## 226. P-19 winterization system

Because of the diverse geographical locations of Air Force bases, the P-19 must be operational in all climate zones. Keeping equipment operational in cold-weather areas is of vital importance. This lesson covers general information about the main winterization system, the water recirculating system, and the operation of the booster heater.

### General information

The winterization system's function is to maintain the temperature in the cab, most of the compartments, and the engine. The winterization system, shown in figure 5-27, uses its own ethylene glycol engine coolant heated by the booster heater. Then, circulation pumps circulate coolant through two heat exchangers and six heater cores. Each heater core uses an electric fan to pass air through the heater core, warming the individual compartments. This prevents the pipes from freezing and keeps the truck ready for emergency operations in sub-freezing weather. The system draws fuel from the vehicle fuel tank. The vehicle batteries provide electric power. However, if you operate the heater for a long period, connect an external power source to the 110 VAC connector at the back of the truck to prevent the batteries from discharging. Controls for the winterization system are located on the left dash panel.



**WINTERIZATION SYSTEM**

**Figure 5-27. Winterization and water recirculating system.**

The winterization system consists of three parts—the main system, engine subsystem, and water subsystem. All three of these systems operate together to provide adequate winterization protection.

System	Operation
Main system	An electric circulating pump circulates ethylene glycol engine coolant from the reservoir to the booster heater. The booster heater heats the coolant, which circulates through plumbing to the six heater cores and two heat exchangers. Electric fans circulate air over the heater cores to maintain compartment temperatures. This system is not connected to the engine's cooling system.
Engine subsystem	In the engine subsystem, a pump circulates coolant through a heat exchanger located in the right front compartment of the truck. Then, the coolant circulates into the engine and cab heater core. The engine subsystem connects to the engine's cooling system. Check valves protect the engine's cooling system.
Water subsystem	A water-recirculating pump circulates water through the heat exchanger located in the booster heater compartment. The water subsystem uses a flow switch, located between the recirculating pump and heat exchanger, to monitor flow. The water-recirculating pump prevents freezing of the water in the water tank and piping system by keeping it circulating through the system.

### Booster heater operation

To help you understand this section on booster heater operation, reference figure 5-28. Placing the booster heater switch in the ON position energizes relays K1, K2, and K3 to the closed position. Relay K1 will remain closed throughout the booster heater operation. Relay K2 energizes the blower motor circuit and will remain closed for 2.5 to 3.0 minutes after combustion stops to purge the combustion chamber of unburned fuel and fumes. Relay K3 allows current to flow through the thermostat control to the contacts on relays K2, K3, and K4. After approximately 20 seconds of starting prime, relay K3 opens and relays K4 and K5 close.

Relay K4 energizes the ignition circuit and relay K5. Relay K5 energizes the fuel solenoid and combustion begins at this point. Current flowing through diodes V22 and V24 serves to hold the relays closed. The light from the flame in the combustion chamber decreases the resistance in the photo resistor to less than 200 ohms, allowing more current to flow through relay K4. This opens K4 and de-energizes the ignition circuit. Combustion is sustained in the chamber by the flame. The resistance of the photo resistor decreases with light and increases without light.

During normal operation, the booster heater operates until the coolant reaches 172 °F. Then, the thermostat control will open, de-energizing relay K5. As soon as relay K5 opens, the fuel solenoid is de-energized and combustion stops. At this time, relay K3 once again closes and remains closed until the thermostat control closes at 162 °F to start the combustion process over again. The blower motor remains energized for 2.5 to 3 minutes, purging the combustion chamber. The coolant pump remains energized as long as the booster heater switch is in the ON position.

Should the thermostat control not open at 172 °F; the high-limit temperature switch opens at 195 °F to de-energize the fuel solenoid and stop the combustion process. The over-temperature fuse opens from excessive heat at 240 °F if the high-limit switch fails to open. The over-temperature fuse also de-energizes the fuel solenoid, stopping the combustion process.

If the combustion process does not begin within 20 seconds after relays K4 and K5 close, relays K4 and K5 reopens, de-energizing the ignition and fuel solenoid circuits and energize the warning circuit.

The control unit uses transistors, resistors, and capacitors to control the operation of the booster heater. It is not a repairable item and if found to be defective, simply remove and replace the unit. Refer to Technical Order (TO) 36A12-8-17-2, *Maintenance and Overhaul Instructions—Truck, Aircraft Crash and Structural Fire Fighting USAF Type AS32P-19 NSN 4210-01-137-9944, USMC Type AS32P-19A NSN 4210-01-137-9943 USAF Type AS32P-19B NSN 4210-01-137-9943 (OSHKOSH Truck Corporation)*, for proper troubleshooting procedures.

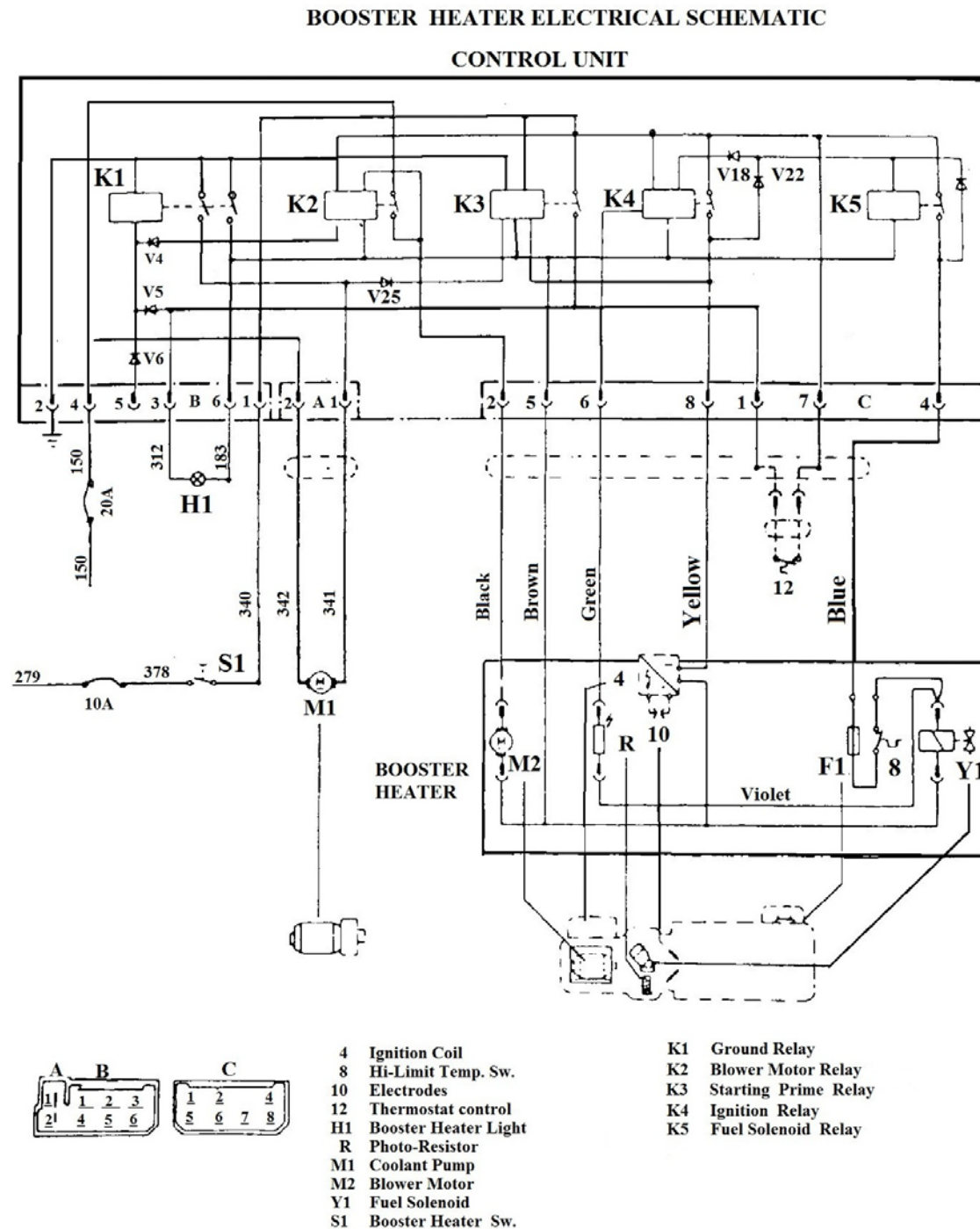


Figure 5-28. Booster heater electrical schematic.

**227. P-19 air system**

The air system on the P-19 consists of an engine-driven compressor and air pressure storage tanks. These components, along with the necessary valves and plumbing, supply and control the various air-operated devices on the truck. Although the air system uses numerous components, you should be



familiar with the operation of four unique air valves. The unique air valves used in the P-19 air system include a three-way control valve, air double-check valves, inversion valve, and a sequence valve.

#### **Three-way control valve**

The three-way control valve (fig. 5-29) is on the right-hand side of the dash and commonly referred to as the *agent selection valve* on the P-19. The valve is operated manually and has a WATER, an OFF, and a FOAM position.

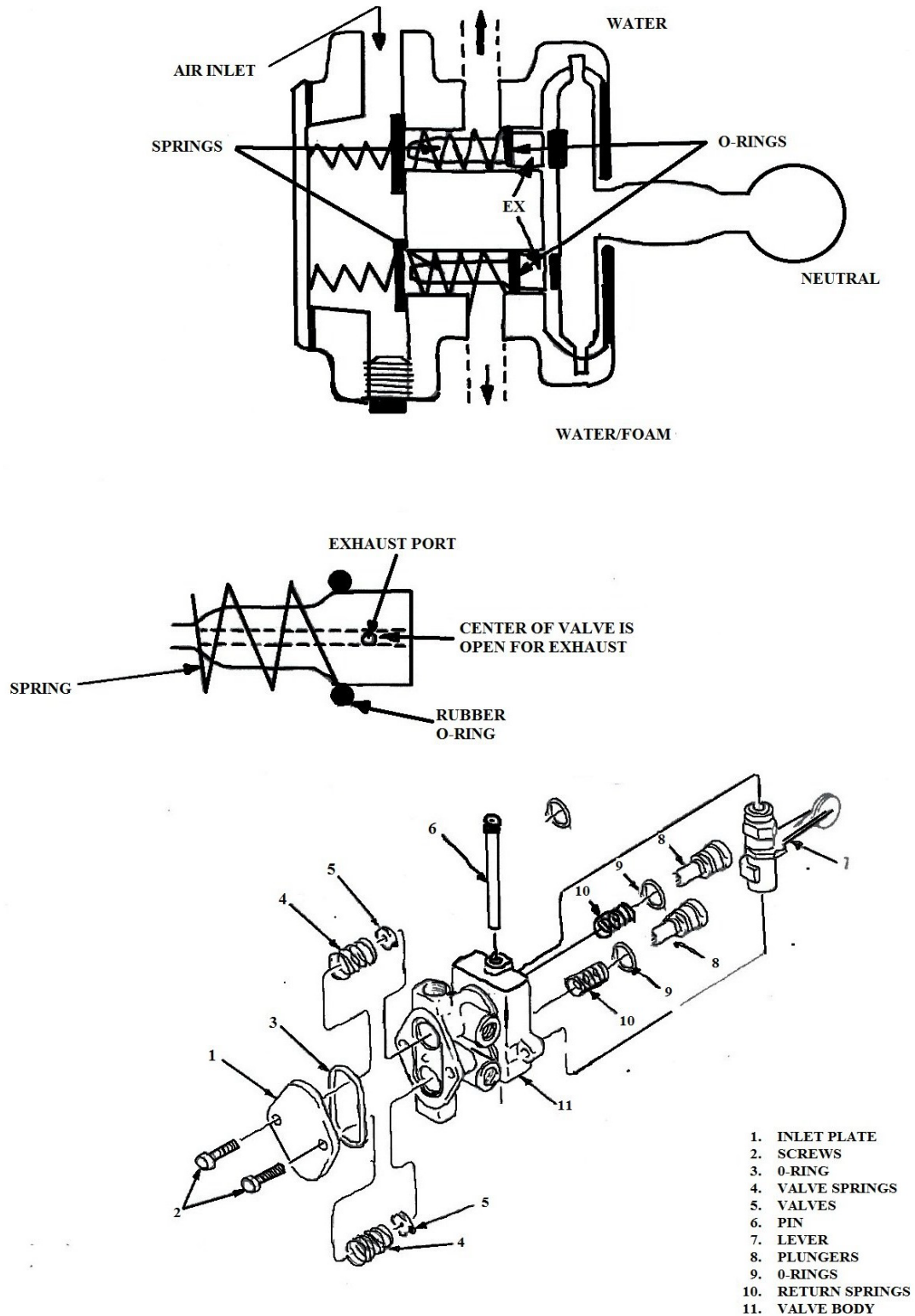


Figure 5-29. Three-way control valve.

### Air double-check valve

There are several air double-check valves used in the P-19 air pressure system. The purpose of the valves is to direct air pressure to the various components. The double-check valve (fig. 5-30) automatically directs the flow of air pressure into a common line from either of two lines. When air pressure is applied to one end of the double-check valve, the shuttle valve slides in the shuttle guide to close off the outlet on the opposite side. Applied pressure to the opposite end slides the shuttle valve in the other direction.

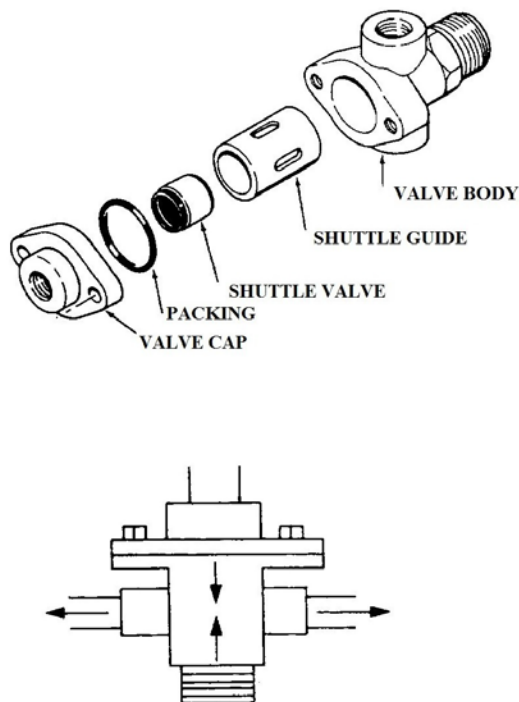


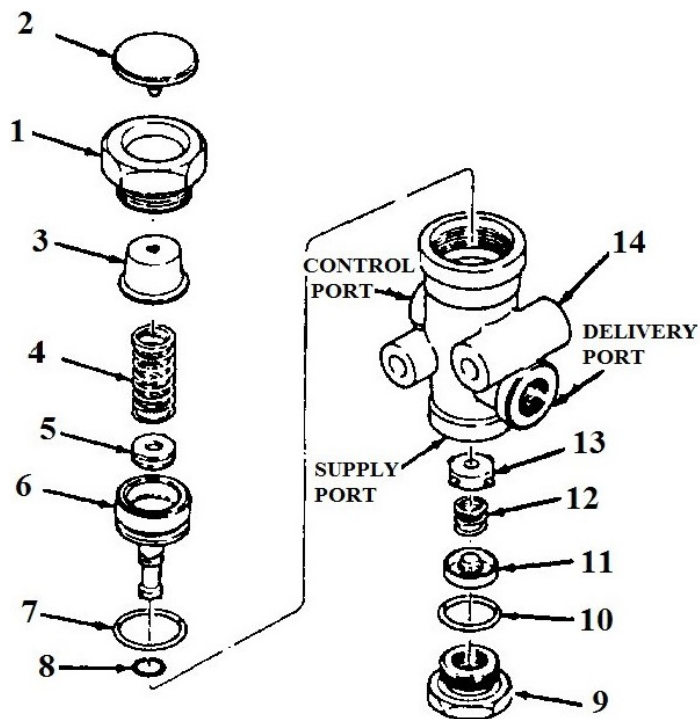
Figure 5-30. Air double-check valve.

### Inversion valve

The inversion valve (fig. 5-31) controls air pressure to an actuating device, such as an air cylinder. When the inversion valve is in the NORMAL (OPEN) position, air pressure from another source enters the valve at the bottom, passes around the seat and flows to an actuating device. When the inversion valve is in the CONTROLLED position, air pressure from a control device lifts the internal piston. This action closes the seat in the bottom of the valve and allows the air in the line to exhaust out the top of the valve (fig. 5-32). When this occurs, the actuating device shifts in the opposite direction. As the controlling device is shifted back to the OFF position, the spring in the top of the inversion valve forces the piston back down to open the seat at the bottom and the valve is in its normal position.

### Sequence valve

Figure 5-33 illustrates the operation of the sequence valve. There is one sequence valve on each P-19 model, which has the same purpose as an inversion valve but operates in an opposite manner. When a sequence valve is in the normal position (closed), spring pressure below the internal piston lifts the piston allowing the valve seat to close and block incoming air. When the sequence valve is in the controlled (open) position, air pressure from a control device pushes down the internal piston forcing the valve seat open allowing air to enter the valve at the bottom. This air passes around the valve seat and flows to an actuating device.



- |                       |                  |
|-----------------------|------------------|
| 1. EXHAUST NUT        | 8. O-RING        |
| 2. EXHAUST DIAPHRAGM  | 9. CUP NUT       |
| 3. DIAPHRAGM RETAINER | 10. O-RING       |
| 4. PISTON SPRING      | 11. VALVE STOP   |
| 5. SHIM               | 12. VALVE SPRING |
| 6. PISTON             | 13. VALVE        |
| 7. O-RING             | 14. VALVE BODY   |

Figure 5-31. Inversion valve.

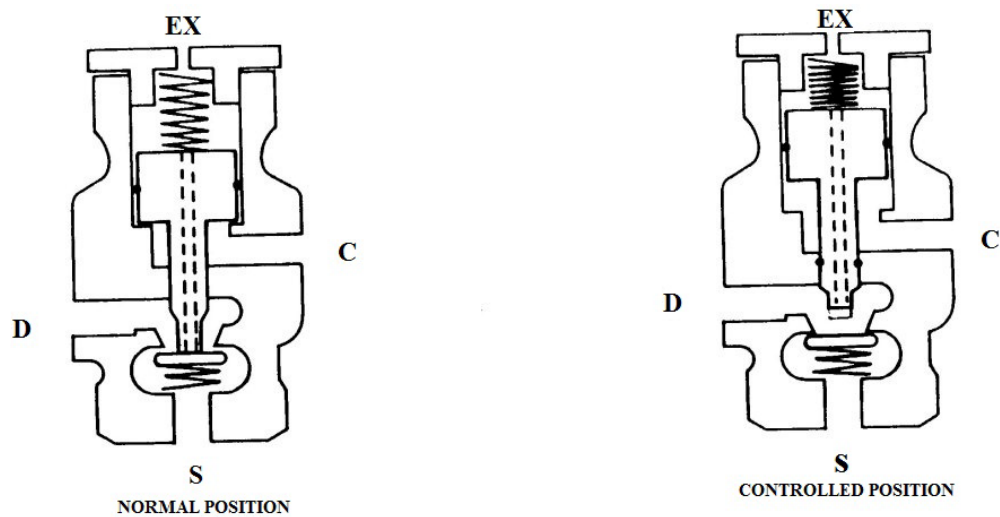


Figure 5-32. Inversion valve operation.

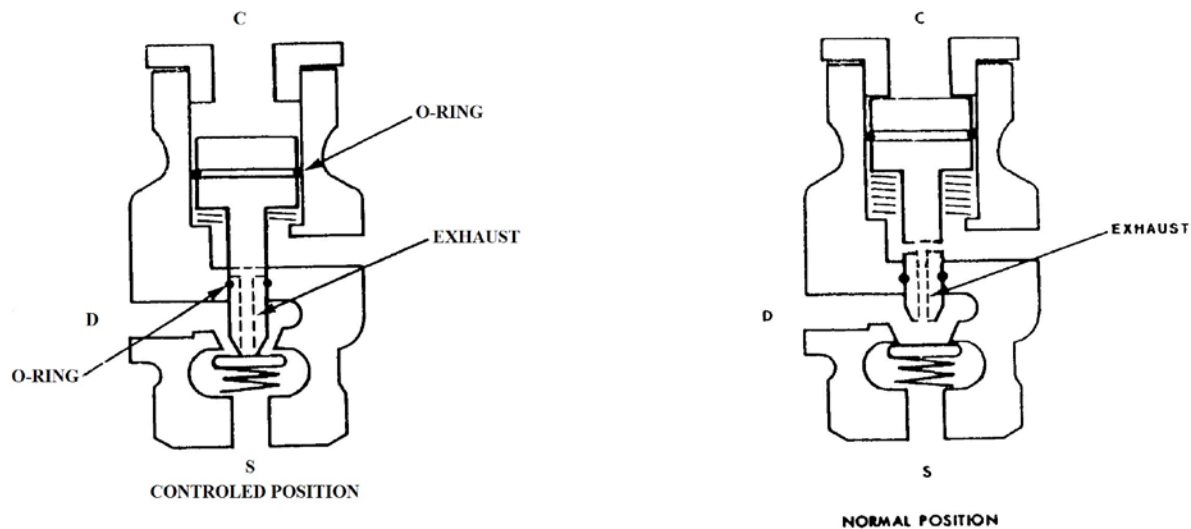


Figure 5-33. Sequence valve.

## Self-Test Questions

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

### 223. P-19 drivetrain

1. What drivetrain component on the P-19 provides power for the main drive and fire-fighting system?
2. Where is the power divider mounted?
3. What component attaches to the power divider and houses the water pump clutch?
4. What does the modulating clutch on the P-19 provide?
5. What activates the modulating clutch air release chamber after placing the agent selector valve in the WATER or FOAM position?
6. What type of clutch is the water pump clutch?
7. What component is located behind the battery compartment and supplies the power divider lubrication system with 10-weight oil?

8. What controls the power divider low oil light on the dash?
9. What is the purpose of the filter screen located in the sump of the power divider?
10. How many speeds does the P-19 transmission provide?
11. How does the nose box mounted on the front of the P-19 front axle function?
12. What feature does the P-19 front and rear axle use? Why?

**224. P-19 dispensing system**

1. The P-19 water tanks made of what material?
2. What is the capacity of the foam tank?
3. What components in the system piping maintain a set operating pressure?
4. Which two components make up the foam proportioning system?
5. What is the purpose of the agent selection valve?
6. What type of water pump does the P-19 dispensing system use?
7. When does the water pump engage?
8. Why does the P-19A/B use a priming pump?

9. Where is the pressure relief valve located?
10. What is the discharge capacity of the P-19 roof turret?
11. What is the discharge capacity of the P-19 bumper turret?
12. What type of hose does the handline hose reel assembly use?

**225. P-19 electrical system**

1. What type of electrical system does the P-19 use?
2. What type of circuit breaker protects most major circuits?
3. What should you do before replacing electrical components?

**226. P-19 winterization system**

1. What is the purpose of the P-19 winterization system?
2. What type of coolant does the winterization system use?
3. How many systems comprise the P-19 winterization system?
4. List the P-19 winterization systems.
5. During normal operation, what temperature will the coolant reach before combustion in the booster heater stops?



6. What component uses transistors, resistors, and capacitors to control the operation of the booster heater?

### **227. P-19 air system**

1. By what name is the three-way control valve commonly referred?
2. What is the purpose of the air double-check valve?
3. What is the purpose of the inversion valve?
4. What position is the inversion valve in when air pressure from a control device lifts the internal piston?
5. Which valve on the P-19 operates in an opposite manner of the inversion valve?

## **5-4. P-19 Fire-fighting Truck Maintenance**

In the last section, you learned about the fundamental systems of the P-19 fire-fighting truck. The knowledge you now have about each system will give you confidence in maintaining the P-19. Maintenance on the P-19 consists of inspections, troubleshooting problems, and component repair or replacement. The following lessons cover some common maintenance actions that you need to know.

ALWAYS reference the appropriate technical order when performing repairs.

### **228. Troubleshooting the P-19 power divider**

The power divider is the key to the P-19 dispensing system. The reason it is the key is the fact it allows you to engage the fire-fighting system while driving the truck, called “pump and roll.” This lesson covers general operation and some troubleshooting procedures on the power divider. Always reference the technical order for up-to-date troubleshooting information.

#### **Modulating clutch**

When operating the P-19, the modulating clutch should have a long service life. However, if there is a loss of power to the vehicle’s transmission, follow this procedure:

1. Check to see that the engine is providing full power. If the engine is operating properly, troubleshoot the modulating clutch.
2. The *first step* in doing this is to build up full system air pressure.
3. Then, place the agent selector valve in the OFF position and turn the engine off.

4. Next, *slightly* loosen the air line at the modulating clutch release chamber. There should be no air pressure present at this time. If air pressure is present, the agent selector valve is defective and requires repair or replacement.
5. If no air pressure is present at the modulating clutch release chamber, check the clutch linkage free travel. To do this, grasp the lever at the top and pull it forward.

**NOTE:** You must apply sufficient force to overcome the spring pressure from the clutch air chamber.

6. Measure the amount of free travel. Free travel at the clevis pin should measure between  $\frac{5}{16}$  and  $\frac{3}{8}$  inch. If the free travel is not within the specified amount, turn the air chamber clevis either OUT to decrease free travel or IN to increase free travel.
7. If no air pressure is present and the free travel adjustment is correct, remove the clutch and check the disc for wear and the pressure plate for proper tension. To do this, remove the complete power divider assembly. Be sure you use the appropriate technical data when removing the power divider assembly and performing any maintenance.
8. With the power divider removed, disassemble the modulating clutch assembly for inspection. Be sure to clamp the assembly down before loosening the pressure plate half bolts. This helps relieve spring tension. The next step is to alternate loosening the half bolts. This prevents the halves from becoming warped. With all the parts disassembled, inspect the inner and outer clutch discs for warpage, dishing, and wear. If you find the facings worn to the bottom of the groove pattern, replace the inner discs. Replace the outer discs if they are warped, dished, or worn. Check the pressure plate springs on a spring compression tester to ensure they have the proper tension at the appropriate height. Replace the springs if they are weak.

Servicing the modulating clutch ensures proper lubrication is available. You will learn more about this in the segment covering the modulating clutch oil pump.

### **Modulating clutch oil pump**

The modulating clutch oil pump is the key to extending the power divider's modulating clutch life. A gear-type positive-displacement pump delivers approximately 3 gpm whenever the drive engine is running. A red warning light on the cab dash should come on before you start the truck. The light should go out after a flow switch detects the proper oil flow. If the red warning light does not come on at all, check to see if the bulb or the flow switch is defective. To do this, use a small jumper wire and connect the flow switch terminals to ground. Then turn on the ignition switch. The light should illuminate. If the light comes on, it indicates the flow switch is defective. Replacing the switch will solve this problem. This flow switch is located just before the power divider filter housing in the engine compartment.

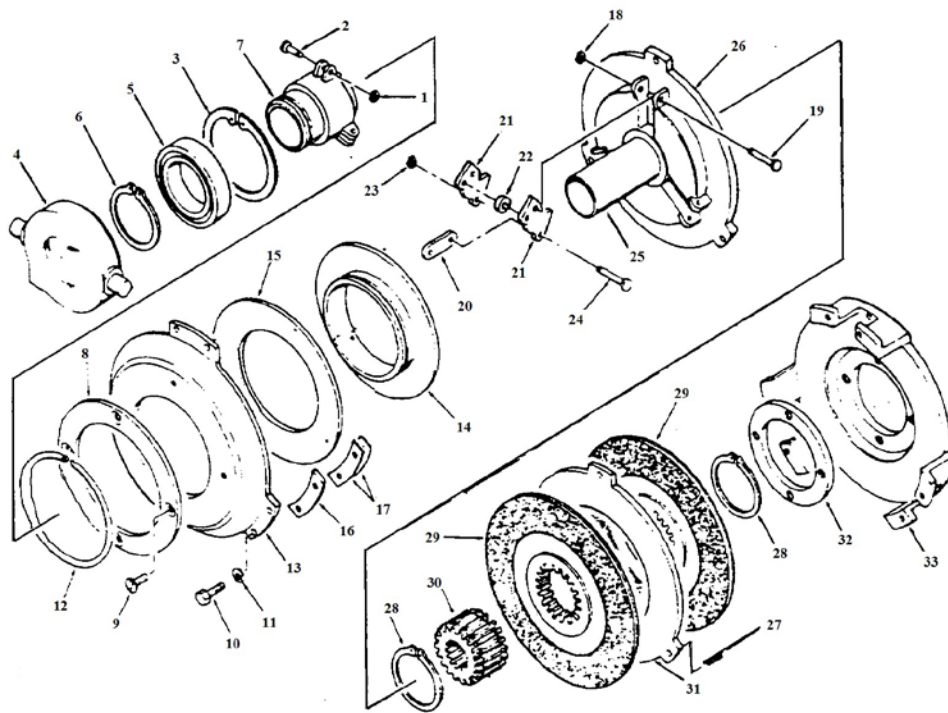
If the red warning light stays on while the engine is running, there is not enough oil flow for clutch lubrication. To check, install a pressure gauge on the inlet side of the power divider's oil filter housing. The pressure should read about 30 psi at 2,100 rpm; at idle speed, it should read a minimum of 4 to 10 psi. If these pressures are extremely low, check the screen in the bottom of the power divider case for cleanliness. If the screen is clean, it indicates the lubrication pump is defective and requires replacement.

Servicing of the power divider lubrication system consists of keeping lubrication oil at the proper level and changing the oil and filter at prescribed intervals.

### **Water pump clutch**

The water pump clutch is a 7-inch, dry-type, multidisc clutch pack (fig. 5-34). A common malfunction of this clutch is slippage. Low or fluctuating water pump pressure is a prime indication of clutch slippage.

1. If slippage is apparent, first check to make sure you have sufficient air pressure (90 psi or higher) to shift the clutch. If you have enough air pressure, check the clearance between the stop screws and the air chamber mount bracket (fig. 5-35). To do this, completely drain vehicle air system.



- |                     |                    |                    |                    |
|---------------------|--------------------|--------------------|--------------------|
| 1. Retaining ring   | 10. Screw          | 18. Retaining ring | 26. Plate          |
| 2. Pin              | 11. Lockwasher     | 19. Pin            | 27. Spring         |
| 3. Retaining ring   | 12. Retaining ring | 20. Link           | 28. Retaining ring |
| 4. Carrier          | 13. Plate          | 21. Lever          | 29. Driven member  |
| 5. Bearing          | 14. Retainer       | 22. Roller         | 30. Spur gear      |
| 6. Retaining ring   | 15. Washer         | 23. Retaining ring | 31. Plate          |
| 7. Sleeve           | 16. Laminated shim | 24. Pin            | 32. Ring           |
| 8. Plate            | 17. Brass shim     | 25. Tube           | 33. Body           |
| 9. Screw and washer |                    |                    |                    |

Figure 5-34. Water pump clutch.

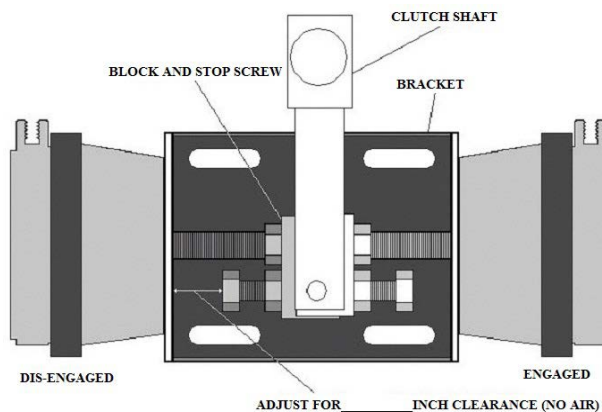


Figure 5-35. Water pump clutch engagement assembly.

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2. After draining the air system, turn both stop screws completely into the block. Next, observe the clutch shaft components as you snap the clutch to the engaged and disengaged positions. The clutch shaft components should not contact the air chambers or the mount bracket. If there is contact, loosen the bracket mount bolts, and reposition the bracket. You may also have to adjust the air-chamber push rod into the block. When you complete these adjustments, engage the clutch, and keep a slight pressure against the release bearing and yoke (*not* shown in fig. 5-34).
3. Now, back out the stop screw against the mount bracket just enough to relieve the pressure from against the release bearing. Lock the stop screw into place. Next, back out the opposite stop screw until the head is 0.84 inch from the mount bracket and lock the screw into position. With these adjustments, the clutch should be fully engaged or disengaged and there should be  $\frac{1}{8}$  to  $\frac{1}{4}$  inch of free travel on the release bearing.
4. If the clutch still slips after these adjustments are completed, you need to troubleshoot further. Again, completely drain the air system. Place the snap-overcenter tool over the clutch engagement shaft box. Place a torque wrench on the tool and measure the torque required to snap the clutch overcenter. It should take a minimum of 500 pounds—approximately 56 foot-pounds on the torque wrench. If the clutch snaps overcenter less than 500 pounds, adjust or replace the clutch. To adjust or replace the clutch disc, you must remove the clutch pack. Refer to the technical manual for removal procedures.
5. With the clutch pack removed, you will see shims in three locations between the assembly plate and the body (refer back to fig. 5-34). Mark the location of each set of shims before disassembly. When the assembly is taken apart, inspect the friction discs for wear or warpage. Replace the discs if worn or warped beyond acceptable limits. If the clutch only requires adjustment because of clutch disc wear, remove an equal amount of shims from each location and reassemble the clutch pack. If a hydraulic press or similar unit is available, use it to apply pressure slowly to the clutch unit carrier. Note the pressure required to snap the clutch over. Again, the required pressure is over 500 pounds. Using the hydraulic press procedure saves time because you can check the adjustment without reinstalling the unit on the vehicle.

Servicing the pump clutch consists of periodically lubricating the release bearings and clutch engagement shafts. In addition, periodic inspection of the air-chamber mount brackets for secure mounting is required. These brackets tend to loosen from vibration.

## **229. Troubleshooting the P-19 dispensing system**

In this lesson, you will learn troubleshooting and maintenance actions required to correct problems of low pressure in the dispensing system.

### **Common causes for low pressure**

Low-dispensing system water or foam pressure on the P-19 can be caused by any of, but is not limited to, the following common malfunctions:

- Improper engine speed.
- Inversion valve malfunction.
- Defective water pump.
- Pilot control valve improperly adjusted.
- Defective or sticking relief valve.

These are only some of the main causes of low system pressure. Always refer to the technical manual for troubleshooting low pressure in the dispensing system.

**NOTE:** On the P-19 A/B, ensure the pilot selector valve is in the proper position for the mode of operation checked.

### **Corrective actions**

Corrective actions for component malfunctions include adjusting, cleaning, repairing, or replacing defective items. During crash mode operation, the engine should be operating steadily at approximately 2,100 rpm. If engine rpm is too low, check the fuel system and Cummins diesel tune-up specifications for the engine. Make necessary repairs if required.

### ***Inversion valve***

If the inversion valve is not operating properly, the water pump clutch will not engage as it should. A common malfunction of this valve is leaking of the seat or O-ring. To check the inversion valve, install a test gauge between a shop air line and the control and supply ports of the valve. Slowly raise the air line pressure. The delivery gauge should show the same pressure as the air line up to 40 psi. At 40 psi, the exhaust port should open and release pressure from delivery. No leakage is allowed at the supply port. A small amount of leakage at delivery and exhaust port is allowed. Excessive leakage indicates a faulty inlet valve. You either repair or replace the defective component.

### ***Water pump***

Figure 5-36 shows an exploded view of the water pump. The usual indication of a defective water pump is excessive noise or vibration caused by a worn impeller or other internal parts. Remove the water pump if excessive noise or vibration exists.

**CAUTION:** The P-19 water pump is heavy and awkward to handle. Use extreme care when removing the pump from the framing and the side compartment.

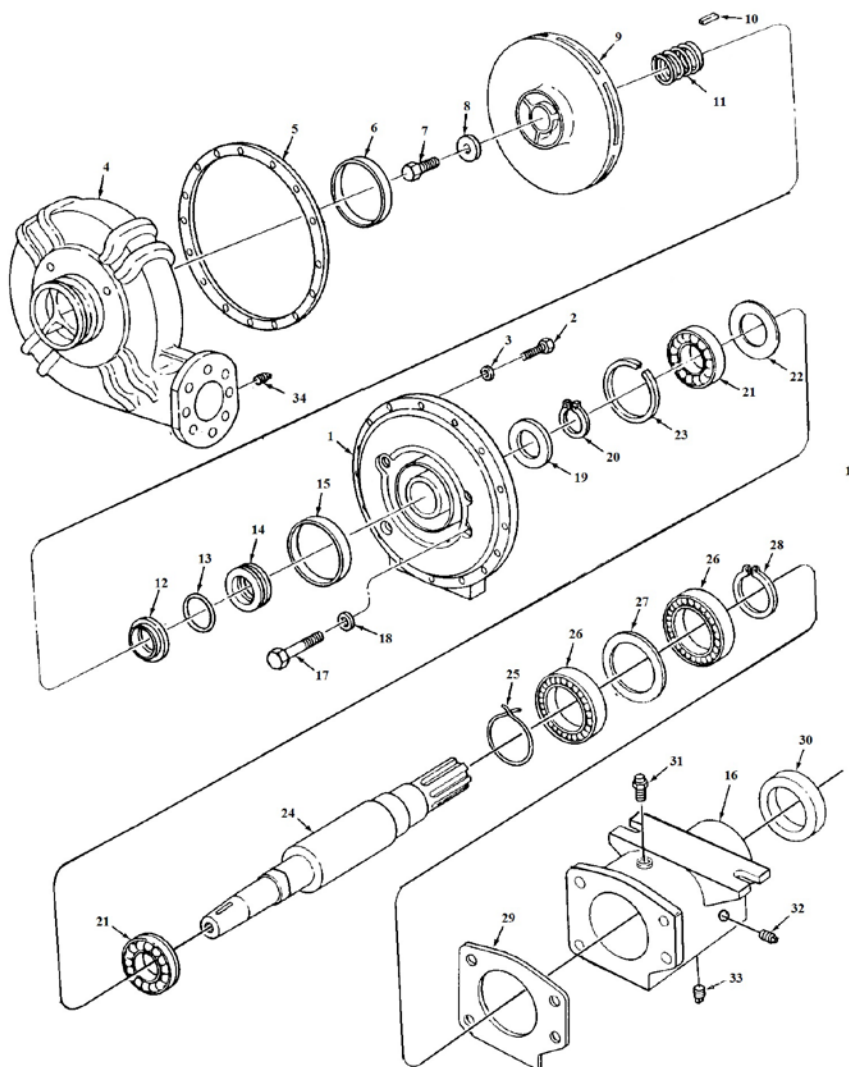


Figure 5-36. Water pump.

If you decide to repair the pump, you must clean all the internal parts with approved cleaning solvents. After soaking parts in solvent, wash away any deposits by flushing or spraying. Where needed, brush with a soft-bristle brush moistened in solvent. Clean any lime deposits, scale, or corrosion on volute body and impeller with a stiff-bristle brush. Use compressed air to dry all parts except the bearings. The bearings must air dry.

**SAFETY NOTE:** *Always* wear personal protective equipment when using cleaning solvents and compressed air!

**WARNING:** NEVER USE GASOLINE TO CLEAN PARTS!

Inspect the impeller for worn or broken vanes. If either condition exists, replace the impeller. Inspect all machined surfaces for small nicks or burrs. Remove nicks and burrs by polishing the marred part with crocus cloth. Inspect the mating surface between seal seat and sealing washer. Replace the entire seal assembly if they are scored or the lip of sealing washer is worn off or damaged.



### *Crash pilot valve*

As you recall, the pilot relief valve is adjustable and controls the discharge pressure during crash-mode operation. When you troubleshoot or adjust this valve, have someone observe the water pressure gauge, or use a discharge pressure gauge while operating the dispensing system in crash mode water operation.

The roof turret on the P-19 fire-fighting vehicle must be open to adjust the crash pilot valve properly. The bumper turret and handline are adjusted properly after adjusting the roof turret to 225 psi. To make an adjustment, insert a handle into the adjusting stem of the valve. Slowly turn the adjusting stem counterclockwise until the relief valve opens and the discharge pressure gauge shows a pressure drop. Now, turn the adjusting stem clockwise until the gauge returns to operating pressure. The relief valve will now operate at the pressure set by the control valve.

If the water pressure does not increase, check for a dirty or restricted orifice. The orifice is located just before the pilot valve. Recheck the system after cleaning a restricted orifice. If the pressure is still low, disassemble the pilot relief valve and inspect the passages in the control body for obstructions. Use a piece of soft wire to clean the passages within the control body.

**NOTE:** You may adjust the pilot valve at any of the three discharge points and achieve the proper system pressure. For operation, the pump pressure should be set at 240 +/- 5 psi.

### *Structural pilot valve*

The structural pilot relief valves directly control pressure relief during crash/structure operation. If low pressure still exists after checking the pilot relief valve and orifice, check the pressure relief valve. If the agent system were drained previously, refill the system, and open all necessary valves to bring the system to operational status. Insert a punch or pin into the pilot control valve's shaft to use as a handwheel. Slowly turn the control valve handwheel clockwise as far as possible. This should bring pump pressure up to 150 psi. Once the pump pressure reaches 150 psi, turn the handwheel counterclockwise until the relief valve opens. Turning the handwheel in and out with pump pressure at 150 psi causes the pressure relief valve to operate. If low pressure still exists, adjust the relief valve. To do this, bring the water pump up to the desired operating pressure using the discharge pressure gauge. Turn the handwheel slowly counterclockwise until the relief valve opens and the discharge pressure gauge shows a pressure drop. Then turn the handwheel clockwise until the gauge returns to operating pressure. The relief valve should operate at the set pressure. If the relief valve does not sustain operating pressure, refer to the appropriate technical manual's troubleshooting chart for assistance in deciding whether to repair or replace the defective component.

## **230. P-19 turret system maintenance**

Turret maintenance normally consists of repairing leaks, replacing and adjusting control cables, adjusting uneven turret water or foam discharge patterns, and replacing defective parts.

### **Roof turret repair**

The P-19 and P-19B roof turrets are remote, manual-type turrets aimed and controlled by an operator from within the cab. An electric toggle switch located on the ceiling must be in the ON position for the turret discharge valve to operate. With the switch ON and after the discharge button has been depressed, water flows through the discharge piping to the roof turret. If either water or foam fails to discharge, the probable cause could be a defective four-way solenoid valve, defective wiring, or defective discharge valve. Figure 5-37 shows an exploded view of the four-way solenoid valve. The valve's purpose is to control air pressure for opening and closing the roof turret foam discharge valve. To ensure proper reassembly, tag or mark all air lines and wires before removing the four-way solenoid valve. After removing the valve, inspect the valve orifice and all air passages in the body for restrictions. Also, inspect the breather for restrictions and the coil for any frayed or broken wires.



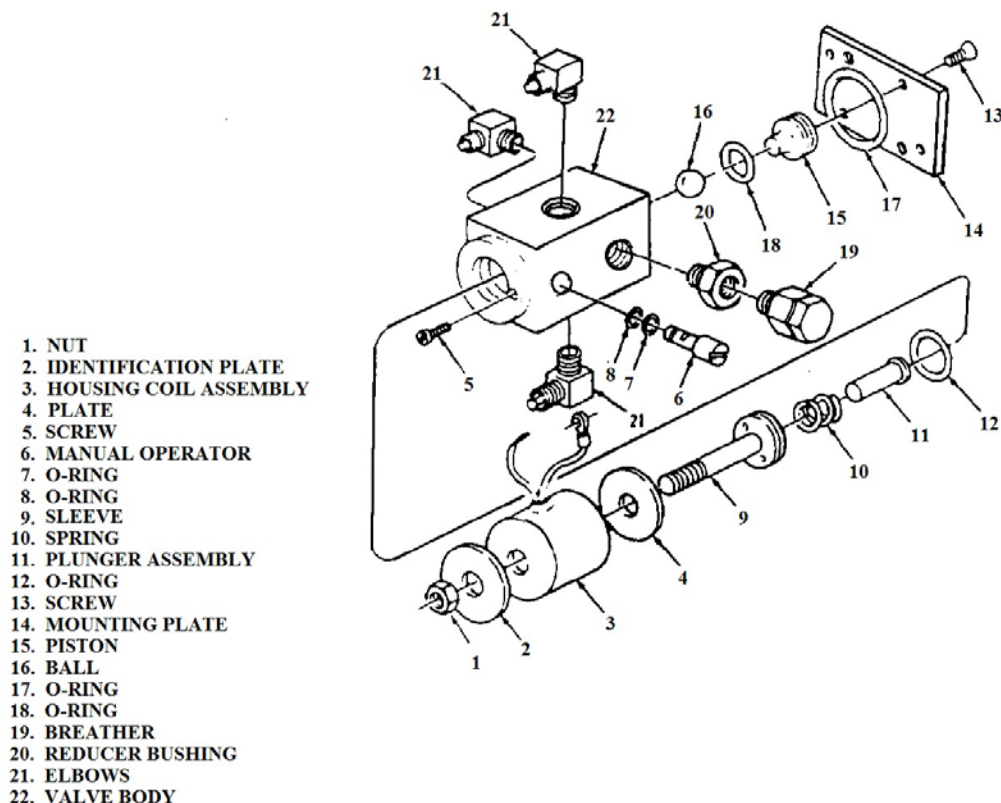


Figure 5-37. Four-way solenoid valve.

The pattern control levers on the P-19 and P-19B are located to the right of the roof turret control column on the interior ceiling. The horizontal and elevation positions of the turret control lever correspond to the position of the turret barrel.

**NOTE:** The ceiling-mounted discharge toggle switch must be in the ON position when using the pushbutton switch on the directional control lever to control roof turret discharge.

If you observe an uneven water or foam discharge pattern in operating the roof turret, it is possible a damaged or dirty turbine or an out-of-adjustment pattern control cable (fig. 5-38) is the problem. When an uneven discharge pattern occurs, inspect and make any necessary adjustments to the pattern cable. If you adjust the pattern control cable, recheck the discharge pattern. The roof turret has a straight stream distance of 175 feet and a dispersed distance of 75 feet. If the pattern is still uneven after you have made all necessary adjustments, use the technical manual instructions to install a new pattern control cable.

**NOTE:** The turret must be elevated to achieve proper distances

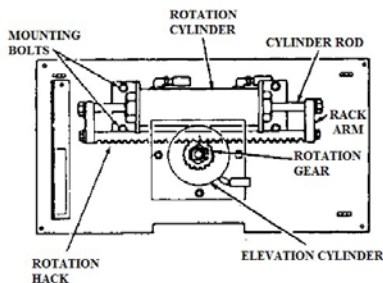
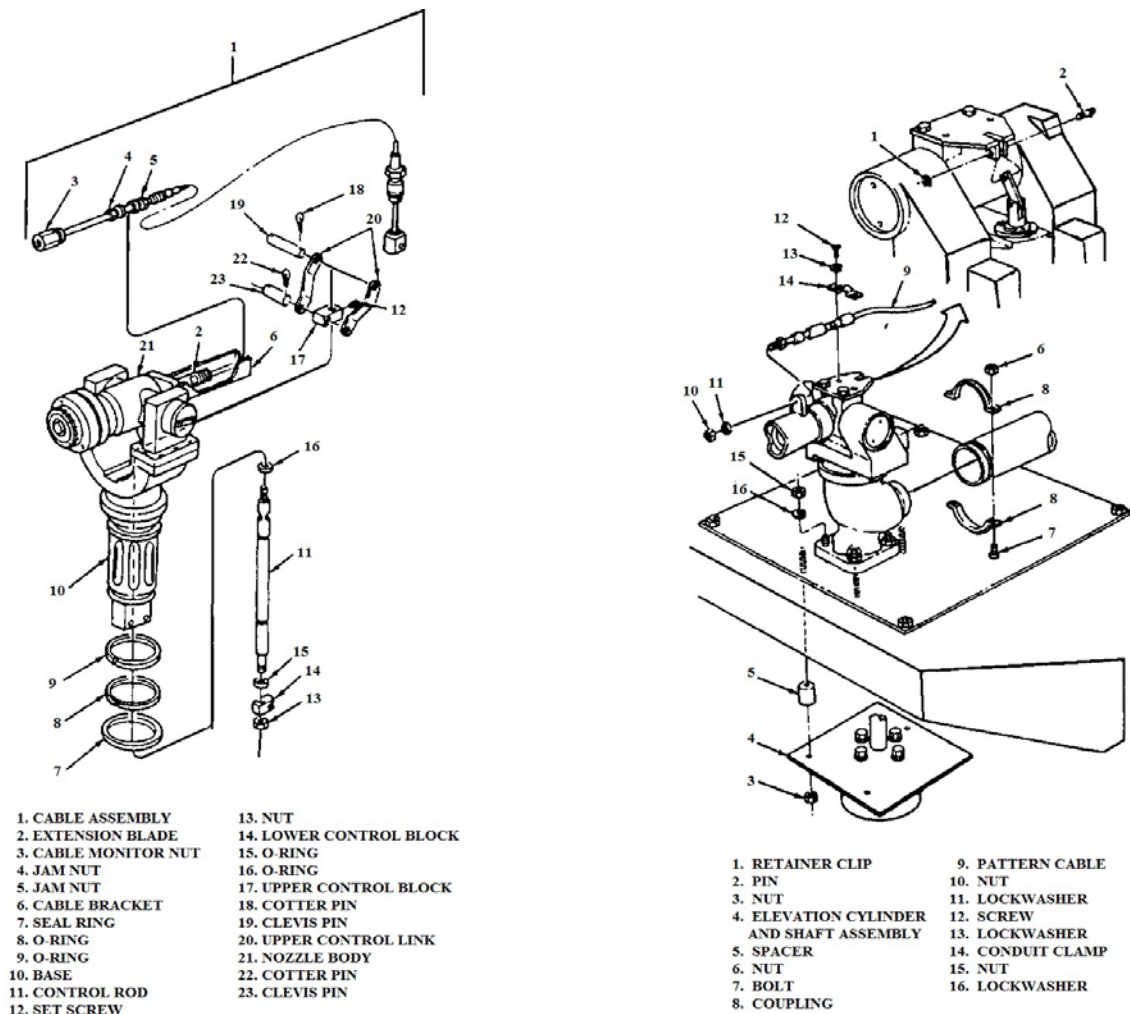


Figure 5-38. Pattern control cable.

If you observe the turret changing discharge pattern by itself from straight stream to wide-angle fog or wide-angle fog to straight stream, the turret has become unbalanced. To correct this problem, add or subtract the 8-32 set screws inside the throat of the turret. You can see these set screws at the outlet

end of the nozzle around the baffle. If the nozzle moves from straight stream to wide-angle fog, remove one set screw at a time until it maintains a straight stream. If the nozzle moves from wide-angle fog to straight stream, add one set screw at a time until it maintains a wide-angle fog. This condition usually happens if you ever need to change the discharge rate of the turret for some reason, but can also occur if one or more of the set screws works loose.

**NOTE.** Install the 8-32 set screws in a symmetrical pattern (opposite sides of the throat from each other).

### Bumper turret repairs

Bumper turret repairs mostly consist of replacing defective parts. If you disassemble the bumper turret, inspect all plastic parts for cracks and distortion. Replace any part failing inspection. Visually inspect internal parts for scratches, nicks, or burrs. If you find scratches, nicks, or burrs, restore the affected part by polishing with crocus cloth. Each time the turret assembly is disassembled, replace all of the packing and O-rings.

### Control cables

The pattern control cable is replaced in much the same manner as the roof turret cable, but it may take more time. Always refer to the appropriate technical order. The bumper turret has an additional cable known as the oscillation cable or, sometimes, the rotation cable. It is operated mechanically by the rotational cylinder, to move a gear rack and control gear with a permanent magnet attached to it. In the oscillation mode of operation, the magnet controls one normally closed and one normally open limit switch (fig. 5-39). The cable, by itself, does not rotate the bumper turret in either the manual or the oscillation mode of operation (fig. 5-40).

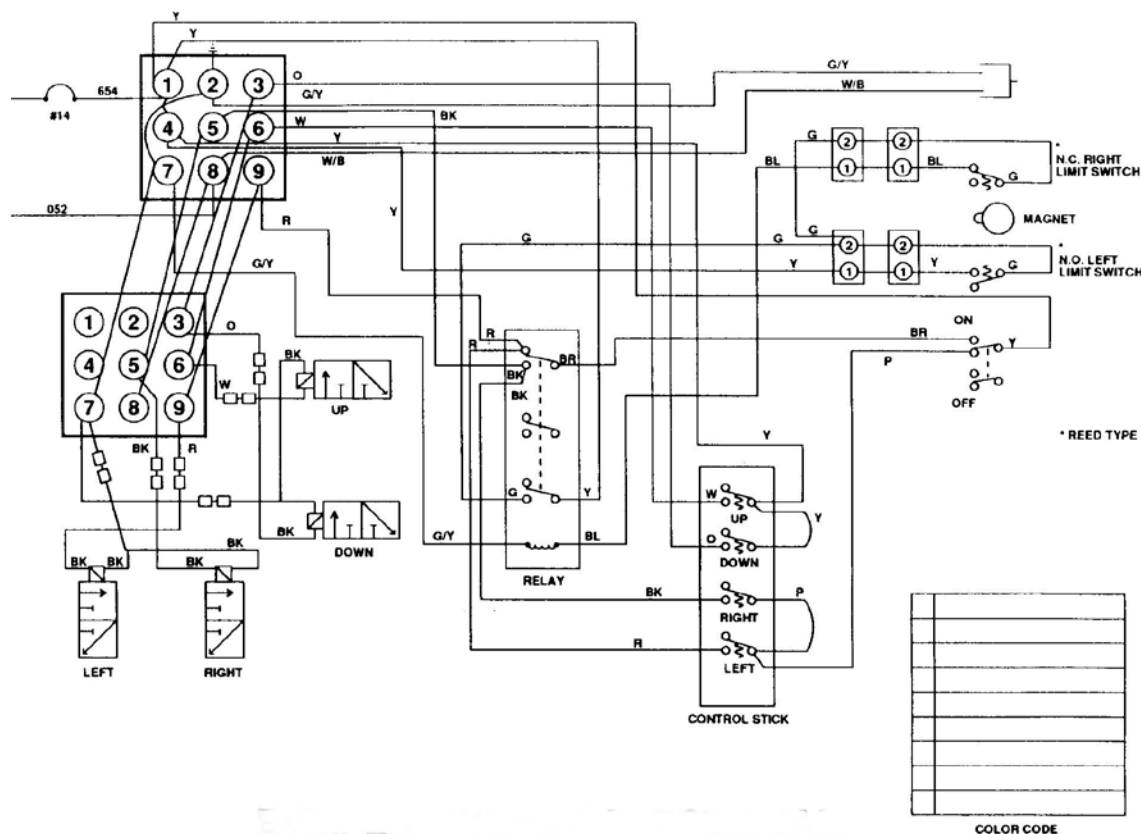


Figure 5-39. Bumper turret electrical.

Clean the cables with a lint-free cloth moistened with solvent. Inspect the cable for flexibility and the condition of the cable jacket. Only the rod seal and hardware items of the cable ends are serviceable. If the turret fails to operate from side-to-side in manual mode, check the microswitches in the control box and the electrical connections. If the turret fails to move from one side to the other side in oscillation mode, check the limit switches and the holding relay for proper operation.

**NOTE:** The system air pressure must be above 90 psi for the turret to operate.

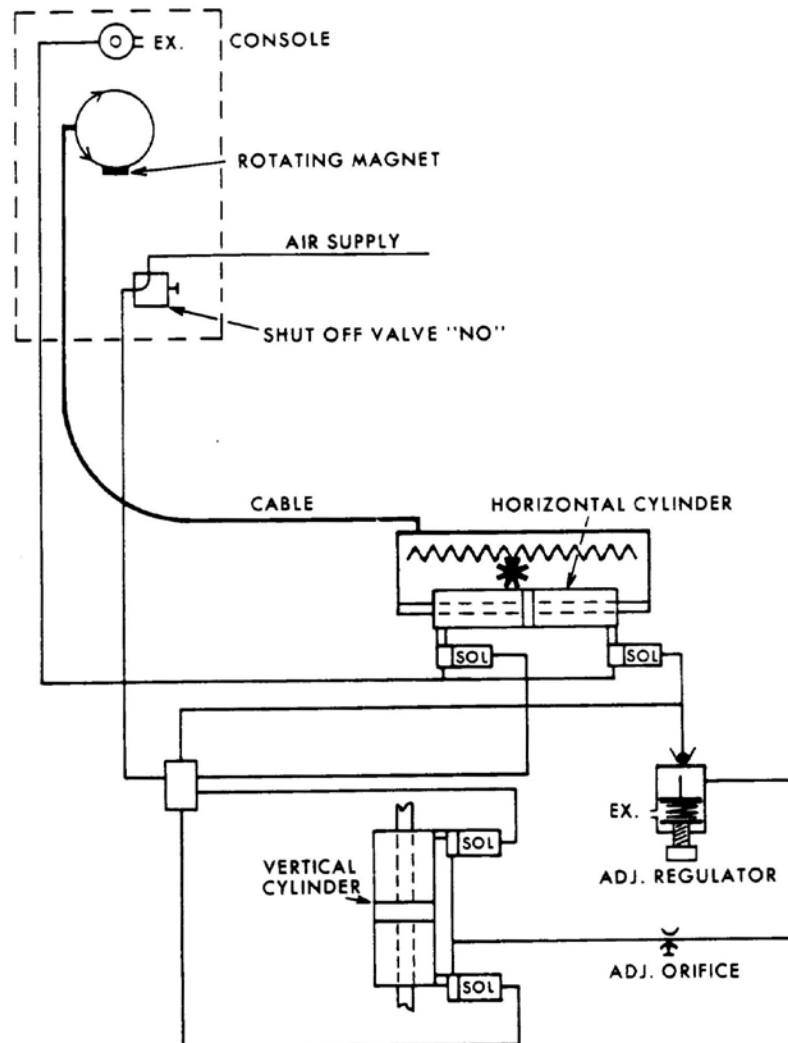


Figure 5-40. Bumper turret air schematic.

## Self-Test Questions

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

### 228. Troubleshooting the P-19 power divider

1. What is the first step for troubleshooting the P-19 modulating clutch?

2. What is indicated if air is present at the modulating clutch release chamber with the agent selector valve in the OFF position?
3. How is the modulating clutch free travel adjusted?
4. When should the modulating clutch inner discs be replaced?
5. Where is the pressure gauge installed when you are troubleshooting the modulating clutch oil pump?
6. What are two malfunctions that can cause low modulating clutch oil pressure?
7. What servicing is required for the P-19 power divider lubrication system?
8. What is a prime indication of the P-19 water or foam pump clutch slippage?
9. What is the first check when troubleshooting the water or foam pump clutch for slippage?
10. What maintenance is required if the pump clutch snaps over with less than 500 psi?
11. What servicing is required on the water pump clutch?

### **229. Troubleshooting the P-19 dispensing system**

1. List five causes for low dispensing system pressure.
2. What malfunction occurs if the inversion valve is not operating properly?
3. What is an indication of a faulty water pump?

4. What is used to clean internal parts of a water pump?
5. What maintenance action is required if small nicks or burrs are found on the internal machined surfaces of a water pump?
6. What should you check for if the water pressure does not increase after adjusting the pilot relief valve?
7. If water pressure is still low after cleaning the pilot relief valve orifice, what is the next maintenance action?
8. What should the discharge pressure be during crash/structure operation?
9. If water pressure is still low after testing the pressure relief valve, what is the next maintenance action?

**230. P-19 turret system maintenance**

1. What possible conditions exist when either water or foam fails to discharge?
2. What is the purpose of the four-way solenoid valve?
3. What is the probable cause of an uneven water or foam discharge pattern, from the roof turret?
4. What is the correct dispersed distance for a properly adjusted pattern control cable on the roof turret?
5. What maintenance action is required when plastic parts on the bumper turret are cracked or distorted?
6. What should you look for when checking the internal parts of a bumper turret?

7. How is the oscillation cable operated?
8. What do you check if the bumper turret fails to operate from side to side in manual mode?

---

## Answers to Self-Test Questions

### 219

1. 400 gallons.
2. Hydraulically driven, self-priming, piston type.
3. 1100 to 1500 psi at 60 gpm.
4. The foam tank is empty.
5. One minute.
6. 140°F.
7. On the driver side of the vehicle, below the structural pump panel.

### 220

1. The battery charger/conditioner and engine block heater.
2. When the vehicle transmission is in park and the parking brake is engaged.
3. When the parking brake is released and any device is opened or deployed.

### 221

1. An electric air compressor and an air tank.
2. At least once a month.
3. Cut off power source.
4. Allow compressor to cool for 30 minutes to allow thermal overload switch to reset.

### 222

1. Insufficient engine power; discharge relief valve not at correct setting; damaged or worn pump.
2. To cool and lubricate the packing.
3. 10 minutes.

### 223

1. The engine.
2. Between the engine and transmission.
3. The water pump clutch wing.
4. A means to safely operate the dispensing system at full engine speed, while driving the truck.
5. Air pressure at a minimum of 90 psi.
6. Dry type, snap overcenter.
7. Reservoir.
8. Flow switch.
9. Collect large debris before the oil returns to the reservoir.
10. Five speeds forward and one reverse.
11. Like a transfer case to transmit torque downward to the front axles.
12. Controlled traction to provide better traction in soft terrain or slippery conditions.



**224**

1. Fiberglass.
2. 130 gallons.
3. A pressure relief valve with a bypass pipe.
4. Multimetering manifold and eductor.
5. To select either foam or water as the agent.
6. Single-stage, centrifugal-type.
7. Whenever the agent selection valve on the dash is in the WATER or FOAM position.
8. The centrifugal pump cannot create its own vacuum.
9. In the piping, on the outlet side of the water pump.
10. 500 gpm at approximately 225 psi discharge pressure at the pump.
11. 250 gpm at 240 psi.
12. A hard hose.

**225**

1. 24 volt.
2. Automatic reset type.
3. Disconnect batteries.

**226**

1. Maintain the temperature in the cab, most compartments, and the engine.
2. Ethylene glycol engine coolant.
3. Three
4. (1) Main system (2) engine subsystem (3) water subsystem.
5. 172°F.
6. Control unit.

**227**

1. Agent selection valve.
2. To direct air pressure.
3. Controls air pressure to an actuating device such as an air cylinder.
4. CONTROLLED.
5. Sequence valve.

**228**

1. Build up full system air pressure.
2. Agent selector valve is defective.
3. By turning the air-chamber clevis.
4. When the facings are worn to the bottom of the groove pattern.
5. On the inlet side of the power divider oil filter housing.
6. Clogged screen in bottom of power divider or a defective lubrication pump.
7. Keeping the lubricating oil at the proper level and changing the oil filter at prescribed intervals.
8. Low or fluctuating water pump pressure.
9. Make sure there is sufficient air pressure.
10. Adjust or replace the clutch.
11. Periodically lubricating the release bearings and clutch engagement shafts.

**229**

1. (1) Improper engine speed, (2) inversion valve malfunction, (3) defective water pump, (4) pilot control valve improperly adjusted, and (5) defective or sticking relief valve.
2. Water pump clutch will not engage, as it should.
3. Excessive noise or vibration.
4. Approved cleaning solvent.
5. Use crocus cloth.
6. A dirty or restricted orifice.
7. Disassemble the pilot valve and inspect passages in control body for obstructions.
8. 150 psi.
9. Adjust the relief valve.

**230**

1. Defective four-way solenoid valve, defective wiring or defective discharge valve.
2. Controls air pressure for opening and closing of the roof turret foam discharge valve.
3. Damaged or dirty turbine or an out-of-adjustment pattern control cable.
4. 75 feet.
5. Replace them.
6. Scratches, nicks, or burrs.
7. Mechanically.
8. Microswitches in the control box and the electrical connections.

**Do 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.

**Do not return your answer sheet to AFCDA.**

51. (219) In the event of loss of discharge pressure, what shuts down the rapid intervention vehicle (RIV) agent pump?
  - a. Low-flow switch.
  - b. Low-pressure switch.
  - c. Pump fail-safe valve.
  - d. Emergency relief valve.
52. (219) How much water/foam solution are the rapid intervention vehicle's handlines capable of delivering?
  - a. 900–1000 psi at 15 gallons per minute (gpm).
  - b. 900–1000 psi at 20 gpm.
  - c. 1100–1500 psi at 10 gpm.
  - d. 1100–1500 psi at 15 gpm.
53. (220) What is the arrangement of the rapid intervention vehicle's (RIV) batteries?
  - a. Two batteries wired in parallel.
  - b. Two batteries wired in series.
  - c. Four batteries wired in parallel.
  - d. Four batteries wired in series.
54. (220) Which conditions must be met before the high idle switch can be activated on the rapid intervention vehicle (RIV)?
  - a. Transmission in neutral, parking brake released.
  - b. Transmission in drive, parking brake released.
  - c. Transmission in neutral, parking brake engaged.
  - d. Transmission in drive, parking brake engaged.
55. (220) What would occur if an operator were to release the parking brake while a device is opened or deployed on the rapid intervention vehicle (RIV)?
  - a. The vehicle will automatically shut down.
  - b. The DO NOT MOVE APPARATUS light will illuminate.
  - c. The transmission will not shift out of neutral.
  - d. The parking brake will automatically re-engage.
56. (221) Which is a possible cause if the thermal overload protector cuts out repeatedly on the Kovatch rapid intervention vehicle (RIV)?
  - a. Blown fuse.
  - b. Faulty circuit breaker.
  - c. Compressor valves failed.
  - d. Ambient temperature too low.

- 
- 
57. (222) What is the desirable leakage rate of the rapid intervention vehicle (RIV) pump packing housing when operating at a discharge pressure of 150 pounds per square inch (psi)?
- a. 10 to 100 drops per minute.
  - b. 50 to 100 drops per minute.
  - c. 10 to 120 drops per minute.
  - d. 50 to 150 drops per minute.
58. (222) When performing a pump packing adjustment on the rapid intervention vehicle (RIV), how long must the pump operate *prior* to observing leakage?
- a. 5 minutes.
  - b. 10 minutes.
  - c. 15 minutes.
  - d. 20 minutes.
59. (222) When performing a packing adjustment on the rapid intervention vehicle (RIV), how much should the packing gland nuts be tightened at one time?
- a. 1/8 turn.
  - b. 1/6 turn.
  - c. 1/4 turn.
  - d. 1/2 turn.
60. (223) What *minimum* air pressure activates the P-19 fire-fighting truck water pump clutch air chamber?
- a. 20 pounds per square inch (psi).
  - b. 40 psi.
  - c. 90 psi.
  - d. 150 psi.
61. (223) Which P-19 fire-fighting truck power divider hydraulic system component supplies the system with 10-weight oil?
- a. Reservoir.
  - b. Pump.
  - c. Engine oil pan.
  - d. Transmission sump.
62. (223) How are the gears and modulating clutch lubricated in the P-19 fire-fighting truck power divider?
- a. Gravity.
  - b. Draft.
  - c. Pressure.
  - d. Splash.
63. (223) The P-19 fire-fighting truck's controlled traction clutch pack is applied when an operator engages the
- a. transmission.
  - b. agent selection valve.
  - c. booster heater switch.
  - d. differential lock switch.

64. (224) Before filling the P-19 fire-fighting truck's water tank from a hydrant you must *first*
- a. disconnect batteries.
  - b. open drain valves.
  - c. close the top hatch.
  - d. open the top hatch.
65. (224) Which P-19 fire-fighting truck's component maintains a set operating pressure within the dispensing system piping?
- a. Pressure relief valve.
  - b. Flow control valve.
  - c. Flow regulator valve.
  - d. Flow monitor valve.
66. (224) When operating the P-19 fire-fighting truck in *crash* mode, what must the engine speed be at before shifting the agent selection valve?
- a. 0 revolutions per minute (rpm).
  - b. full engine rpm.
  - c. midrange rpm.
  - d. idle.
67. (225) The P-19 fire-fighting truck's electrical system is a
- a. 6-volt electrical system.
  - b. 12-volt electrical system.
  - c. 20-volt electrical system.
  - d. 24-volt electrical system.
68. (226) Which P-19 fire-fighting truck's winterization system component circulates the coolant?
- a. Heater cores.
  - b. Booster heater.
  - c. Heat exchanger.
  - d. Circulating pump.
69. (226) Which P-19 fire-fighting truck's winterization system component heats the coolant?
- a. Booster heater.
  - b. Heat exchangers.
  - c. Heater cores.
  - d. Circulating pump.
70. (226) The P-19 fire-fighting truck's high limit temperature switch opens at
- a. 90 degrees Fahrenheit.
  - b. 95 degrees Fahrenheit.
  - c. 195 degrees Fahrenheit.
  - d. 400 degrees Fahrenheit.
71. (227) The P-19 fire-fighting truck uses a three-way control valve that is commonly called the
- a. relief valve.
  - b. pilot relief valve.
  - c. pressure relief valve.
  - d. agent selection valve.

- 
- 
72. (227) Which P-19 fire-fighting truck's air system valve controls air pressure to an actuating device?
- a. Relief valve.
  - b. Agent selection valve.
  - c. Inversion valve.
  - d. Air double-check valve.
73. (227) The P-19 fire-fighting truck's air system inversion valve piston is forced back to the normal position by
- a. a cable.
  - b. a spring.
  - c. the agent selection valve.
  - d. the air double-check valve.
74. (227) The P-19 fire-fighting truck's sequence valve is
- a. hydraulically operated.
  - b. electrically operated.
  - c. normally closed.
  - d. normally open.
75. (228) If the P-19 fire-fighting truck's clutch lubrication system has low oil flow, the operator is notified by
- a. an illuminated red light.
  - b. an audible buzzer.
  - c. an audible horn.
  - d. a gauge.
76. (228) When troubleshooting the P-19 fire-fighting truck's water pump clutch for slippage, your *first* troubleshooting step is to check if air pressure is
- a. 60 pounds per square inch (psi) or lower.
  - b. 80 psi or lower.
  - c. 90 psi or higher.
  - d. present at the chamber.
77. (229) Why would there be low flow while dispensing water or foam with the P-19 fire-fighting truck?
- a. A faulty fuse.
  - b. Low hydraulics.
  - c. High electrical output.
  - d. Improper engine speed.
78. (229) Why would there be excessive noise or vibration at the P-19 fire-fighting truck's dispensing system water pump?
- a. Worn impeller.
  - b. Leaking O-rings.
  - c. Broken return spring.
  - d. Worn drive shaft bearings.

79. (230) What *must* be done to ensure proper reassembly of the P-19 fire-fighting truck's four-way solenoid valve?
- a. Mark the bolts.
  - b. Tag the bolts.
  - c. Tag or mark the bolts.
  - d. Tag or mark air lines and wires.
80. (230) The recommended procedure for cleaning the cables on a P-19 fire-fighting truck's dispensing system bumper turret is to
- a. use compressed air.
  - b. wipe them with a crocus cloth.
  - c. wipe them with a lint-free cloth moistened with solvent.
  - d. soak them in an approved solvent and dry them with air.

**Please read the unit menu for unit 6 and continue ➔**



## Unit 6. Expeditionary Fuels Equipment

<b>6-1. Fuels Mobility Support Equipment.....</b>	<b>6-1</b>
231. R-14 Air Transportable Hydrant Refueling System .....	6-1
232. R-22 trailer-mounted transfer pump assembly .....	6-4
233. FFU-15E filter separator .....	6-7
234. TPI-4T-4A additive injector .....	6-9
235. PMU-27M Air-Transportable Trailer-Mounted Refueling System .....	6-10
236. Aerial Bulk Fuel Delivery System .....	6-12
237. Fuel bladders.....	6-15
238. Forward area manifold cart .....	6-16
<b>6-2. Fuels Operational Readiness Capability Equipment.....</b>	<b>6-22</b>
239. R-18 pumping unit .....	6-24
240. R-19 filter separator unit .....	6-31
241. R-20 multi-aircraft servicing platform .....	6-32

**T**ODAY'S AIR FORCE is more agile than ever, deploying to and operating from bases around the world. These installations may be fully developed with all the amenities and support capabilities of a contiguous United States assignment, or a bare base with nothing more than a runway, a potable water source, and a few tents. When a bare base is established, one of the top priorities is providing a fuels initial operating capability. Under these conditions, effective fuels management is essential to meeting mission requirements. This unit will cover the fundamentals of two types of expeditionary fuels equipment you may encounter while deployed. We will begin with fuels mobility support equipment (FMSE), and follow it up with its successor, known as fuels operational readiness capability equipment (FORCE).

### 6-1. Fuels Mobility Support Equipment

FMSE is included in the war reserve materiel (WRM) bare base support system, and is specially designed to support contingency locations and operations. All USAF FMSE is air transportable in C-130 or larger aircraft. Other than routine operations for inspection, maintenance, and school training, FMSE is not used or moved without the approval of Headquarters USAF. This section covers the major items that comprise the FMSE system.

#### 231. R-14 Air Transportable Hydrant Refueling System

The R-14 Air Transportable Hydrant Refueling System (ATHRS) is the prime item of fuel support equipment for the Air Force. It is capable of receiving, storing, and distributing large quantities of fuel to aircraft at remote airstrips. There are four advantages of the R-14 system:

1. Easily deployed.
2. Quickly operational upon arrival at destination.
3. Performs various fueling operations.
4. Three R-14 modules can be transported in one C-130 aircraft.

The R-14C has the capability of servicing large aircraft like the KC-135 and B-1 at the rate of 600 gpm. One module can service two fighter aircraft at one time at a combined flow rate of 200 gpm.

There are three types of R-14 systems: the R-14A, R-14B, and the R-14C. While all three systems are similar, this lesson focuses on the newest of the three models, the R-14C (fig. 6-1). Consult the

applicable technical orders for detailed explanation of the operating and maintenance procedures of the R-14A or R-14B ATHRS you may be using.

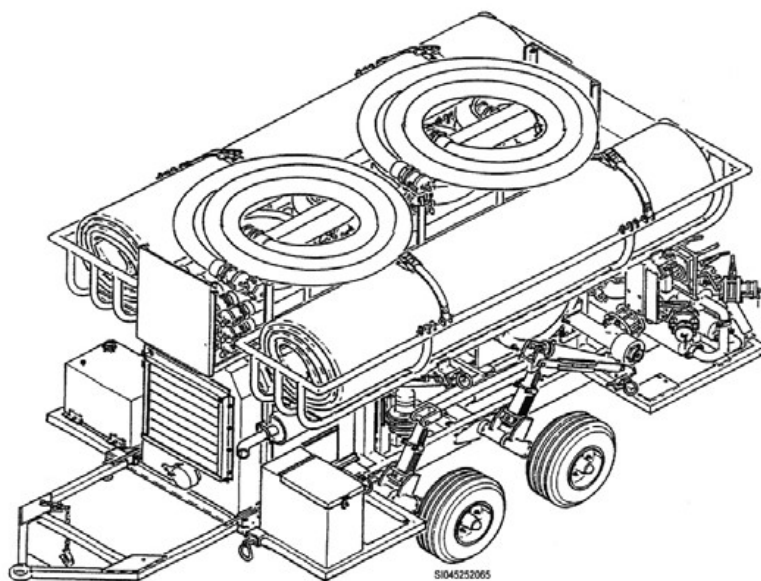


Figure 6-1. R-14C air transportable hydrant refueling system.

### Purpose

The R-14C is a modular, mobile, high-flow, large storage capacity “bare base” fuel system. It consists of one servicing module that weighs approximately 10,500 pounds without tanks. This permits flexibility for use in support of the flying mission. The R-14C primarily services aircraft where permanent systems are not available.

### Components

An R-14C fuel-servicing module has two 50,000 gallons, collapsible, coated-fabric fuel tanks stowed in the cradle assemblies on top of the module. By using the winch assembly located on top of the module, you can load and unload the fuel tanks, cradles, and hose rack. Fueling hoses are provided in various lengths and sizes so that, when the module is coupled with the appropriate adapters and nozzle assemblies, a variety of fueling configurations can be provided (e.g., servicing two fighter aircraft at the same time). The fueling assemblies are equipped with cam-lock fittings, female at one end and male at the other. All fittings have dust plugs or caps.

A diesel engine drives the module pump. Fuel-defuel manifolds and butterfly valves direct fuel-flow from the module. As the fuel pumps, a positive-displacement meter measures it. The filter separator located in the piping between the pump and the meter assures the issue of clean, dry fuel to the aircraft or equipment being serviced. The module also contains a deadman control flow and pressure system. The components are mounted on a trailer assembly consisting of a welded frame assembly supported by a retractable running gear assembly.

The control panel, deadman control valve and hose reel, function-selector butterfly valves, and other controls and indicators for unit operation are arranged across the rear of the trailer for maximum operator convenience and efficiency and safety during operation. Two fire extinguishers are mounted at the operator position. Let's take a closer look at some of these components.

### ***Frame assembly***

All major functioning components on the module are mounted on a four-wheel, tandem-axle, spring-mounted chassis assembly. The chassis incorporates a skid-type base on which the module rests during operation. Pneumatic air control knobs or manually operated hydraulic hand pumps pressurize hydraulic cylinders on each side of the chassis to raise the entire module to the three mobility positions: high, medium, and low. Relief of hydraulic pump pressure allows the module to settle to the retracted position. The high position is used for clearing ramps and other surface obstructions. Normally, the medium position is used for towing the unit over rough terrain. The low position is used to tow over smooth surfaces or to clear an overhead obstruction when necessary. All major functioning components are removable from the chassis assembly for maintenance and/or replacement.

### ***Pump***

A centrifugal, self-priming pump on the module is self-lubricating and delivers 600 gpm at 2,400 rpm with a discharge pressure of 110 psi.

### ***Engine***

A multi-fuel diesel engine drives the module pump. The engine is a three-cylinder, in-line, two-stroke diesel, with fuel injection. It is rated at 95 hp at 2,800 rpm. It is constructed of a steel block and heads, is liquid cooled, and operates on diesel or jet fuel. The engine operates from one 24-volt battery, which makes it a 24 VDC electrical system.

### ***Basket strainer***

The 80-mesh basket strainer is located on the inlet side of the pump. It functions to trap and remove large particles of solid contamination from the fuel before it enters the pump and filter/separator.

### ***Filter separator***

The filter separator incorporates six American Petroleum Institute® filter elements and two Teflon™ screen canisters. Together, they remove suspended solid contaminants and water from the fuel. A float control valve starts a process that stops fuel flow if the amount of water in the filter/seperator gets too high. A manual valve drains water from the sump. A manual vent valve is installed on the air eliminator to vent off vapors until the filter/seperator is full of fuel.

### ***Deadman control and pressure system***

The deadman control system consists of a regulator air compressor, air dryer, air receiving tanks, three-way valve for switching between flow settings, two pressure regulators (one for high flow and one for low flow), quick dump valve, 100 feet of twin weld hose, and associated fittings necessary to connect all components.

The pressure control system consists of a main pressure control valve with a surge control pilot valve and a Venturi assembly with needle valve adjustment. There is an adjustable pilot valve for control of low flow at 100 gpm, an adjustable pilot valve for limiting high flow at 600 gpm, and an adjustable pilot valve for setting nozzle pressure. To switch the control system from high flow to low flow, there is an on/off pilot valve. Additionally, there is another on/off pilot valve to stop fuel flow in the event water in the filter/seperator exceeds normal levels.

### ***Meter***

A positive displacement meter rated at 600 gpm measures fuel output. The meter has a totalizer to permit proper accounting when it is used in field conditions.

### Control panel

A control box with a weather-tight cover has been installed on the operator's end of the module (fig. 6-2). Within the box are all the switches, controls, indicators, and gauges required to start and control the engine and pump. The electrical components are sealed hermetically and the entire control panel is shock mounted to the frame.

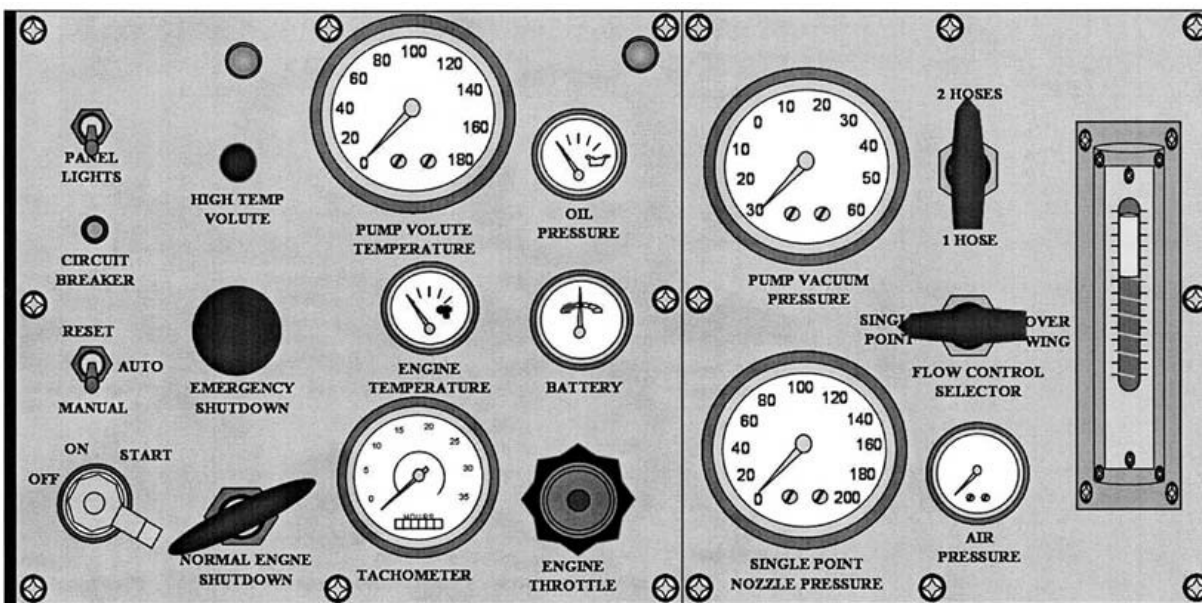


Figure 6-2. R-14C control panel.

### Refuel/defuel manifold

The refuel/defuel manifold, located below the control panel, incorporates wafer valves, and inlet and outlet connections to set up the module to perform its various functions:

- Fuel through one single-point nozzle at 600 gpm at 2,200 rpm.
- Fuel through two single-point nozzles at 300 gpm each at 2,200 rpm.
- Fuel through one 2-inch overwing nozzle at rates up to 100 gpm at 1,000 rpm.

### Fuel bladders

The R-14C is equipped with two 50,000-gallon bladders made of a single-ply, nylon fabric with reinforced corners. When completely unrolled, a 50,000-gallon bladder measures 24 feet by 65 feet.

Each tank is equipped with a fill-discharge assembly at either end of its top surface. Each tank has a tank vent-pipe assembly located on the center of the top surface, which allows the tank to breathe and allows for the removal of water.

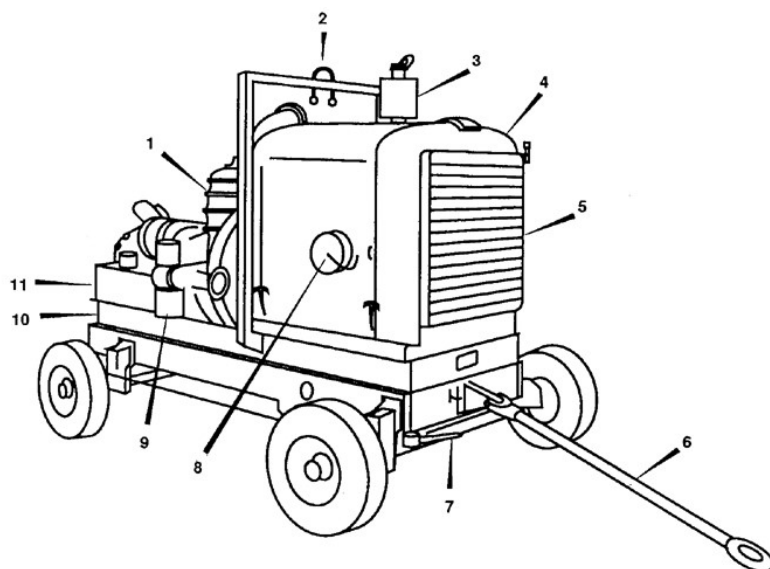
### Winch

The R-14C is shipped with 50,000 gallon, collapsible, coated-fabric fuel tanks in the tank cradles. The winch removes and installs the tank cradles in the vertical member on either side of the upper frame assembly.

## 232. R-22 trailer-mounted transfer pump assembly

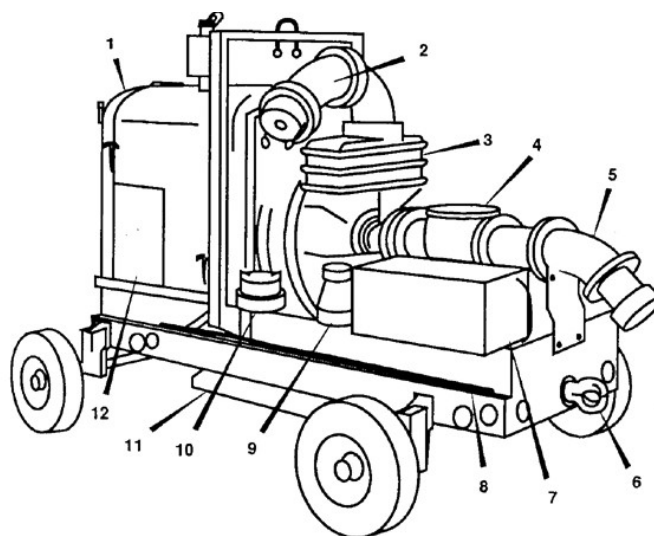
The R-22 (figs. 6-3 and 6-4) is a self-contained, trailer-mounted pumping unit powered by a multi-fuel diesel engine. It has no filtering or pressure control system, and therefore is *not* authorized for

use in direct aircraft servicing, except when used in conjunction with MH-2 series hose carts or an FFU-15E filter separator.



- |                     |                        |                    |
|---------------------|------------------------|--------------------|
| 1. CENTRIFUGAL PUMP | 5. SHUTTER ASSEMBLY    | 9. DISCHARGE VALVE |
| 2. LIFTING BAIL     | 6. DRAWBAR             | 10. FRAME          |
| 3. MUFFLER          | 7. PARKING BRAKE LEVER | 11. FUEL TANK      |
| 4. ENGINE           | 8. HEATER ADAPTER      |                    |

Figure 6-3. R-22 trailer-mounted transfer pump (front view).



- |                              |                   |                           |
|------------------------------|-------------------|---------------------------|
| 1. ENGINE                    | 5. SUCTION PIPING | 9. REDUCER                |
| 2. DISCHARGE PIPING          | 6. PINTLE HOOK    | 10. REDUCER               |
| 3. PUMP BODY                 | 7. BATTERY BOX    | 11. PARKING BRAKE LINKAGE |
| 4. SUCTION STRAINER ASSEMBLY | 8. GROUNDING ROD  | 12. CONTROL PANEL DOOR    |

Figure 6-4. R-22 trailer-mounted transfer pump (rear view).

### Purpose

The R-22 rapidly and safely pumps large quantities of fuel under any operating condition at a maximum capacity of 600 gpm. The R-22 also can transfer fuel from the bulk storage area to the operating storage area.

### Components

This trailer-mounted unit consists of a centrifugal pump powered by a three-cylinder, multi-fuel engine. It has a basket strainer, control panel, fuel tank, and accessories. The unit is 6 feet, 6¼ inches in height, 5 feet, 6-inches in width, and 9 feet, 6-inches in length (drawbar folded up) or 13 feet, 6-inches in length (drawbar extended). It weighs 2,290 pounds. Let's take a closer look at each of the components of the R-22 unit.

### Pump

The centrifugal pump is self-lubricating and self-priming. If the unit is dry, you need to prime it before operation; to do this, use the port above the pump inlet. There is a second port on the pump casting used to drain the unit for shipment or storage.

The pumping rate and the discharge pressure for the R-22 varies with the rpm. The following table identifies the discharge pressures and the gpm rates the R-22 is capable of pumping at various rpms:

RPM	Differential Pressure (DP)	GPM
1,000	10 psi	100
1,300	28 psi	220
1,500	30 psi	310
1,800	45 psi	400
2,000	60 psi	470
2,400	85 psi	600

### Engine

The diesel engine is a two-stroke cycle, water-cooled, three-cylinder, multi-fuel engine protected by a housing with side panels to allow access to the engine. Louvers covering the radiator help regulate engine temperature. During cold weather starting, you can use either ether or forced air heating on the engine housing to accelerate startup.

### Tank

The trailer mounted unit fuel tank has the following components attached:

- A strainer mounted in the filler opening.
- An external fuel gauge mounted on one end of the tank.
- A float valve, which allows fuel from the discharge side of the pump to fill the engine tank.
- Two three-position valves located on the top of the tank to allow the use of unit fuel, auxiliary fuel (hoses are provided for this operation), and off positions.

### Strainer

A 6-inch, 60-mesh basket strainer is installed upstream from the pump to protect the pump by removing sediment.



### Control panel

The control panel is enclosed in a weatherproof box, which should be closed when not in operation. There are five indicators on the panel:

1. rpm/hourmeter.
2. Amp meter.
3. Engine oil pressure.
4. Engine temperature.
5. Pump discharge pressure.

In addition, the panel has an engine start switch and an ether injector knob to aid in cold weather starting. There is an engine stop handle, which stops the fuel flow to the engine. The throttle also is located on the control panel, and has a locking ring and a quick-shutdown button. The panel lights are located above the pump discharge pressure gauge.

### Accessories

The accessories consist of two reducers and a grounding rod (all mounted on the chassis) and one 4-inch gate valve.

### 233. FFU-15E filter separator

The FFU-15E (fig. 6-5) is a skid frame mounted vessel intended for use as an integral part of a fueling system.

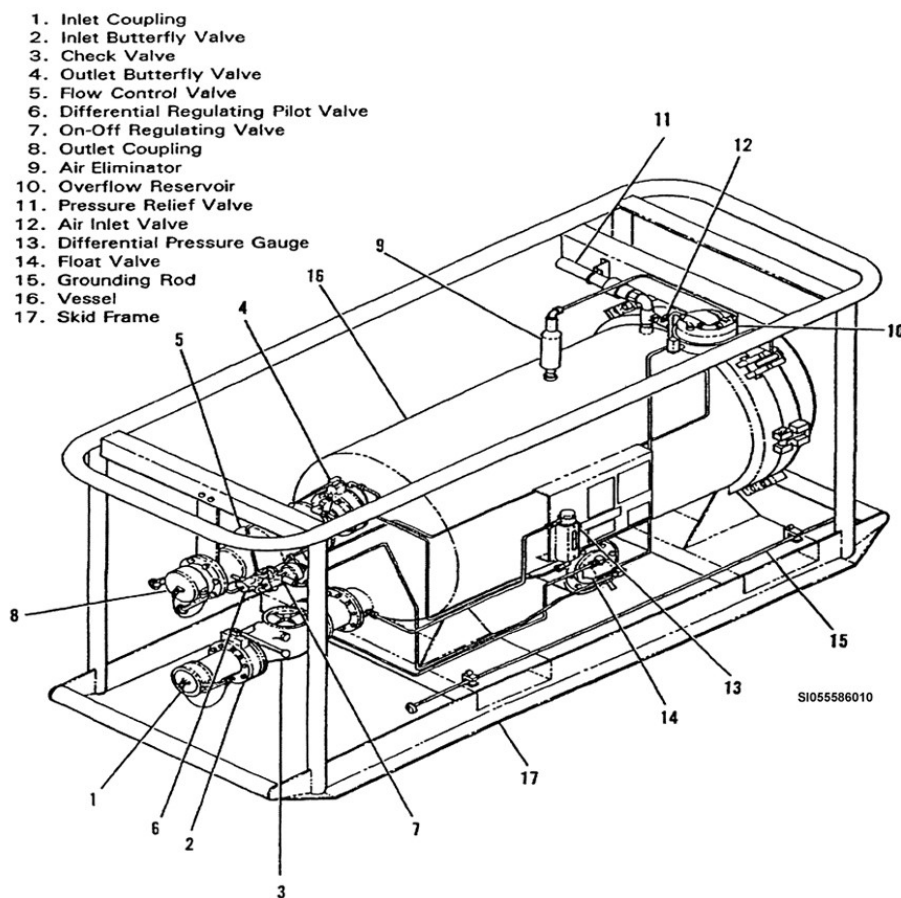


Figure 6-5. FFU-15E filter separator.



The FFU-15E is shipped fully assembled and only requires removal from the shipping container and inspection before being placed in service. It can be used with other military branches' equipment to provide increased flexibility in fuels operations.

### Purpose

The FFU-15E filters particles and separates water from fuel. It can filter petroleum fuels at a rate of up to 600 gpm. The FFU-15E can be configured for use with many different systems to provide clean, dry fuel.

### Components

The FFU-15E filter separator is equipped with an air eliminator, six elements, two canisters, a float valve, a flow control discharge valve, two pilot valves, a pressure relief valve, a DP gauge, and quick disconnect type inlet and outlet couplings. Let's take a closer look at these components:

FFU-15E COMPONENTS	
Item	Description
Elements	The 6 elements in the filter/separator filter out solid contaminants from the fuel and perform coalescing action (causes water in the fuel to form into comparatively large drops). Change the elements when 20 psi differential is reached or three years, whichever comes first.
Canisters	The canisters are constructed of aluminum. On the outside of each canister, there is a 100-mesh, Teflon™-coated screen that does not filter, but does repel water that has formed into drops by the coalescing action of the elements, and at the same time permits the fuel to pass through.
Float valve	This valve prevents the discharge of water from the FFU-15E. The float valve has two positions: HIGH and LOW. As with float valves on other filter separators you've encountered, when the float is in the low position, fuel is allowed to pass through the unit. When water collects in its chamber and raises the float to the HIGH position, it transmits fuel pressure to the on/off regulating pilot valve, which in turn closes the flow control valve. The flow control valve remains closed until the water level drops.
Manual sump drain valve	This valve drains water and sediment from the unit manually.
2-inch sump drain valve	This valve drains the contents of the filter separator rapidly. This valve is most commonly used to drain the unit for element replacement.
Air eliminator safety valve	This valve allows air to vent from the unit. Close the valve if the air eliminator fails.
Air eliminator reservoir	This reservoir captures any fuel escaping from the air eliminator and returns it to the system.
Reservoir relief valve	This valve allows the air eliminator reservoir to empty back into the system.
Inlet and discharge wafer valves	These valves isolate the FFU-15E from the fuel system.
Check valve	This valve, located on the inlet side of the unit, prevents the reverse flow of fuel.
Flow control valve	This valve, located on the discharge side of the unit, performs two functions. <ol style="list-style-type: none"> <li>1. Closes when excess water is detected in the sump.</li> <li>2. Limits total flow to a preset rate.</li> </ol>

FFU-15E COMPONENTS	
Item	Description
	<p>This valve has two pilot valves which help it accomplish these functions:</p> <ol style="list-style-type: none"> <li>1. On/Off regulating valve — As mentioned earlier, when the float valve reaches the HIGH level, it forces fuel pressure to the on/off regulating pilot valve, which in turn closes the flow control valve to prevent water from being dispensed.</li> <li>2. Differential regulating pilot valve —regulates the maximum flow through the filter separator to 600 gpm.</li> </ol>
Sight gauge	Use this to determine if there is water in the sump.
DP gauge	This gauge indicates the difference between the inlet and outlet pressures of the unit.
Sampling connections	The FFU-15E has two sampling connections. One is on the inlet side of the unit, while the other is located on the discharge side of the unit. Laboratory personnel use these connections to take in-line samples for analysis.

### 234. TPI-4T-4A additive injector

There are situations during fuels operations when you must manually add chemicals to your fuel supply to bring the fuel system icing inhibitor (FSII), conductivity, or corrosion inhibitor content up to the acceptable use limits listed in TO 42B-1-1, *Quality Control of Fuels and Lubricants*. The TPI-4T-4A portable additive injector is designed to do this task (fig. 6-6).

#### Purpose

The TPI-4T-4A additive injector is designed to inject multiple fuel additives at different blending ratios simultaneously. It can handle up to four separate additives at different ratios, and its special dual-ratio gear reduction allows for a very wide range of injection ratios.

Extremely low ratios, such as those found in antistatic agents and corrosion inhibitors, can be injected simultaneously with very high ratio additives, such as anti-icing agents.

#### Components

The TPI-4T-4A injector is mounted in a rugged skid enclosure. Every part of the system is designed for rough, portable service. The TPI-4T-4A has a variety of fuel hose connections and additive source lines. The TPI-4T-4A can be rapidly deployed to draw additive from either custom tanks or standard drums. The following table identifies some of the characteristics of the TPI-4T-4A.

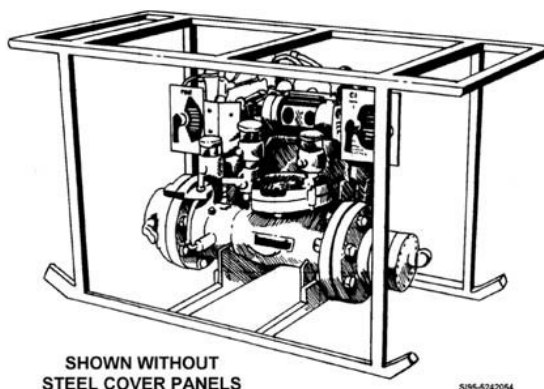


Figure 6-6. TPI-4T-4A additive injector.

Characteristics of the TPI-4T-4A Injector	
No external power	The efficient TPI-4T-4A fluid-powered turbine “borrows” just enough energy from the flowing product line to do the job. There is no need for an external electricity source, air, or pressurized additive lines.
No controls	The TPI-4T-4A automatically operates when the rest of the system operates. There is no need to remember to turn the injector on or off. When it is connected to a system, the injector “remembers” when to run, how much to run, and when to stop. The operator has nothing to remember, nothing to adjust, and nothing to forget.
No meters	Because the fluid-powered turbine acts as a meter, it requires no directions, pulses, or controls from outside meters. The turbine responds smoothly to changes in flow rates, maintaining accurate injection ratios over the full range of the system’s operating conditions.
Better blending	Unlike some systems that inject large slugs into the product at metered intervals, the TPI- 4T-4A injector continuously dispenses the precise amount of additive that matches the product flow rate. There are no gaps in the injection process. Since the injection point is usually upstream of the turbine, thorough blending of product and additive is achieved.
On/Off operation	The TPI-4T-4A is passive in that it operates when product passes through the turbine. When flow stops, injection stops. The system maintains the proper ratio throughout the entire operating range. If additive is not desired, a simple on/off valve is standard. Additive can be turned off or on selectively at any time during a product transfer.
Additive supply	To provide an adequate supply of additive, flooded suction is preferred (moderate suction lift is acceptable) and the supply should not be pressurized. The TPI-4T-4A draws additive from any size container with special adapters available for factory additive containers.
Ratio stability at low flows	Even if startup and shutdown flow rates are below stated minimums, the unit can be calibrated to maintain overall ratios. The system maintains the ratio for the total product throughput.

### 235. PMU-27M Air-Transportable Trailer-Mounted Refueling System

The PMU-27M (fig. 6-7) is a four wheeled towable unit designed to pump aviation and ground fuel. It is also capable of issuing ground products. When used in conjunction with the 117 mobility readiness spares package (MRSP) kit, the PMU-27M refueling system can be set-up as a bare base service station and can issue fuel from one 10,000-gallon collapsible bladder, four 500-gallon sealed drums, or four 55-gallon steel drums.

#### Purpose

The primary purpose of the PMU-27M pumping assembly is to pump and deliver fuel at a rate of 50 gpm. It is designed to support the transfer of small quantities of fuel and, secondarily, to support the servicing of small aircraft. It is also capable of defueling four 55-gallon drums simultaneously, pumping from an external source, and defueling aircraft auxiliary tanks.

#### Components

The pumping assembly is a four-wheeled towable unit consisting of the following components:

- A gasoline or multi-fuel diesel engine.
- A 50-gpm pump.
- Suction and discharge hose assemblies.

- Two line strainers.
- Filter separator.
- DP and outlet pressure gauges.
- Meter register.
- Drum off-loading valves.
- Discharge nozzle.
- Static grounding reels.
- A sampling connection.

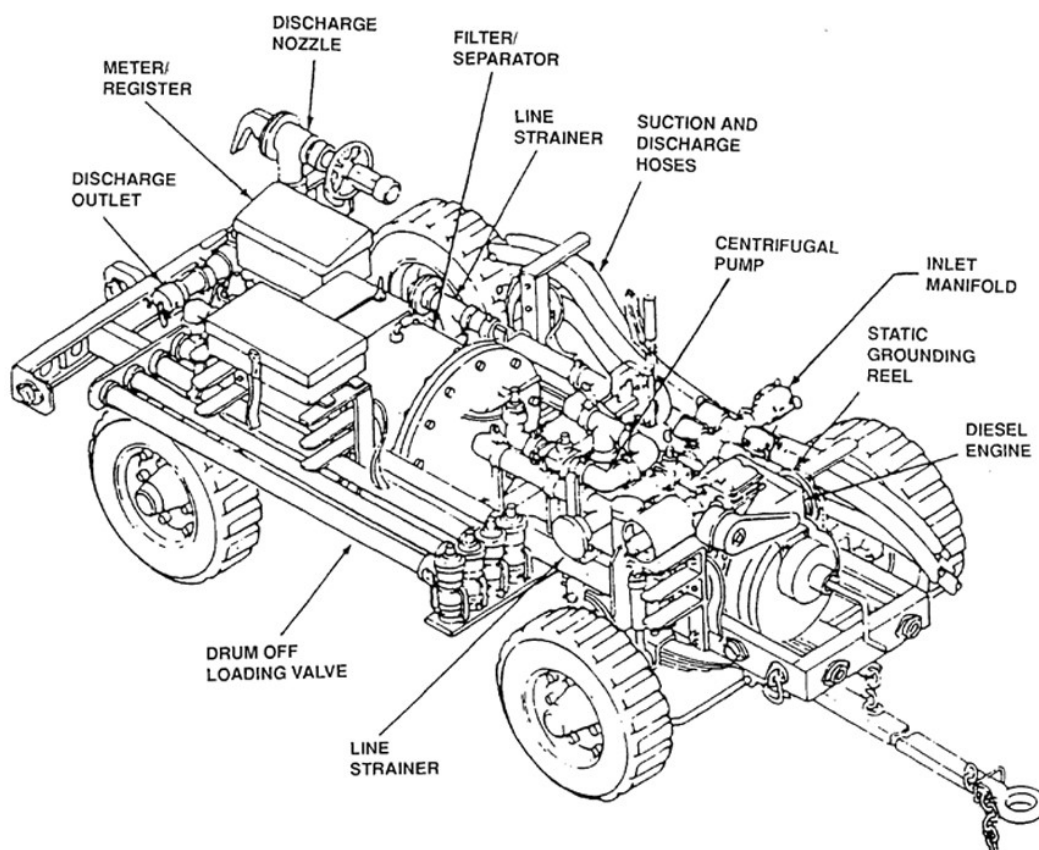


Figure 6-7. PMU-27M Air-Transportable Trailer-Mounted Refueling System.

A three-way stubbed valve bypasses the filter separator and meter register during fueling operation. A 50-foot static ground reel is mounted on the unit. Let's cover each of the pumping assembly components and the functions they perform.

#### *Engine and pump assembly*

The centrifugal, self-priming pump on the unit is capable of delivering 50 gpm at 3,600 rpm, with a pump discharge pressure of 35 psi. The pump is self-lubricating, and it is driven by a gasoline or multi-fuel diesel engine. The engine is a one-cylinder, two-stroke, fuel-injected engine rated at 6.5 hp at 3,600 rpm. The PMU-27M is equipped with a 3½-gallon fuel tank.

### *Filter separator*

A filter separator removes water and contaminants from the fuel. The filter separator contains three filter elements and one Teflon screen. The elements are made of a fabric coalescent sock and a fiberglass filter element. A manually operated air eliminator eliminates all the air trapped in the filter separator. Also provided are automatic and manual water drain valves to prevent water buildup in the filter separator.

### *Meter and valves*

A positive-displacement meter, rated at 50 gpm and equipped with a digital readout measures the fuel. The flow control valve consists of two controls and a valve connected together with tubing and fittings. Also, the unit has an inlet valve that controls the flow of fuel from the suction hoses to the pump. The three-way stubbed valve controls the flow of fuel from the pump to the filter separator and bypass of the filter separator. A priming valve facilitates priming. A manual water drain valve, an air eliminator valve, and a sampling connection valve are also incorporated into this unit.

### *Gauges*

The PMU-27M is equipped with two gauges:

1. The DP gauge on the filter separator indicates the difference between the inlet and outlet pressures. This pressure cannot exceed 15 psi.
2. The discharge pressure gauge indicates the outlet pressure from the pump. A normal reading should be 35 psi.

## **236. Aerial Bulk Fuel Delivery System**

The Aerial Bulk Fuel Delivery System (ABFDS) delivers fuel by air to forward operating locations in a cargo aircraft when resupply by other methods is not possible. These operations are commonly referred to as “Bladder Bird” missions. The ABFDS can be installed on C-130, C-5, and C-17 aircraft.

### **Purpose**

The ABFDS deliver fuel when resupply by other possible methods of fuel delivery is not possible. The ABFDS can be installed on C-130, C-5, and C-17 aircraft. When used on a C-130, the system is made up of two 3,000-gallon tanks, while on the C-17 the system is made up of three 3,000-gallon tanks. When used on the C-5, the system uses 10 3,000-gallon tanks. ABFDS systems can be modified with alternate capability equipment (ACE) to refuel aircraft directly from the ABFDS.

### **Components**

The ABFDS system consists of aerial pillow tanks coated with buna-nitrile, two pumping modules, metering equipment, various sections of hoses, platforms, pallets, tie-down harness equipment, and an auxiliary storage box.

### *Collapsible fuel storage tanks*

The 3,000-gallon capacity rubber pillow tanks are made in such a way that the fuel cannot “slosh.” In other words, the fuel does not move to the forward or the rear end of the aircraft rapidly. This movement of the fuel could make the aircraft unstable. Each tank is mounted on a platform (fig. 6-8), which is held securely in place by a series of straps. Each pillow tank has an automatic vapor eliminator connected by a ¾-in hose to an overboard vent port on the aircraft. This prevents the buildup of fuel vapors inside the aircraft.

### *Pump module*

The ABFDS pumping system consists of two pumping modules (fig. 6-9) mounted on an HCU-6E cargo-handling pallet. A crossover manifold that permits filling or evacuation of tanks by one module

connects these modules. Each module contains two 30 gpm centrifugal pumps, giving the system a total flow rate of 600 gpm at 2,300 rpm. A four-cylinder, air-cooled multi-fuel diesel engine drives the pump. The engine's fuel tank is located on the module. A 24-volt battery provides the starting power for each module. The engine exhaust system is equipped with a flexible exhaust pipe insulated for handling ease. It is long enough to extend outside the aircraft through the aircraft ramp when the engine is operating. Each module is also equipped with four flow-direction wafer valves that make up the refuel/defuel manifold. This manifold is similar to the one on the R-14 system. The instruction plate on the module shows you how to position the valves for any desired operation.

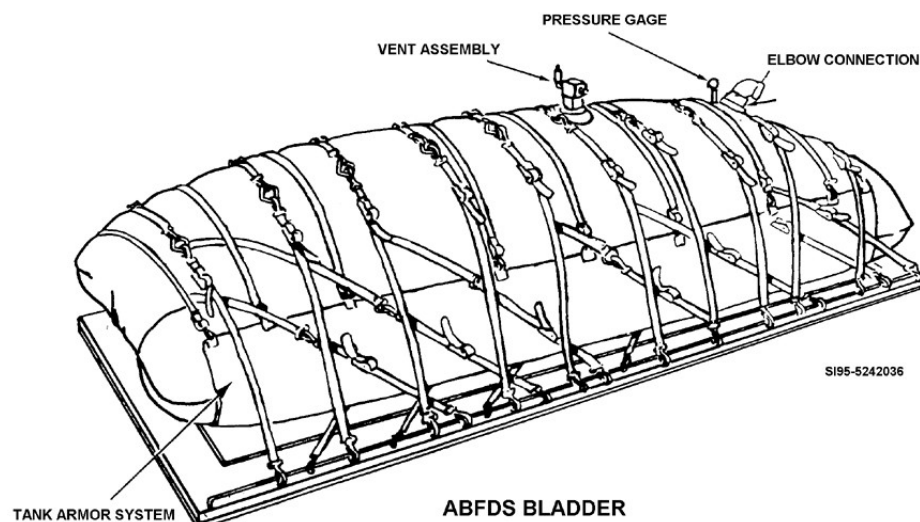


Figure 6-8. Aerial Bulk Fuel Delivery System pillow tank on pallet.

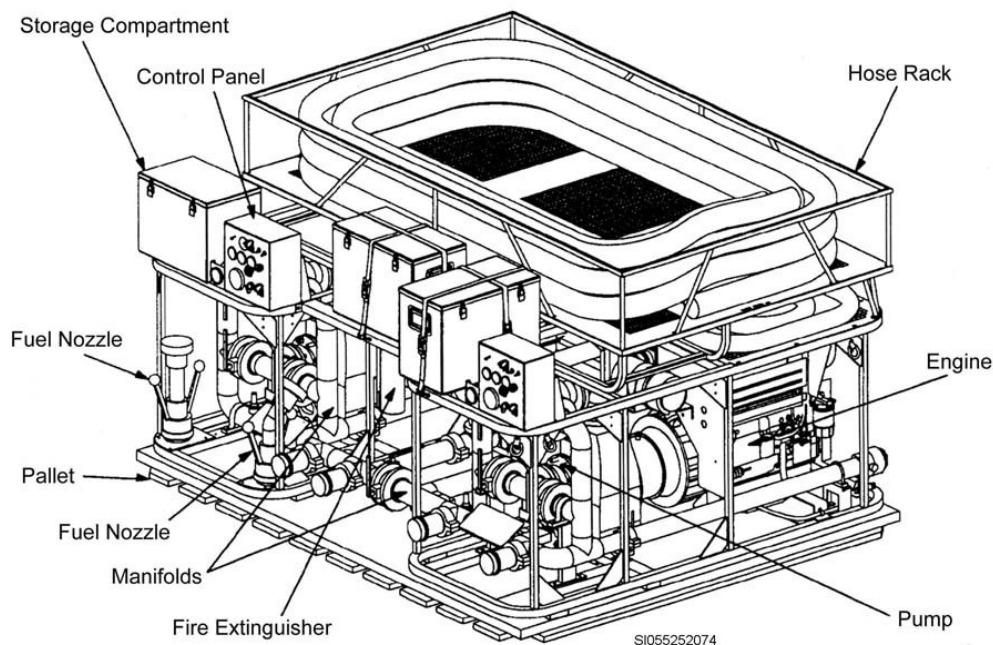


Figure 6-9. Aerial bulk fuel delivery system pumping module.



### Flow meter

Each module is equipped with a flow meter that measures the amount of fuel issued or received. When the ABFDS is equipped with an ACE package, these meters are replaced with an electronic digital meter.

### Hoses and nozzles

The ABFDS contains 186-feet of 4-inch diameter connecting hoses. Unisex couplings connect these hoses. Each ABFDS module comes equipped with one D-1 and one D-2 single-point nozzle.

### Aerial Delivery and Dispensing System

The ABFDS has been modified to include an ACE package by adding a filter separator the ABFDS pumping system (fig. 6-10). When the ABFDS pumping system is combined with an ACE package, the unit is referred to as the Aerial Delivery and Dispensing System (ADDS). The ADDS is designed for transportation on aircraft and to issue large quantities of fuel to ground locations. The advantage of the ADDS is it allows for direct servicing of aircraft. Components of the ACE package are described in the table following the graphic.

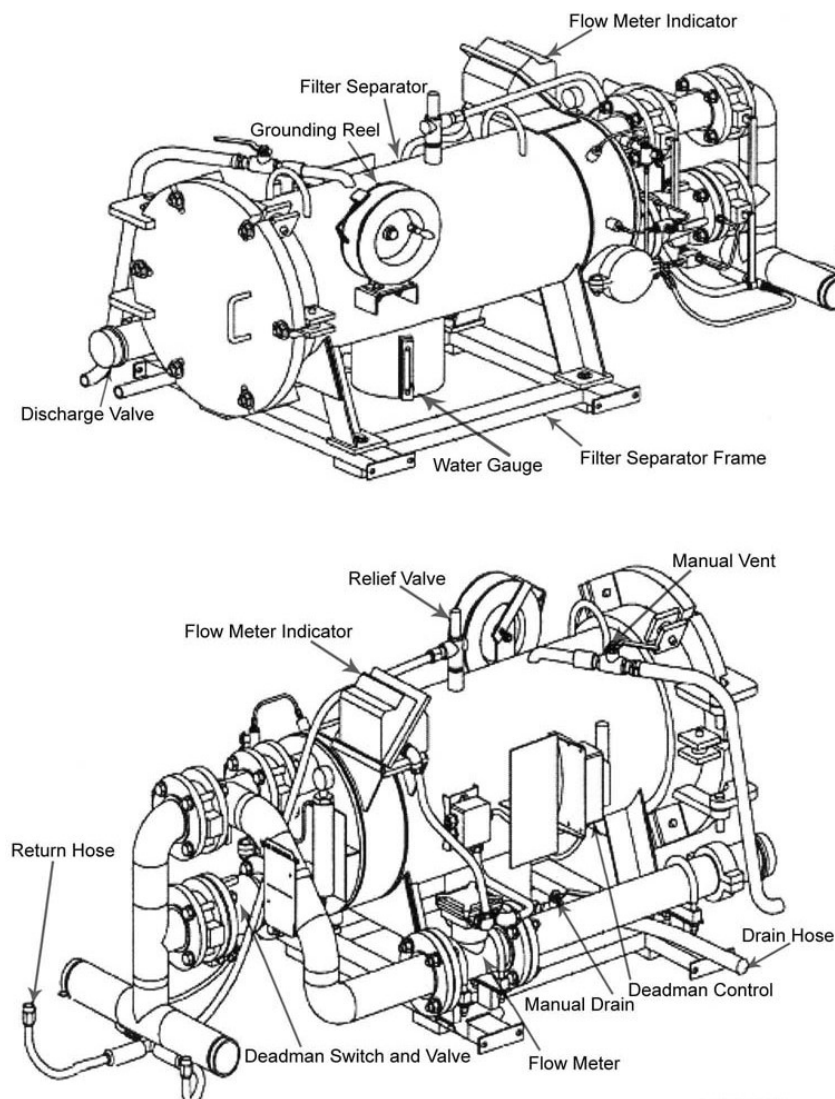


Figure 6-10. Aerial Bulk Fuel Delivery System alternate capability equipment.



ACE Package Components	
Item	Description
Filter separator module	<p>This fits between the two pumping modules. It connects both outlets by means of an interconnecting manifold, thus permitting operation of either pumping module. The filter separator is rated at 300 gpm and incorporates a manual vent valve with sufficient hose to allow overboard venting when required. The filter contains three elements and one canister. The outlet of the filter is fitted with a dry break adapter (single-point release type) to allow disconnecting in the aircraft without the hazard of spilling fuel.</p> <p><b>NOTE:</b> Using both pumping modules when the ABFDS is equipped with an ACE package can damage the filter separator elements due to excessive pressure.</p>
Hoses	The ACE includes three 2 ½-inch by 60-foot sections of delivery hose, each fitted with simple cam-lock couplings at each end: one female and one male. These hoses collapse at 7 inches of mercury, permitting their complete evacuation for storage and transport.
Fire extinguishers	Two hand-held fire extinguishers with mounts are provided, each containing 5 pounds of Halon™. One is mounted for access to the equipment operator and the second is mounted for access by the aircraft servicing personnel.
Static grounding reel	A manually operative static discharge reel is mounted on the filter frame. The reel contains 145 feet of grounding cable for attaching to the aircraft being serviced.
SPR nozzle	The ACE is equipped with one D-1 and one D-2 single point nozzle for servicing aircraft. These single point nozzles differ from the nozzles that come with the ABFDS. ACE single point nozzles incorporate a built-in pressure/flow regulator that limits the fuel delivery pressure. The D-1 nozzle is limited to 35 psi at the aircraft, while the D-2 is limited to 55 psi at the aircraft. Also included is a quick-disconnect, dry break coupler with an in-line strainer. The nozzle is fitted with a 2½-inch cam-lock male for attaching to the 2½-inch delivery hose.

### *Fume detector*

A fume detector is shipped with each ABFDS and ADDS system. The fume detector is an important piece of equipment that must be used on all ABFDS missions. The ABFDS crew uses the fume detector while the aircraft is taxiing and during flight to ensure the ABFDS system does not endanger the aircraft crewmembers by leaking deadly fumes into the aircraft compartment.

### **237. Fuel bladders**

In any fuels operation, mission success cannot be achieved if sufficient storage is not available. Established locations may have permanently installed storage systems that provide enough capacity to carry out any operation within the airfield's ability. However, where fuel infrastructure is inadequate or when operating in forward or austere locations, fuel bladders can be used to meet storage requirements.

#### **Purpose**

Fuel bladders come in various sizes. The most commonly used bladders are the 10,000 gallon, 50,000 gallon, 200,000 gallon, and 210,000 gallon bladders. All types of bladders use a single-ply, nylon fabric material with reinforced corners. Each tank is equipped with a fill-discharge assembly at either end of its top surface. Each tank has a vertical vent pipe assembly located on the center of the top surface, which allows the tank to breathe. This vent pipe assembly also removes water from the tank.

There are three distinct advantages to using fuel bladders:

1. Portability – they weigh only a fraction of the weight of metal drums and tanks.
2. Minimum vapor loss – the ability to expand or contract with fuel volume prevents vaporization loss.
3. All-weather reliability – they can withstand temperatures from  $-40^{\circ}\text{F}$  to  $160^{\circ}\text{F}$ .

Due to the versatility and flexibility of FMSE, there is practically no limit to the number of bladders that can be added to a system. Remember to remove external components before rolling up the bladders for storage.

### Components

Fuel bladders are equipped with a fill-discharge assembly at either end of its top surface. Fuel bladders also have vertical vent pipe assemblies located on the center of the top surface, which allows vapors to vent. The vertical vent pipe assembly also removes water from the fuel bladder.

### Wooden plugs

Use 3-inch and 5-inch wooden plugs to make temporary repairs of fuel leaks on holes up to 2 inches in diameter (fig. 6-11). Insert the plug into the hole and screw it until the plug is tight against the wall of the tank.

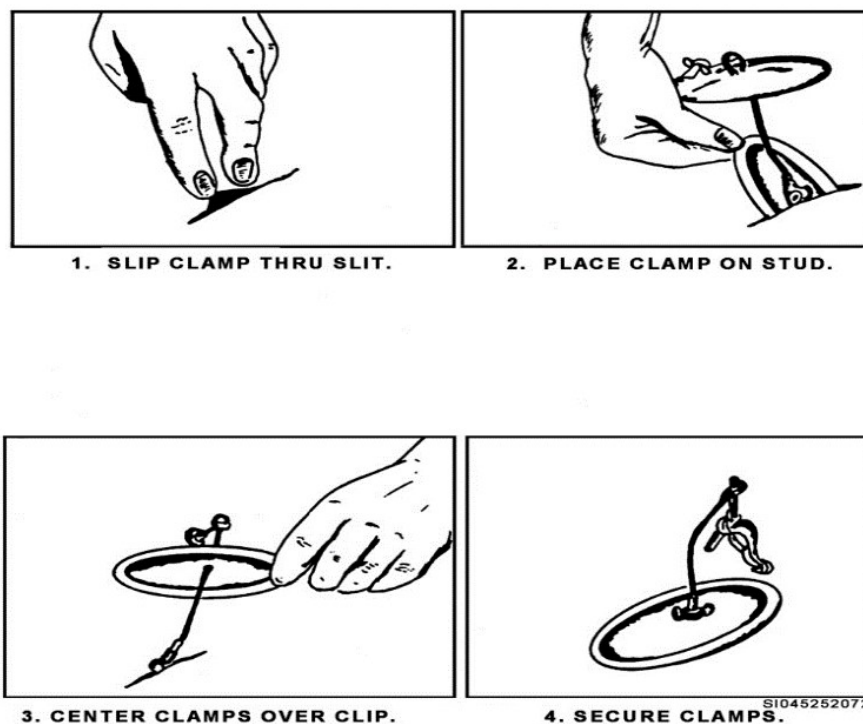


Figure 6-11. Emergency bladder repair.

### 238. Forward area manifold cart

The forward area manifold (FAM) cart is used for forward area rearming and refueling point (FARP) operations (fig. 6-12). The procedures to conduct FARP operations are not difficult; however, operating two or more aircraft in close proximity to one another in a harsh, covert environment can be an extremely hazardous undertaking. Transferring fuel from one running aircraft to another running aircraft can be very dangerous if equipment is not maintained to standards.

## Purpose

The primary purpose of the FAM cart and related equipment is to provide an interface for fuel transfer from tanker aircraft to a maximum of three receiver aircraft simultaneously in austere or remote locations. The FAM cart is designed primarily as a manifold that maintains pressure and flow rates to receiver aircraft. The tanker and receiver aircraft may have engines running. Under normal conditions, the FAM cart's mounted engine and pump are used in operations. However, in the event of engine or pump failure, or use of open port nozzles, the cart may be used as a manifold without operation of the engine and pump.

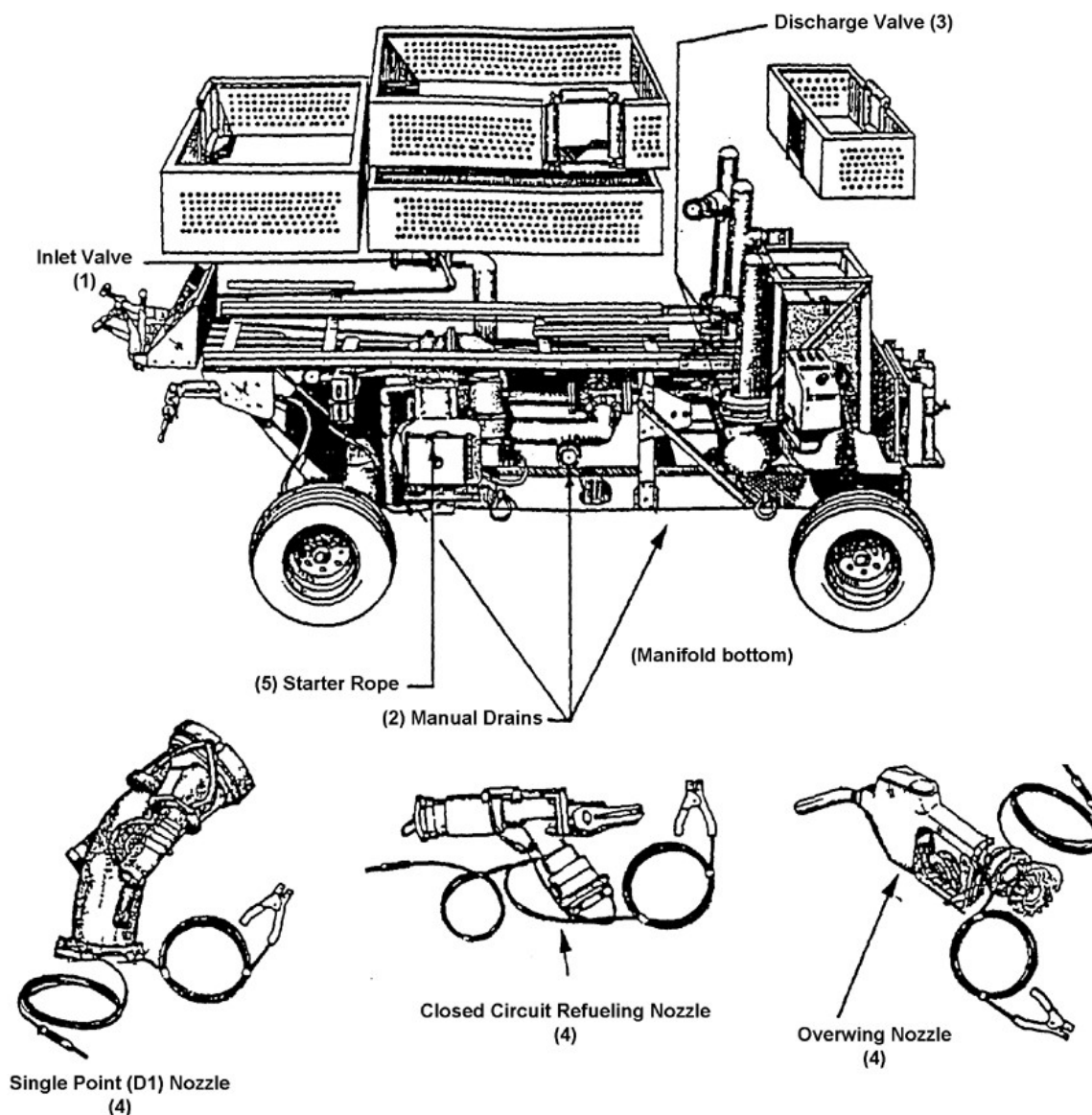


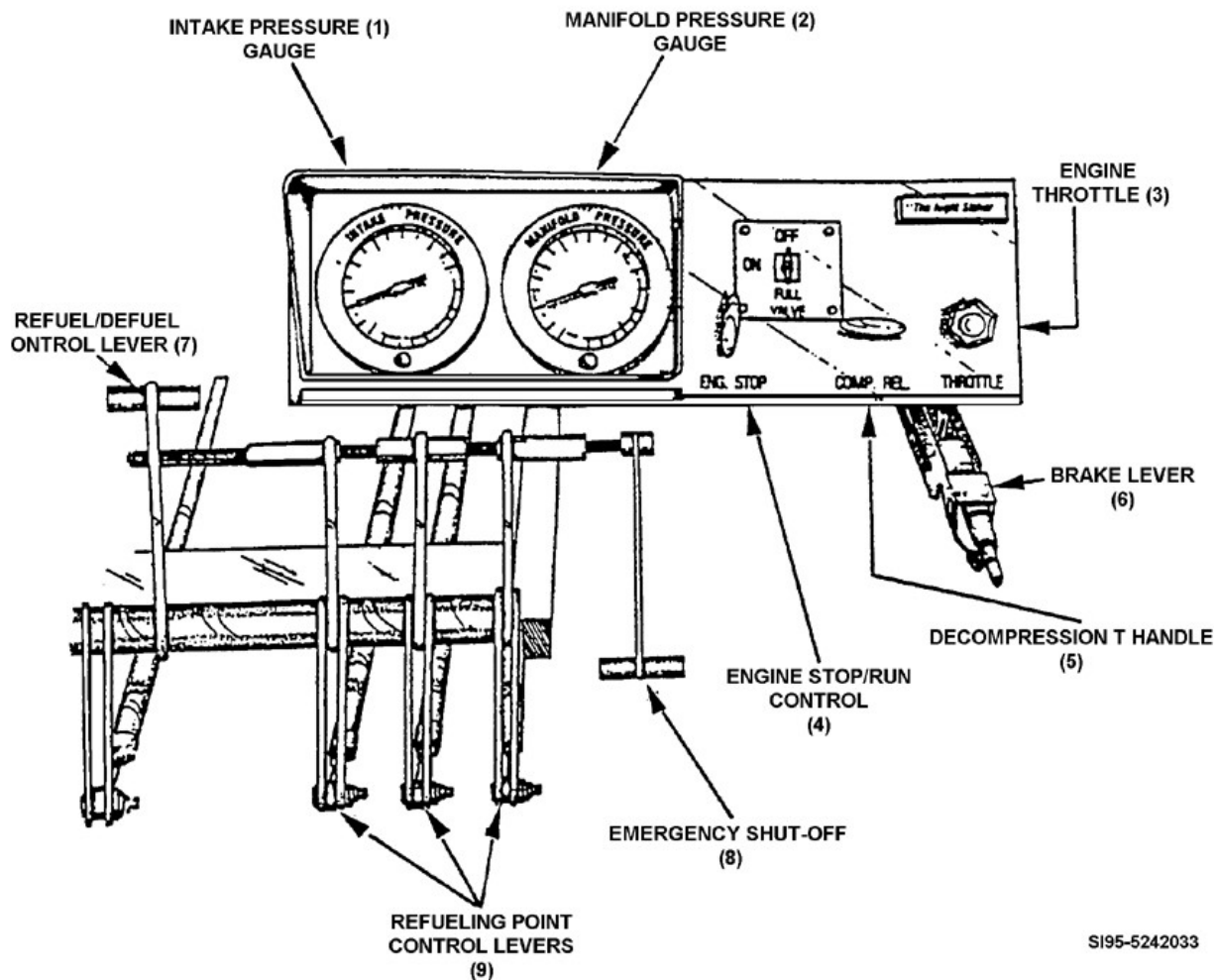
Figure 6-12. Forward area manifold cart.

## Components

The FAM cart is equipped with a one-cylinder, air-cooled, 9.2 hp diesel engine manufactured by Lombardini. The engine can run on JP-5, JP-8, or Jet A fuels. It has no electrical system or battery; therefore, it is started by a rope pull mechanism. It is connected to a Gorman Rupp®, 365 gpm pump.

A series of five control levers at the aft end of the cart select the refuel or hose evacuation modes of operation (fig. 6-13). All required refueling equipment for transferring fuel from the tanker aircraft to the receiver aircraft are carried on the cart. The emergency shutoff lever at the cart inlet may shut off fuel flow.

Fuel is received from an aircraft, which acts as a fuel supply source, through 200 feet of 2-inch fuel hose. It then flows into the inlet of the cart manifold, through the emergency shutoff valve, and into the 365 gpm pump driven by the 9.2 hp diesel engine. The 2-inch fuel hose is lightweight and contains internal bonding wires and unisex couplings for safety, reliability, and operational ease during hot refueling operations. Fuel passes through the pump to the fuel/defuel valve. When this valve is in the fuel mode, fuel passes through the discharge valve and manifold out to three separate refueling points. Each point can be opened or closed independently, so one or all may be used for refueling. Refueling and defueling (hose evacuation) may not be accomplished at the same time.



SI95-5242033

Figure 6-13. Forward area manifold cart control panel.

The engine operates to maintain pressure. The FAM cart is equipped with two gauges—intake pressure and manifold pressure. These gauges provide pressure and vacuum readings. In the refuel or defuel mode, the gauges indicate the pressure or vacuum. The manifold gauge indicates the pressure at the discharge manifold and the intake pressure gauge indicates vacuum/pressure from the supply hose.

## Self-Test Questions

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

### **231. R-14 Air Transportable Hydrant Refueling System**

1. List the four advantages of the R-14 ATHRS.
2. What is the primary use for the R-14C?
3. At what rate is the R-14C self-priming pump designed to deliver fuel?
4. What R-14C component is equipped with a float control that stops fuel flow if the water gets too high?
5. Which R-14C component includes all of the switches, indicators, and gauges required to start and control the engine and pump

### **232. R-22 trailer-mounted transfer pump assembly**

1. What is the maximum capacity the R-22 can rapidly and safely pump?
2. The R-22 uses what type of pump?
3. What gpm rate is the R-22 capable of pumping when the throttle is set at 1,800 rpm?

4. What are the accessories for the R-22?

**233. FFU-15E filter separator**

1. At what rate can the FFU-15E handle petroleum fuels?
2. How often should the filter elements be changed in the FFU-15E?
3. What are the two positions of the float valve in the FFU-15E filter separator?

**234. TPI-4T-4A additive injector**

1. How many different additives can the TPI-4T-4A injector handle?
2. What external power source is required to operate the TPI-4T-4A injector?
3. What type of meter is on the TPI-4T-4A injector?

**235. PMU-27M Air-Transportable Trailer-Mounted Refueling System**

1. What was the PMU-27M designed to do?
2. The self-priming pump on the PMU-27M is capable of delivering how many gallons per minute?

3. The PMU-27M is equipped with what type of engine?
4. What PMU-27M component controls the flow of fuel from the suction hoses to the pump?

### 236. Aerial Bulk Fuel Delivery System

1. On which type of aircraft can the ABFDS be installed?
2. Match the ABFDS/ACE component in column B with the function in column A. Components in column B are used once.

#### *Column A*

#### *Column B*

- |   |                                   |
|---|-----------------------------------|
| ____(1) Equipped with four flow-direction wafer valves.       | a. Filter separator.              |
| ____(2) 3,000-gallon capacity.                                | b. Hoses.                         |
| ____(3) Connected together by unisex couplings.               | c. Flow meter.                    |
| ____(4) Measures amount of fuel issued or received.           | d. Pump module.                   |
| ____(5) Rated at 300 gpm.                                     | e. Fume detector.                 |
| ____(6) Ensures ABFDS system does not endanger aircraft crew. | f. Collapsible fuel storage tank. |

3. What is the major advantage of the ADDS?
4. Describe how the single point nozzles on the ACE differ from those on the ABFDS.

### 237. Fuel bladders

1. What are the most commonly used sizes of fuel bladders?



2. What are the advantages to using fuel bladders?

### **238. Forward area manifold cart**

1. What is the primary purpose of the FAM cart?
2. The FAM cart is equipped with what type of engine?
3. What starts the FAM cart?
4. What is the pumping capacity of the FAM cart?
5. How many receiver aircraft can FAM carts service at one time?

## **6-2. Fuels Operational Readiness Capability Equipment**

The FORCE system was developed to complement, and eventually replace, aging FMSE components. It is capable of providing 400,000 gallons a day of sustained capability, and up to 1 million gallons a day surge capability. The FORCE system provides a deployable, aboveground, constant pressure, and flow-on-demand fueling system for aircraft.

A typical equipment arrangement to perform servicing operations uses three R-18 pumping units, three R-19 filter separator units, three R-20 multi-aircraft servicing platforms, along with hoses, fittings, and components from the R-21 plumbing assembly (fig. 6-14).

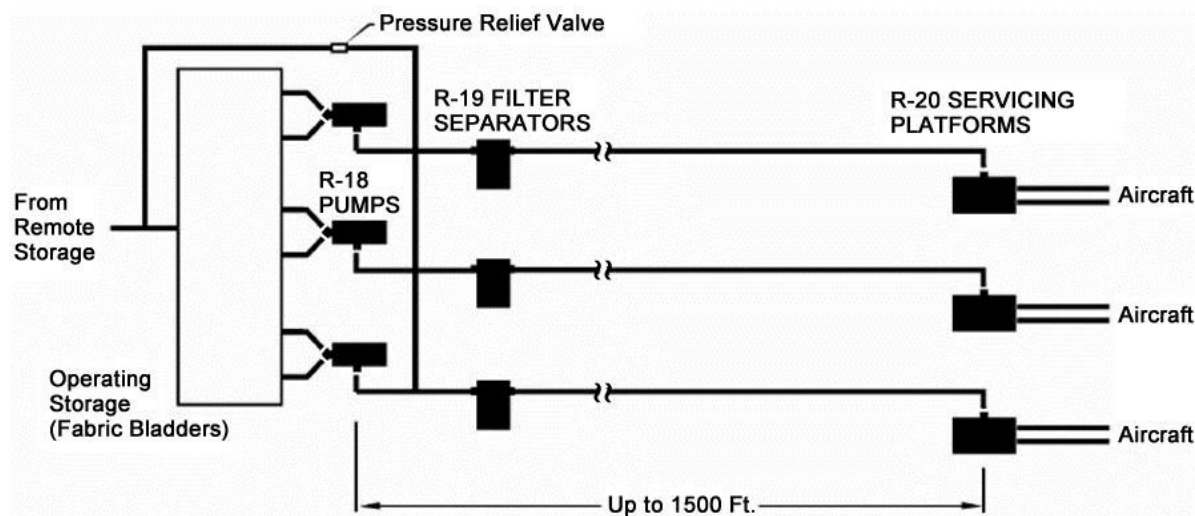


Figure 6-14. Typical FORCE fuel-servicing arrangement.

The FORCE system accomplishes three primary missions: fuel servicing, off-loading, and transferring. The FORCE module arrangement provides up to 2,700 gpm directly to the aircraft. The individual components of the FORCE system provide stand-alone or mix-and-match capability for almost any fuel transfer or aircraft-fueling scenario (fig. 6-15).

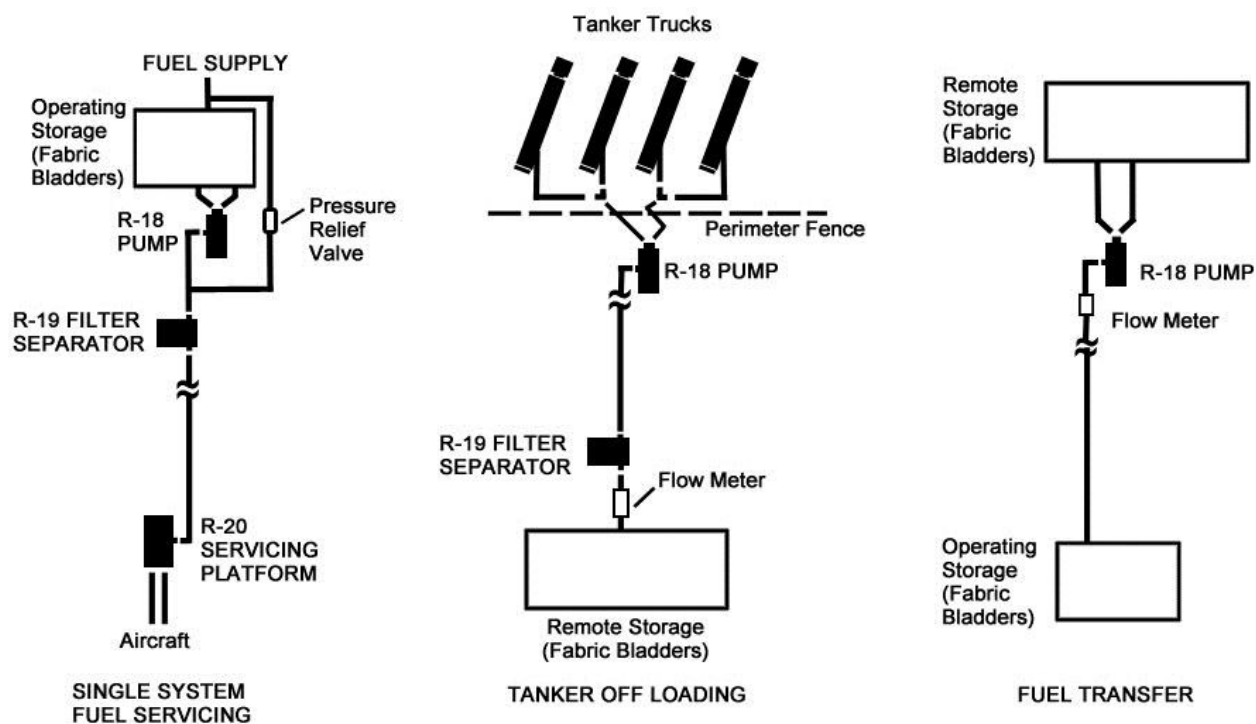


Figure 6-15. FORCE multi-mission capabilities.

A FORCE module is made of five R-18s, four R-19s, three R-20s, and one R-21, consisting of 11-tricon containers. The mix of equipment within a FORCE module provides basic capability for off-loading, transferring, and a fuel servicing operations.

**NOTE:** The R-21 plumbing assembly consists of a large assortment of loose equipment, including hoses, valves, adapters, and fittings, which connect the FORCE subsystems into operational configurations. The R-21 also includes special-purpose, skid-mounted assemblies that perform specific functions in the overall FORCE concept. It is not necessary to discuss the R-21 further in this text.

### 239. R-18 pumping unit

The R-18 pumping unit is functionally similar to the R-22 trailer-mounted transfer pump assembly. There are five R-18s included in a FORCE module.

#### Purpose

The R-18 pumping unit acts as a transfer pump and off-loads, transfers, and issues aviation fuel. A multi-fuel engine powers the R-18 pumping unit. It is capable of pumping over 900 gpm of aviation fuel at an output pressure of 150-psi. The pump is a self-priming centrifugal pump driven by a speed-increasing gearbox attached to the engine.

#### Components

The following table describes the various components that make up the R-18 pumping unit remote control panel, which is located on the left side of the unit. Refer to figure 6-16 while reading the description of each component.

R-18 Pumping Unit Remote Control Panel Components	
Item Number	Component Name and Function
Item 1	The master data fail indicator light flashes on the lead pumping unit when a servicing platform or remote pumping unit has not communicated in the past five minutes. The indicator light has no function on the remote pumping units.
Item 2	The communication active indicator light illuminates when one or more remote pumping units have communicated with the lead pumping unit in the last five minutes. Upon a loss of communication exceeding five minutes, the light extinguishes and the pump control returns to its idle speed.
Item 3	When the no flow/rupture detect switch is in the ON position, the no-flow/rupture alarm light illuminates when no flow/rupture pressure switch activates for more than 10 seconds.
Item 4	The emergency stop indicator light illuminates when any emergency stop switch activates.
Item 5	For hand-held operation, the manual/remote control switch is set to REMOTE. The hand-held does not function if the switch is set to MANUAL.
Item 6	When the offload/servicing switch is in the OFFLOAD position, the control panel operates independently for fuel transfer. In the SERVICING position, the control panel operates in conjunction with other pumping units and servicing platforms control panels.
Item 7	When offload/servicing switch is in the OFFLOAD position, the deadman selector switch selects between DEADMAN or NO DEADMAN operation.
Item 8	Pressing the emergency stop switch stops engines system wide, and closes servicing platform control valves while in servicing mode.
Item 9	Pressing the lamp test switch illuminates all front panel lights and the alarm light on top of the panel.
Item 10	With no flow/rupture detect switch set to ON, engine will return to idle speed under certain conditions indicating no flow or hose rupture condition.

R-18 Pumping Unit Remote Control Panel Components	
Item Number	Component Name and Function
Item 11	The emergency stop reset switch resets operational circuits following an emergency shutdown.
Item 12	The station unit ID switch selects modem address (1 to 10) for unit determining its operational sequence (SERVICING only).
Item 13	The quantity pump units switch is set to number (1 to 10) designating number of pumping units in operation (SERVICING only).
Item 14	The quantity service platforms switch is set to a number (1 to 10) designating the number of servicing platforms in operation (SERVICING only).
Item 15	The beacon light flashes upon the occurrence of a no flow/rupture or emergency stop activation.

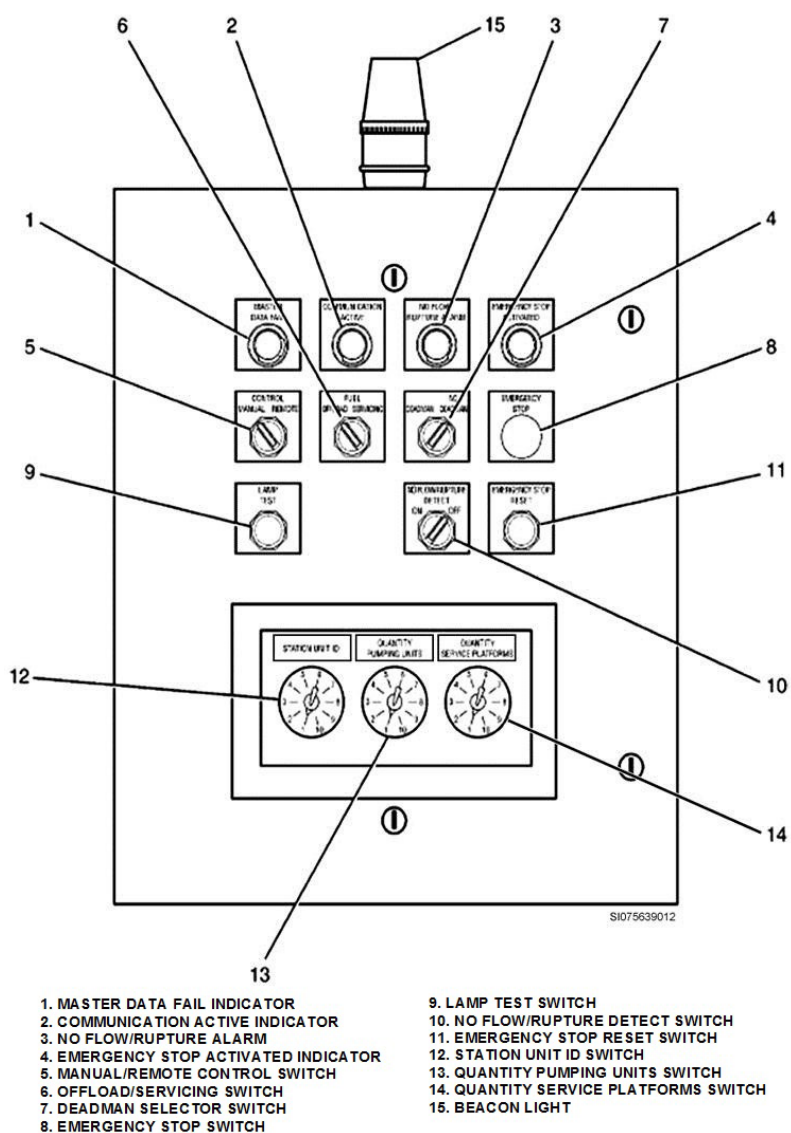


Figure 6-16. R-18 pumping unit communications panel components.

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Refer to figure 6-17 while reading the descriptions in the following table that continues describing the various R-18 pumping unit control panel components.

<b>R-18 Pumping Unit Controls and Indicators (Continued)</b>	
<b>Item Number</b>	<b>Component Name and Function</b>
Item 16	The oil pressure gauge indicates the engine oil pressure.
Item 17	The ammeter indicates amperes generated from engine alternator for recharging batteries.
Item 18	The throttle control regulates engine speed. Rotating the handwheel counterclockwise increases engine speed.
Item 19	The outlet pressure gauge indicates the pump outlet pressure in psi.
Item 20	The panel light illuminates the gauge panel.
Item 21	The inlet pressure gauge indicates pump inlet pressure in psi.
Item 22	The WARNING light illuminates when the engine ECM senses an engine problem that should be checked, but is not urgent.
Item 23	The increment/decrement switches navigate to the next or previous display of maintenance codes indicated by the stop light when the diagnostic/normal switch is in DIAGNOSTIC position.
Item 24	Set the diagnostic/normal switch to the NORMAL position for routine engine operation. Upon engine problem indication, move to DIAGNOSTIC to diagnose malfunctions in engine operation.
Item 25	The STOP light illuminates when the ECM indicates a serious problem with the engine. It flashes numeric diagnostic code for troubleshooting an engine problem.
Item 26	When the run/idle switch is set to RUN the engine speed can be adjusted or returned to set speed, using the throttle control. When set to IDLE, engine speed is reduced to idle.
Item 27	The area light switch turns the area spotlights ON and OFF.
Item 28	The panel lights switch turns panel illumination lights ON and OFF.
Item 29	The tachometer/hourmeter indicates engine speed in rpm times 100. Digital indicator inset in gauge registers hours of engine operation.
Item 30	The ignition switch controls the unit's electrical system. Turning to ON energizes electrical system; turning to START engages engine starter when released switch returns to ON. Set to OFF to shutdown engine and turn off power to unit.
Item 31	The WAIT TO START indicator light illuminates when ignition switch is set to ON. When light goes off, it is safe to start the engine.
Item 32	The temperature gauge indicates the temperature of engine coolant in degrees Fahrenheit and Celsius.
Item 33	The low voltage alarm bypass switch bypasses the low voltage cutoff circuit. This switch must be held down to start the engine when the battery is low.

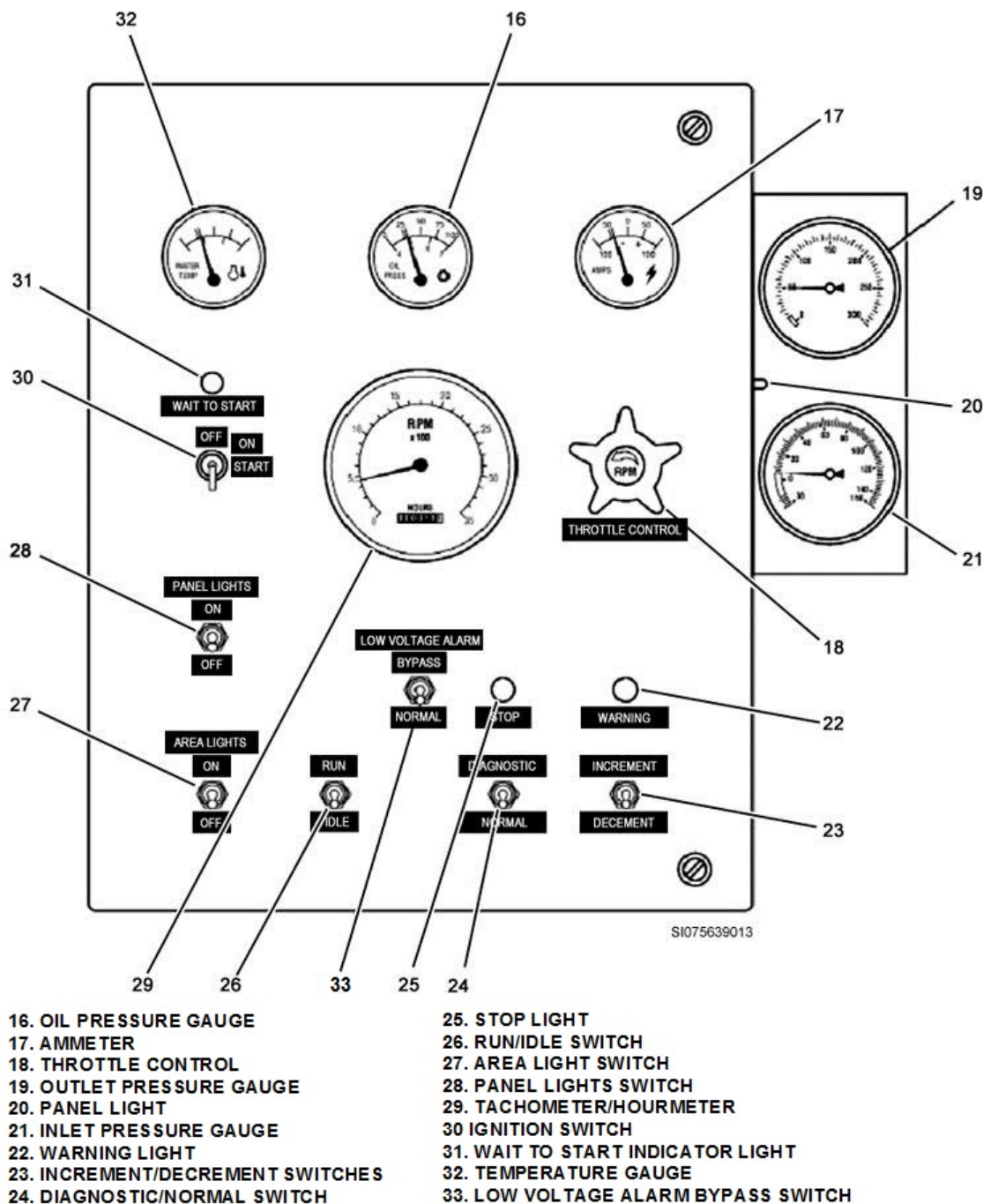


Figure 6-17. R-18 pumping unit control panel.

The following table describes additional R-18 pumping unit controls and indicators located on the left side of the unit. Refer to figure 6-18 while reading the descriptions of each component.

R-18 Pumping Unit Controls and Indicators (Continued)	
Item Number	Component Name and Function
Item 34	The interlock switch interrupts the engine starting circuit when either engine housing side door is open.
Item 35	The air restriction gauge indicates the condition of inlet air cleaner filter element.
Item 36	The power panel switch controls electrical power to the remote control panel.
Item 37	The battery master switch controls electrical circuit for the pumping unit by connecting or disconnecting the batteries.
Item 38	The jumper cable receptacles are a pair of 24 VDC electrical connections that provide auxiliary power to start the unit if batteries are discharged.

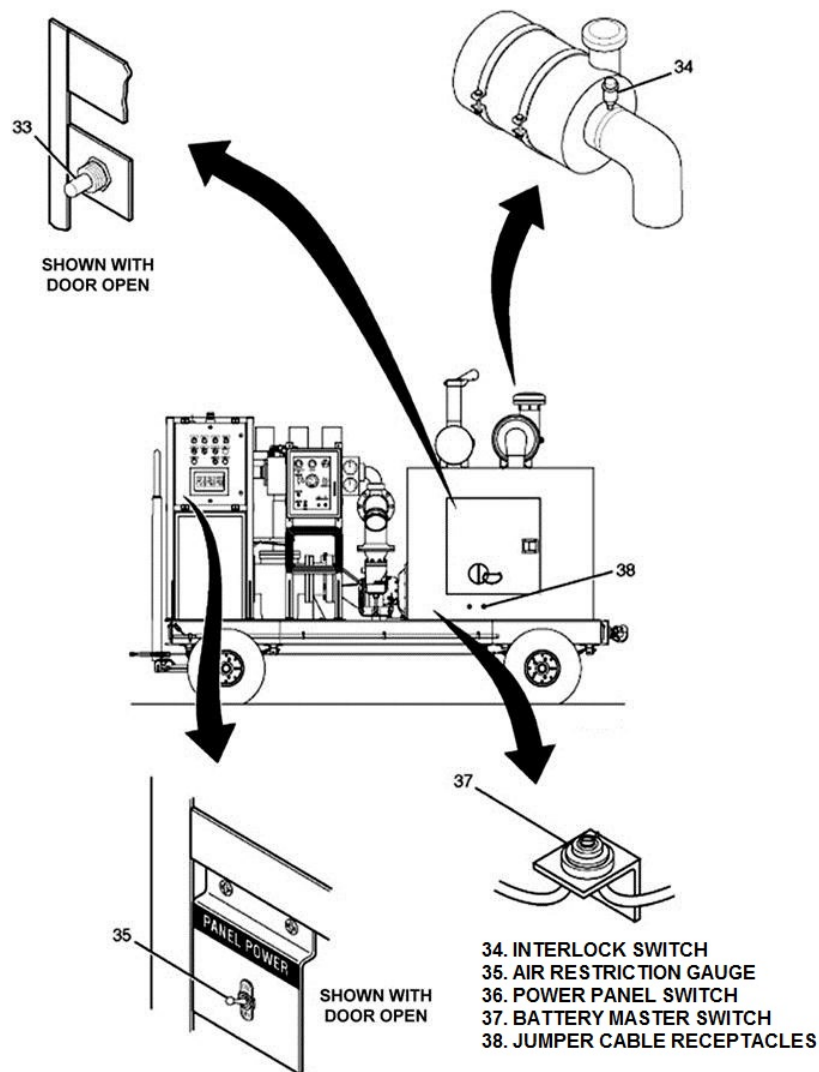


Figure 6-18. Additional R-18 pumping unit controls and indicators.



The following table describes components located on the right side of the R-18 pumping unit. Refer to figure 6-19 while reading the descriptions of each component.

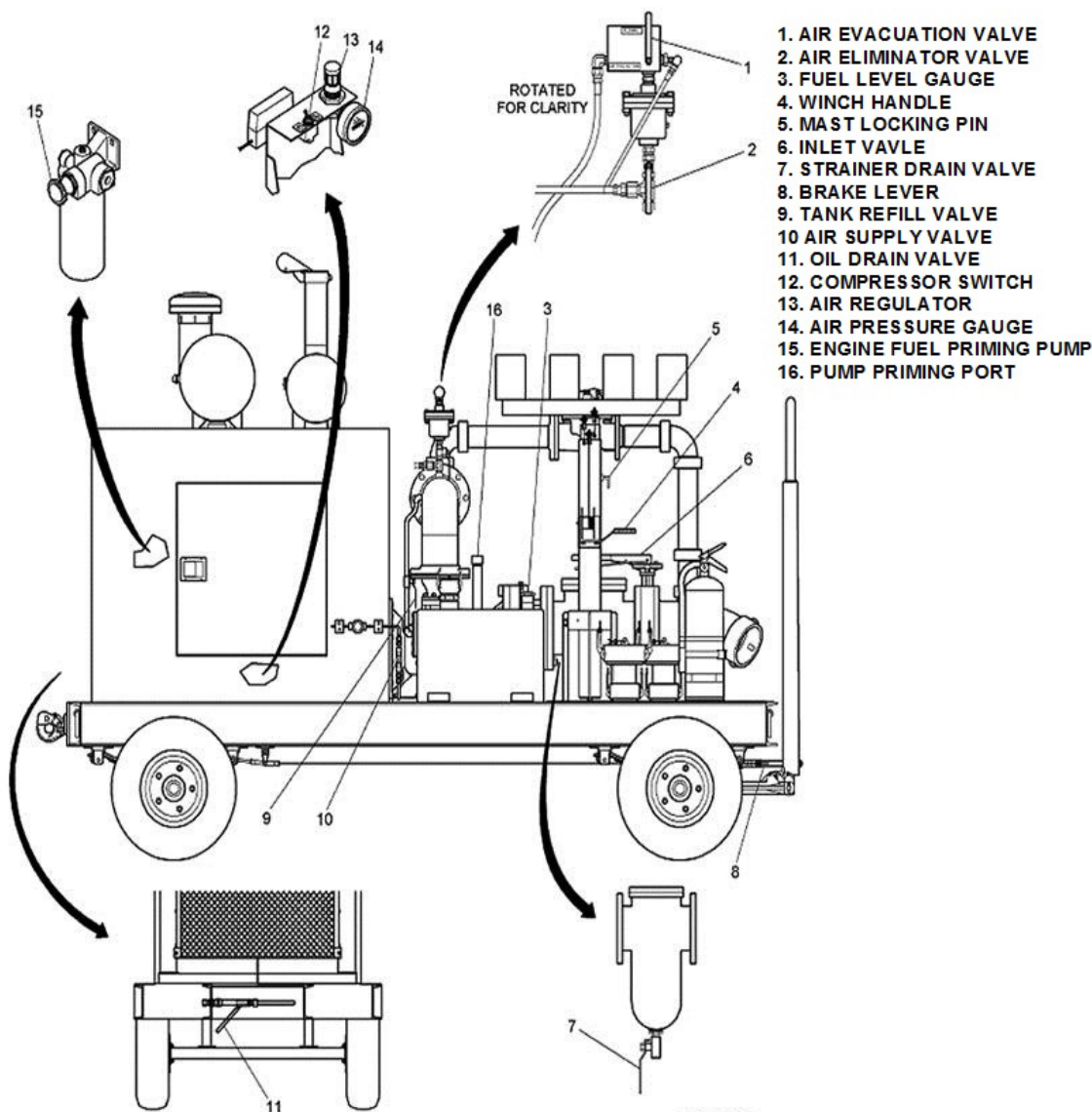


Figure 6-19. R-18 components (right side).

R-18 Pumping Components (Right Side)	
Item Number	Component Name and Function
Item 1	The air evacuation valve is a two-position valve. In the NORMAL position, air is eliminated from the fuel piping during normal operation. When moved to AIR EVACUATION position, air is evacuated from the inlet hose by compressed air passing through an eductor that pulls air through an air eliminator until the hose is filled with fuel and the pump is primed.
Item 2	The air eliminator valve opens and closes air eliminator inlet.
Item 3	The fuel level gauge indicates the level of fuel in the engine fuel tank.

Item 4	The winch handle raises and lowers the area spot light mast.
Item 5	The mast locking pin locks the area spot light mast in position.
Item 6	The inlet valve is a locking butterfly valve that opens and closes the fuel inlet.
Item 7	When opened, the strainer drain valve drains the contents of the basket strainer body.
Item 8	The brake lever engages or releases parking brakes.
Item 9	When the tank refill valve is opened, fuel is drawn from the pump outlet piping through a float valve into the engine fuel tank.
Item 10	The air supply valve opens and closes the air supply from the onboard compressor. In the OPEN position (aligned with piping), compressed air is directed to the eductor, which is part of the air evacuation system. In the CLOSED position (opposite piping) air is available through the quick disconnect air coupling, if the compressor is ON.
Item 11	The oil drain valve drains the engine oil.
Item 12	The compressor switch turns the air compressor ON and OFF.
Item 13	The air regulator sets the air compressor's output pressure.
Item 14	The air pressure gauge indicates the compressor output pressure.
Item 15	The engine fuel priming pump primes the engine fuel system.
Item 16	The pump priming port allows the pump housing to fill with fuel to prime the pump.

The following table describes the R-18 pumping unit's hand-held remote controls and indicators. Refer to figure 6-20 while reading the descriptions of each component.

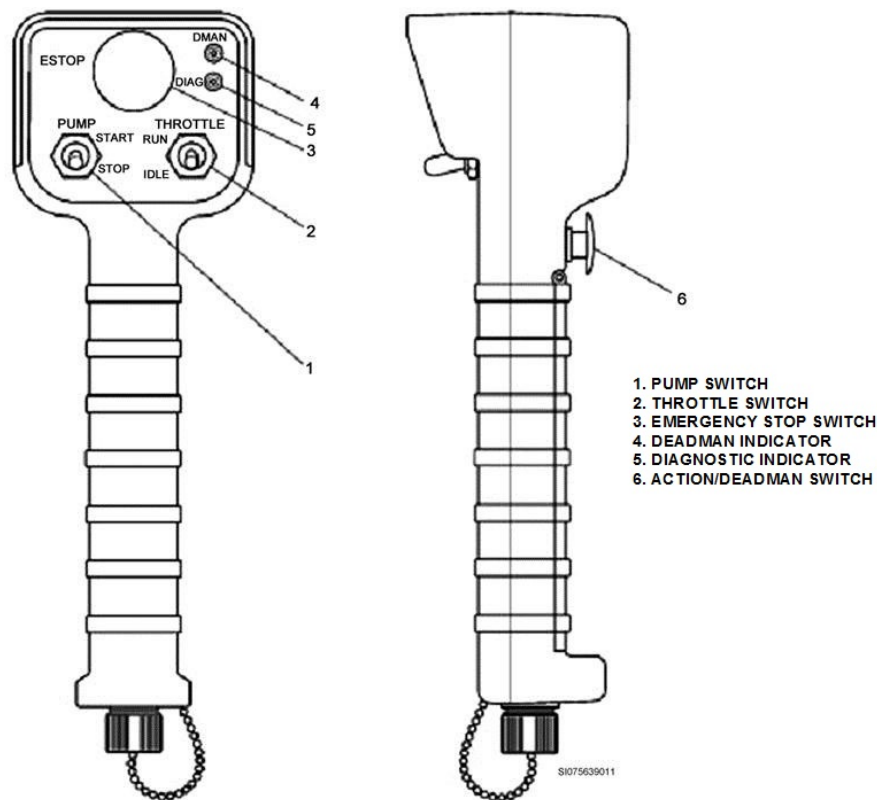


Figure 6-20. R-18 pumping unit hand-held remote.

R-18 Pumping Unit Hand-Held Remote Components	
Item Number	Component Name and Function
Item 1	The pump switch starts and stops the pump.
Item 2	The throttle switch controls the engine speed. When set to RUN the engine returns to the speed set by the throttle control. When set to IDLE, the engine speed decreases to idle speed.
Item 3	The emergency stop switch activates the emergency stop.
Item 4	The deadman indicator flashes at a slow rate to notify the operator that the action/deadman switch must be released and depressed to continue operations.
Item 5	The diagnostic indicator has three flash patterns that display while the hand-held unit is awake. Steady on indicates a low battery condition. A slow flash indicates a communication error. A quick flash indicates the hand-held unit has learned the address of the receiver module.
Item 6	Pressing the action/deadman switch starts and stops the engine. In the NO DEADMAN position, pressing the switch puts the engine at RUN or IDLE, if it has been started. In the DEADMAN position, the switch must be held down to maintain the engine in RUN condition.

## 240. R-19 filter separator unit

The R-19 filter separator unit is similar functionally to the FFU-15E filter separator.

### Purpose

The R-19 filter separator unit functions in the same manner as other filter separators. It is used in conjunction with other FORCE equipment for fuel servicing and off-loading operations. It is a trailer-mounted unit with two 600-gpm aluminum alloy filter separators configured to run in parallel at a maximum filtering rate of 1200 gpm or individually at 600 gpm.

### Components

Refer to figure 6-21 while reading the descriptions of each component of the R-19 filter separator unit. The table following the figure describes these components.

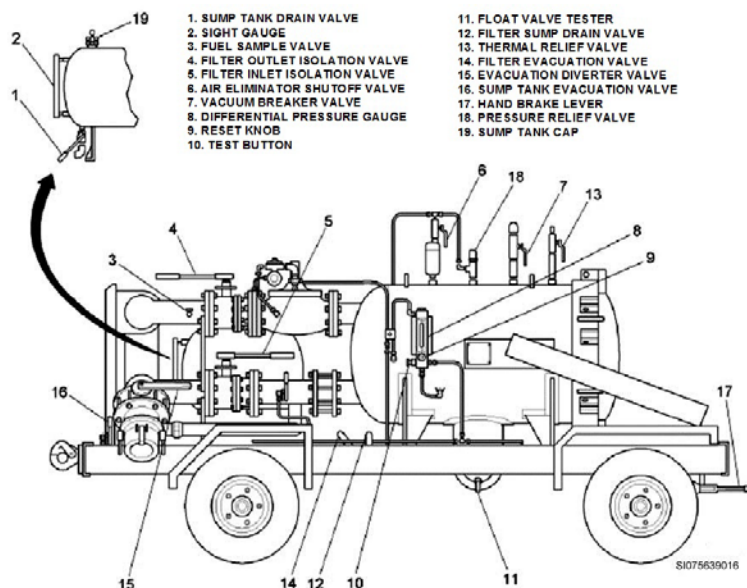


Figure 6-21. R-19 filter separator unit components.

R-19 Filter Separator Unit Components	
Item Number	Component Name and Function
Item 1	The sump tank drain valve drains the contents of the sump tank.
Item 2	The sight gauge indicates the fluid level in the sump tank.
Item 3	The fuel sample valve opens and closes the fuel sample connector.
Item 4	The filter outlet isolation valve stops the flow of fuel from the outlet side of the filter when closed.
Item 5	The filter inlet isolation valve stops the flow of fuel to the inlet side of the filter when closed.
Item 6	The air eliminator shutoff valve opens and closes the outlet of the air eliminator.
Item 7	The vacuum breaker valve allows air to enter the filter vessel to facilitate draining.
Item 8	The DP gauge displays the pressure differential between the inlet and outlet of the filter separator
Item 9	The RESET knob resets the DP gauge when it is rotated.
Item 10	The TEST button tests the DP gauge operation.
Item 11	The float valve tester simulates a high water level in the filter separator sump.
Item 12	The filter sump drain valve opens and closes the filter separator sump drain.
Item 13	The thermal relief valve relieves internal filter pressure that may be caused from exposure to the sun during inactivity.
Item 14	The filter evacuation valve opens the filter vessel to evacuation piping for emptying the vessel.
Item 15	The evacuation diverter valve diverts inlet flow to the evacuation circuit, when closed or partially closed
Item 16	The sump tank evacuation valve directs the contents of the sump tank to the evacuation piping.
Item 17	The hand brake lever sets and releases the parking brakes.
Item 18	The pressure relief valve opens at 175 psi and sends fuel to the sump tank.
Item 19	The sump tank cap allows trapped air to escape during startup and prevents the creation of a vacuum during sump tank evacuation.

## 241. R-20 multi-aircraft servicing platform

The R-20 multi-aircraft servicing platform is the fuel distribution point of the FORCE package.

### Purpose

The R-20 multi-aircraft servicing platform is used in conjunction with other FORCE equipment to service aircraft. It is a trailer-mounted unit capable of supplying up to 900 gpm of fuel through two servicing hoses simultaneously.

### Components

The following table describes the R-20 multi-aircraft servicing platform sump tank components. Refer to figure 6-22 while reading the descriptions of each component.

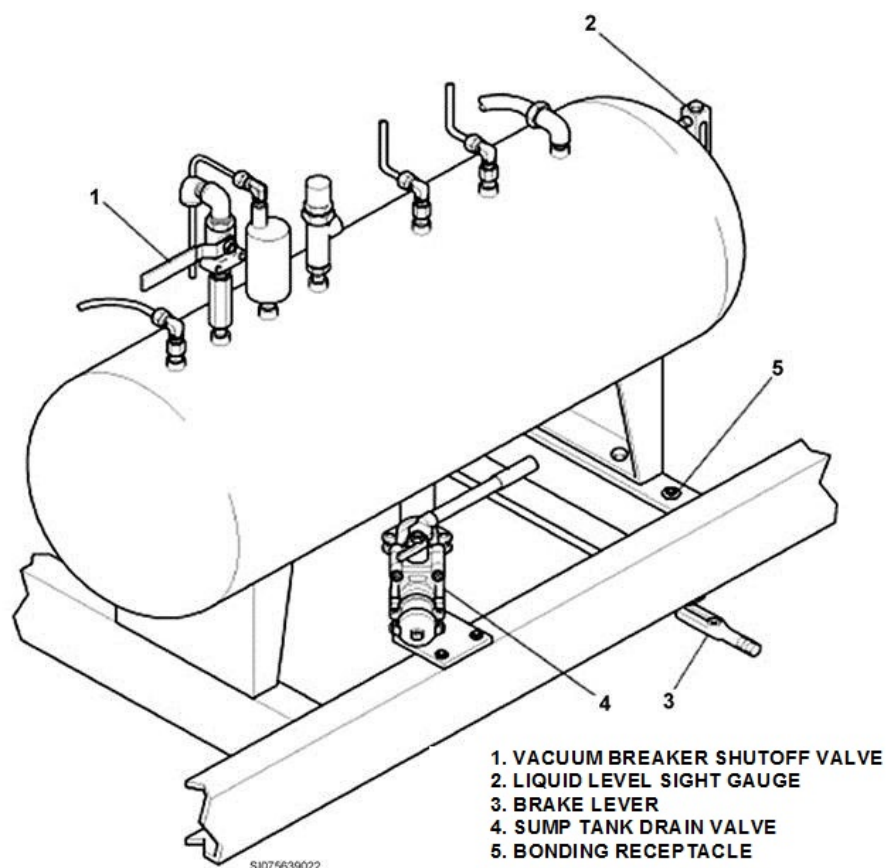


Figure 6-22. R-20 multi-aircraft servicing platform sump tank components.

R-20 Sump Tank Components	
Item Number	Component Name and Function
Item 1	The vacuum breaker shutoff valve allows air to enter the sump tank to facilitate draining.
Item 2	The liquid level sight gauge indicates the level of fuel in the sump tank.
Item 3	The brake lever engages and releases the parking brake.
Item 4	The sump tank drain valve drains the sump tank. The handle is spring-loaded to the closed position.
Item 5	The bonding receptacle connects a bonding cable plug.

The following table describes the R-20 multi-aircraft servicing platform servicing controls. Refer to figure 6-23 while reading the descriptions of each component.

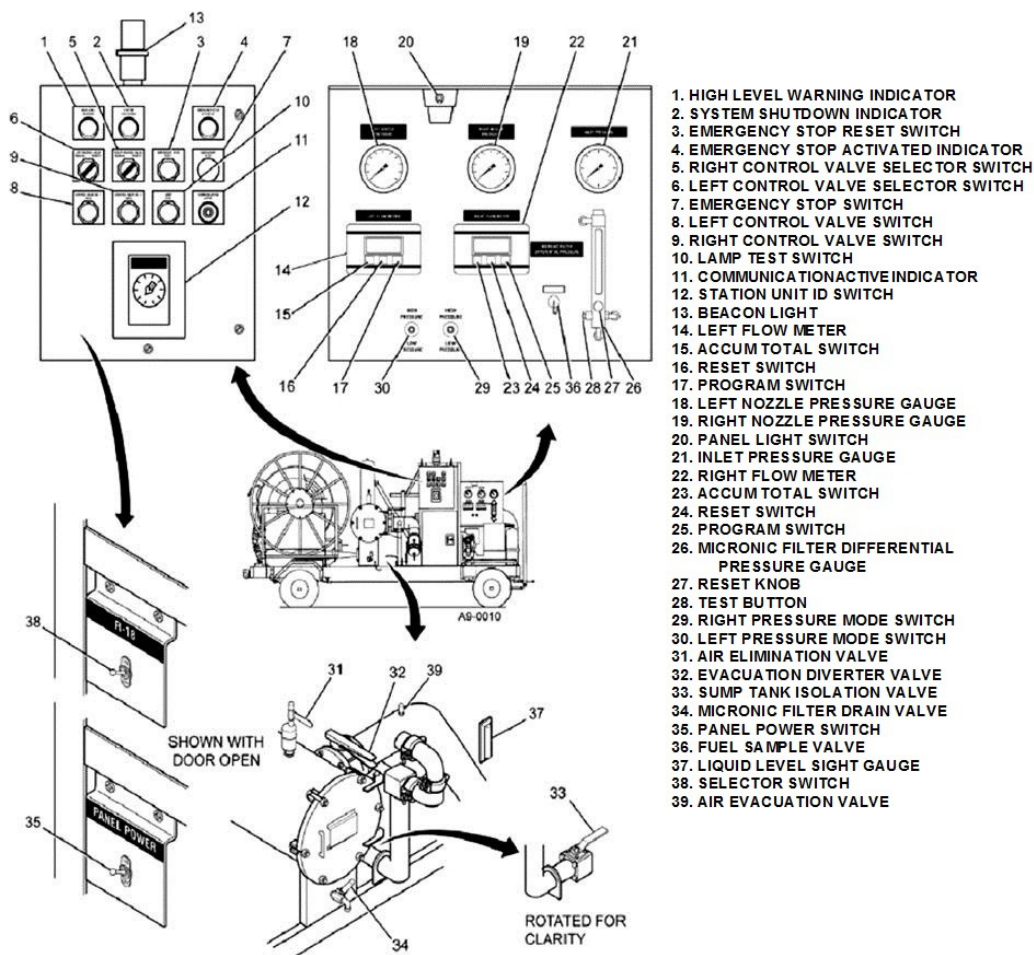


Figure 6-23. R-20 multi-aircraft servicing platform servicing controls.

R-20 Servicing Controls	
Item Number	Component Name and Function
Item 1	The high level warning indicator light illuminates when the level in the sump tank reaches 75 percent level.
Item 2	The system shutdown indicator light illuminates when the level in the sump tank reaches 95 percent level. Control valves close.
Item 3	The emergency stop reset switch resets the operational circuits following emergency shutdown.
Item 4	The emergency stop activated indicator light illuminates in the event any of the emergency shutdown switches are pushed.
Items 5 and 6	The left and right control valve selector switches select the mode of operation for the left and right control valves. Turning the switch to REMOTE allows hand-held remote control of the valve. Turning the switch to MANUAL allows control of valve using the switch.



R-20 Servicing Controls	
Item Number	Component Name and Function
Item 7	The emergency stop switch shuts down the engine on the unit and closes the flow control valves.
Items 8 and 9	The left and right control valve switches are pressed, when the left (or right) control valve selector switch is in the MANUAL position, to open the left (or right) control valve. The valve is closed when the button is released.
Item 10	The lamp test switch tests all indicator lights.
Item 11	The communication active indicator light illuminates when the servicing platform has communicated with the lead pumping unit within the past five minutes. Upon a loss of communication exceeding five minutes, the light goes out and the control valves close.
Item 12	The station unit ID switch identifies the modem address for the operational platform.
Item 13	The beacon light flashes when the high level warning indicator, system shutdown indicator, or emergency stop has occurred.
Items 14 and 22	The left and right flow meter indicator indicates flow through the left (or right) meter in total gallons and rate of flow in gpm.
Items 15 and 23	The accum total switch displays the cumulative total in gallons.
Items 16 and 24	The reset switch resets the totalizer to zero.
Items 17 and 25	The program switch reprograms the RATE and TOTAL display.
Item 18	The left nozzle pressure gauge indicates pressure at the nozzle operating on left side of platform in psi.
Item 19	The right nozzle pressure gauge indicates pressure at nozzle operating on the right side of the platform in psi.
Item 20	The panel light switch turns the panel light on and off.
Item 21	The inlet pressure gauge indicates fuel pressure at the platform inlet in psi.
Item 26	The Micronic filter DP gauge indicates the pressure differential between the Micronic filter inlet and outlet.
Item 27	The reset knob resets the Micronic filter DP gauge when rotated.
Item 28	The test button tests the Micronic filter DP gauge operation.
Items 29 and 30	The pressure mode switch selects high pressure or low pressure mode for the pressure-regulating valve on the left and right side fuel piping.
Item 31	The air elimination valve opens and closes the air eliminator outlet.
Item 32	The evacuation diverter valve controls inlet fuel flow and diverts flow to the sump tank evacuation circuit.
Item 33	The sump tank isolation valve is opened during servicing operations to allow fuel to be drawn from the sump tank when the evacuation diverter valve is partially closed to reduce fuel flow.
Item 34	The Micronic filter drain valve drains the Micronic filter.
Item 35	The panel power switch controls electrical power to the remote control panel.
Item 36	The fuel sample valve opens and closes the fuel sample connector.
Item 37	The liquid level sight gauge indicates the fluid level at bottom of sump tank, and when educting fuel from the sump tank provides a visual indication of when the sump tank is almost empty.



R-20 Servicing Controls	
Item Number	Component Name and Function
Item 38	The selector switch configures the R-18/R20 radio frequency communications system. When the switch is set to ON, the R-20 must communicate with the master pumping unit. When the switch is set to OFF, the R-20 hand-held remotes will work without R-18/R-20 communications, if the left and right control valve selector switches are set to REMOTE. In addition, when the switch is set to OFF, the R-20 can operate independently of other FORCE components (e.g., with a fixed base hydrant system having a maximum pressure of 150 psi).
Item 39	During system start up, the air evacuation valve is opened, with the evacuation diverter valve closed, in order to allow air in the supply hose to be evacuated.

The following table describes the R-20 multi-aircraft servicing platform hose reel components. Refer to figure 6-24 while reading the descriptions of each component.

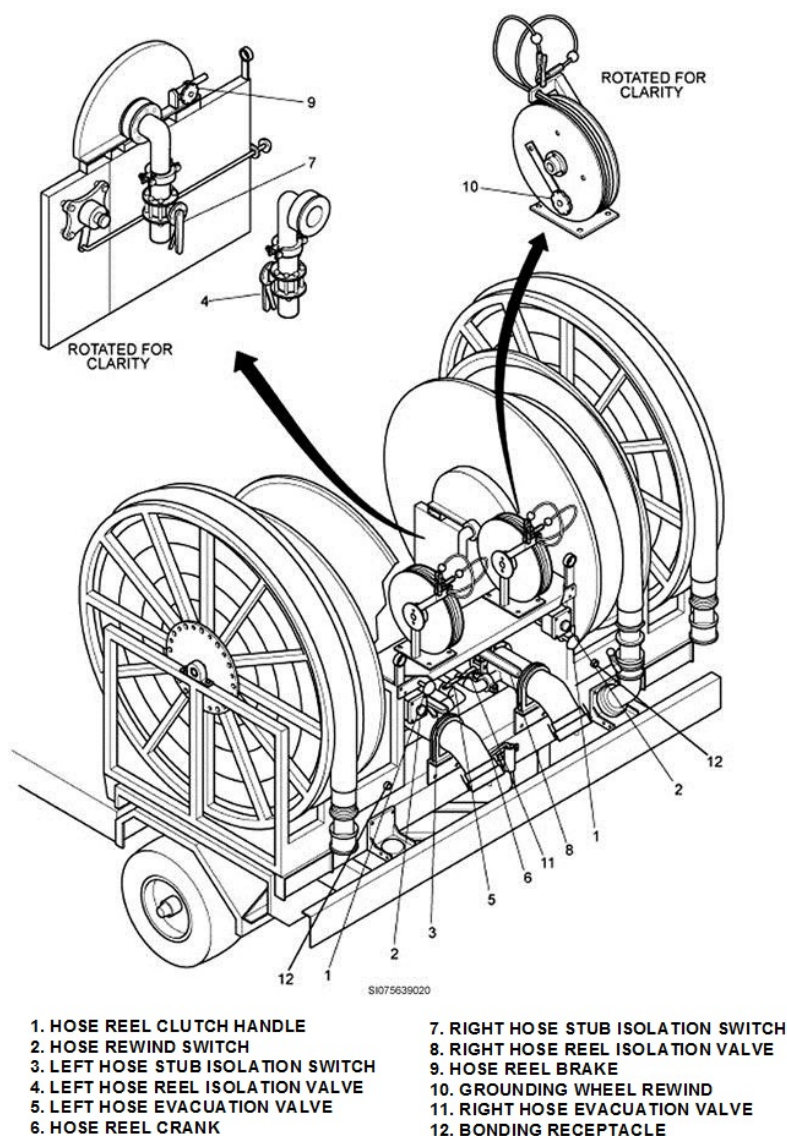


Figure 6-24. R-20 multi-aircraft servicing platform additional components.

R-20 Platform Hose Reel Components	
Item Number	Component Name and Function
Item 1	The hose reel clutch handle controls freewheeling of the hose reels. Pull to engage the clutch, push to disengage.
Item 2	The hose rewind switch operates the hose reel rewind motor. The hose reel clutch handle must be engaged for rewind.
Items 3 and 7	The hose stub isolation valve isolates the left and right hose stubs from fuel flow piping.
Items 4 and 8	The hose reel isolation valve isolates the left and right hose reels from the fuel flow piping.
Items 5 and 11	The hose evacuation valve connects the left and right fueling hoses to the evacuation piping.
Item 6	The hose reel crank rewinds the hose reels manually.
Item 9	The hose reel brake applies the brake to the hose reels.
Item 10	The grounding wheel rewind handwheel rewinds static reel cables manually.
Item 12	The bonding receptacles are for a bonding cable plug.

The following table describes additional R-20 multi-aircraft servicing platform components. Refer to figure 6-25 while reading the descriptions of each component.

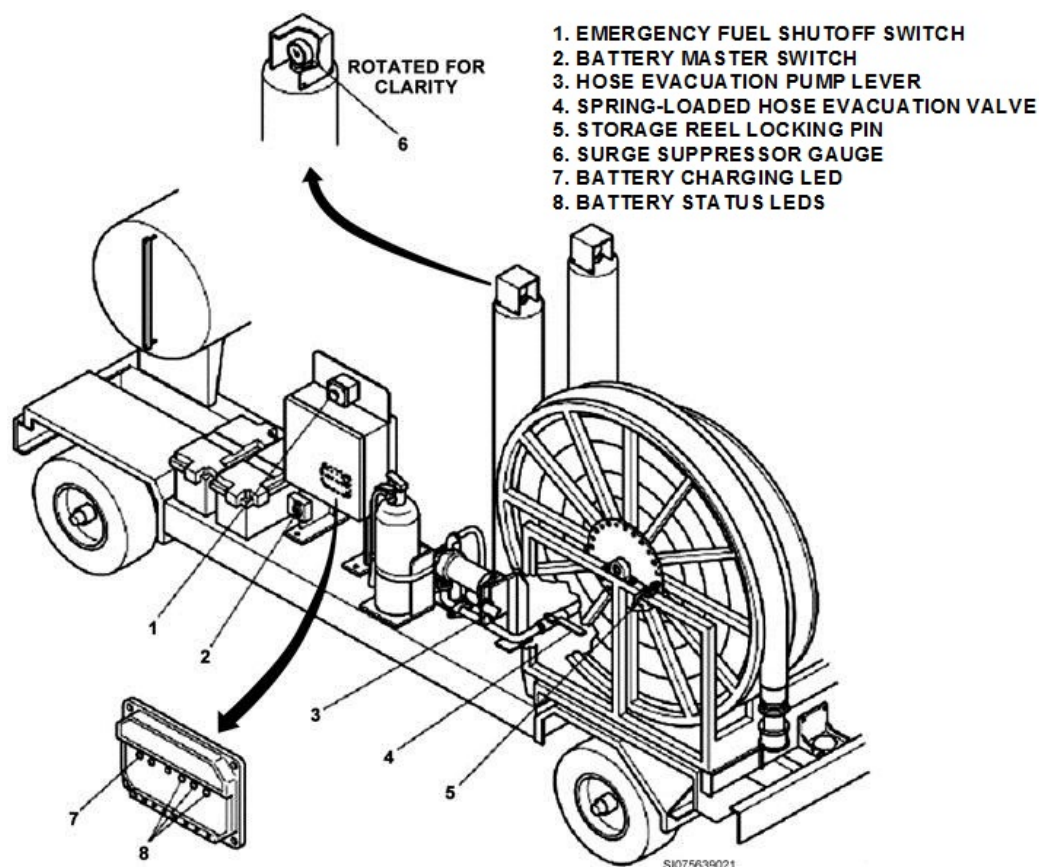


Figure 6-25. Additional R-20 multi-aircraft servicing platform components.

R-20 Platform Components	
Item Number	Component Name and Function
Item 1	The emergency fuel shutoff switch closes flow control valves and shuts down the engine on the pump unit.
Item 2	The battery master switch controls electrical circuit for the servicing platform by connecting or disconnecting the batteries.
Item 3	The hose evacuation pump lever turns the hose evacuation pump on and off. Lift the lever to operate the pump, lower it to turn off the pump.
Item 4	The spring-loaded hose evacuation valve opens the evacuation piping to the evacuation pump inlet.
Item 5	The storage reel locking pin locks the hose storage reel. Pull it out to release the reel and turn it to hold the pin in the unlocked position.
Item 6	The surge suppressor gauge indicates the surge suppressor's charge pressure.
Item 7	The battery charging LED illuminates when the solar panel is charging the battery.
Item 8	<p>The BATTERY STATUS LEDs display the battery status:</p> <ul style="list-style-type: none"> <li>• Green—On steady: Battery near full charge.</li> <li>• Green—Flashing: Battery charging.</li> <li>• Yellow—Battery at middle capacity.</li> <li>• Red—Steady: Battery disconnected.</li> <li>• Red—Flashing: Battery charge low.</li> </ul>

The following table describes the R-20 multi-aircraft servicing unit hand-held remote. Refer to figure 6-26 while reading the descriptions of each component.

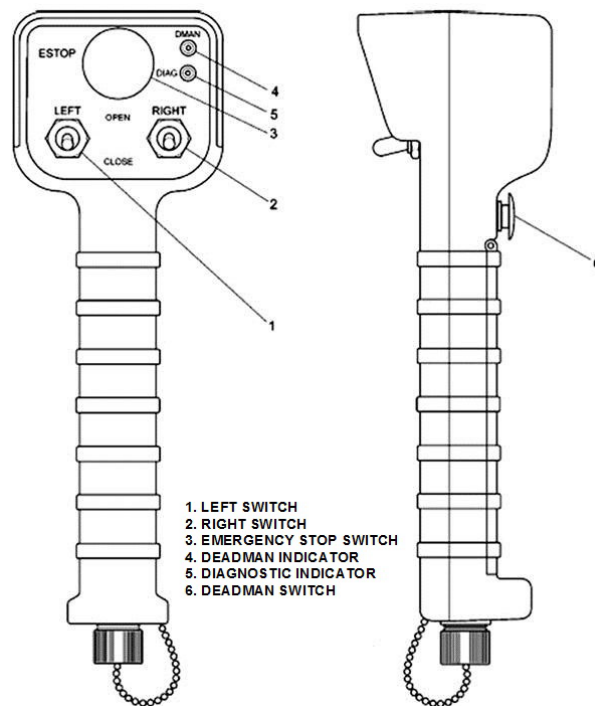


Figure 6-26. R-20 multi-aircraft servicing platform handheld remote components.

R-20 Hand-held Remote Components	
Item Number	Component Name and Function
Item 1	The left switch sets the left side control valve to OPEN or CLOSE.
Item 2	The right switch sets the right side control valve to OPEN or CLOSE.
Item 3	The emergency stop switch activates the emergency stop.
Item 4	The deadman indicator flashes at a slow rate to notify the operator the deadman switch must be released and depressed for normal operations.
Item 5	The diagnostic indicator has three flash patterns that display while the hand-held unit is awake. Steady on indicates a low battery condition. A slow flash indicates a communication error. A quick flash indicates the hand-held unit has learned the address of the receiver module.
Item 6	Pressing the deadman switch opens the flow control valve to begin servicing operations.

### Self-Test Questions

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

#### 239. R-18 pumping unit

1. What is the maximum pumping rate of the R-18 pumping unit?
2. What is the purpose of the beacon light on the R-18 pumping unit?
3. What R-18 pumping unit component indicates a serious problem with the unit engine when illuminated?
4. What R-18 pumping unit component indicates the condition of the inlet air cleaner filter element?
5. What are the two positions on the R-18 pumping unit's air evacuation valve?
6. What component on the R-18 pumping unit hand-held remote flashes at a slow rate to notify the operator that the action/deadman switch must be released and depressed to continue operations?

#### 240. R-19 filter separator unit

1. What is the maximum filtering rate of the R-19 filter separator unit when both filter separators are running in parallel?

2. How is the reset knob on the R-19 filter separator unit DP gauge used?
3. What is the purpose of the float valve tester on the R-19 filter separator unit?
4. At what pressure setting will the pressure relief valve on the R-19 filter separator unit open and send fuel to the sump tank?

**241. R-20 multi-aircraft servicing platform**

1. What is the purpose of the R-20 multi-aircraft servicing platform?
2. What R-20 multi-aircraft servicing platform sump tank component indicates the level of fuel in the sump tank?
3. The system shutdown indicator on the R-20 multi-aircraft servicing platform will illuminate when the sump tank contents reach what level?
4. What R-20 multi-aircraft servicing platform hose reel component controls freewheeling of the hose reel?
5. What does a red flashing light on the R-20 multi-aircraft servicing platform battery status LED indicate?
6. What does a slow flash on the diagnostic indicator of the R-20 multi-aircraft servicing platform handheld remote indicate?

---

**Answers to Self-Test Questions****231**

1. It is easily deployed, is quickly operational upon arrival at destination, it performs various fueling operations, and three R-14 modules can be transported in one C-130 aircraft.
2. To service aircraft where permanent systems are not available.
3. 600 gpm at 2,400 rpm with a discharge pressure of 110 psi.
4. The filter separator.

5. The control panel.

**232**

1. 600 gpm.
2. Centrifugal pump that is self-priming and self-lubricating.
3. 400.
4. Two reducers, a grounding rod, and one 4-in gate valve.

**233**

1. 600 gpm.
2. When the DP reaches 20 psi or every three years, whichever comes first.
3. High and low.

**234**

1. Four.
2. None.
3. None.

**235**

1. To support the transfer of small quantities of fuel and, secondly, support the servicing of small aircraft.
2. 50 gpm.
3. One-cylinder, two-stroke engine rated at 6.5 hp at 3,600 rpm.
4. The inlet valve.

**236**

1. C-5, C-17, and C-130.
2. (1) d.  
(2) f.  
(3) b.  
(4) c.  
(5) a.  
(6) e.
3. The ADDS allows for direct servicing of aircraft.
4. 300 gpm.
5. The single point nozzles on the ACE incorporate a built-in pressure/flow regulator that limits the fuel delivery pressure.

**237**

1. 10,000, 50,000, 200,000, and 210,000 gallons.
2. Portability, minimum vapor loss, and all-weather capability.

**238**

1. To provide an interface for transfer of fuel from tanker aircraft to a maximum of three receiver aircraft simultaneously in austere or remote locations.
2. A one-cylinder, air-cooled 9.2 hp diesel.
3. A pull rope mechanism.
4. 365 gpm.
5. Three.

**239**

1. 900 gpm.
2. It flashes when a no flow/rupture or emergency stop activation occurs.
3. Stop light.
4. Air restriction gauge.
5. NORMAL and AIR EVACUATION.
6. DEADMAN indicator.

**240**

1. 1200 gpm.
2. To reset the DP gauge.
3. It simulates a high water level in the sump.
4. 175 psi.

**241**

1. It is used in conjunction with other FORCE equipment to service aircraft.
2. Liquid level sight gauge.
3. Percent.
4. Hose reel clutch handle.
5. The battery charge is low.
6. A communication error.

**Do 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.

**Do not return your answer sheet to AFCDA.**

81. (231) Which fuels can be used to operate the engine on the R-14C fuel servicing module?
  - a. Jet fuel and gasoline.
  - b. Jet fuel and diesel fuel.
  - c. Diesel fuel and gasoline.
  - d. Diesel fuel, jet fuel, and gasoline.
82. (231) Which component on the collapsible-coated fabric fuel tank allows for removal of water?
  - a. Top vent.
  - b. Open vent.
  - c. Fill/discharge assembly.
  - d. Tank vent pipe assembly.
83. (232) What is the purpose of the float valve on the R-22 pump assembly?
  - a. To fill the engine tank.
  - b. To pump fuel from drums.
  - c. To fill the pump's priming unit.
  - d. To pump fuel from operating tanks.
84. (232) What is used to stop fuel flow to the engine on the R-22 pump assembly?
  - a. Shutoff solenoid.
  - b. Engine off switch.
  - c. Engine stop handle.
  - d. Engine shutdown relay.
85. (233) How many elements are installed in the FFU-15E filter separator?
  - a. 4.
  - b. 6.
  - c. 8.
  - d. 10.
86. (234) How many additives can the TPI-4T-4A additive injector inject simultaneously?
  - a. 2.
  - b. 3.
  - c. 4.
  - d. 6.
87. (235) What is the rated capacity of the PMU-27M self-priming pump?
  - a. 50 gallons per minute (gpm).
  - b. 100 gpm.
  - c. 150 gpm.
  - d. 200 gpm.

88. (235) To facilitate priming, the PMU-27M self-priming pump is provided with a priming
- a. stem.
  - b. hose.
  - c. valve.
  - d. coupler.
89. (236) On the aerial bulk fuel delivery system (ABFDS), how many wafer valves make up the refuel/defuel manifold of each pumping module?
- a. 4.
  - b. 6.
  - c. 8.
  - d. 10.
90. (236) What is the rated capacity of the filter separator on the aerial delivery and dispensing system (ADDS)?
- a. 200 gallons per minute (gpm).
  - b. 300 gpm.
  - c. 400 gpm.
  - d. 600 gpm.
91. (237) What fuel bladder component is used for removing water from the bladder?
- a. Fill assembly.
  - b. Drain assembly.
  - c. Vertical vent pipe.
  - d. Discharge assembly.
92. (238) The forward area manifold cart is capable of servicing up to how many receiver aircraft at one time?
- a. 2.
  - b. 3.
  - c. 4.
  - d. 6.
93. (238) The forward area manifold cart engine can run on all of the following types of fuel *except*
- a. JP-5.
  - b. JP-8.
  - c. gasoline.
  - d. diesel fuel.
94. (239) How many seconds does it take for the no flow/rupture alarm on the R-18 pumping unit to illuminate once the no flow/rupture pressure switch is activated?
- a. 5.
  - b. 10.
  - c. 20.
  - d. 40.
95. (240) At what maximum rate can an R-19 filter separator unit filter fuel individually?
- a. 450 gallons per minute (gpm).
  - b. 600 gpm.
  - c. 750 gpm.
  - d. 1200 gpm.

96. (240) At what pounds per square inch (psi) setting will the pressure relief valve on the R-19 filter separator unit open and send fuel to the sump tank?
- a. 150.
  - b. 175.
  - c. 200.
  - d. 225.
97. (241) What R-20 component will illuminate when the servicing platform has communicated with the lead pumping unit within the past five minutes?
- a. Beacon light.
  - b. System shutdown indicator.
  - c. High level warning indicator.
  - d. Communication active indicator.

**Please read the unit menu for unit 7 and continue ➔**

## Student Notes

## Unit 7. Kovatch R-11 Chassis Systems

<b>7-1. Air System .....</b>	<b>7-2</b>
242. Characteristics of the Kovatch R-11 air system .....	7-2
<b>7-2. Electrical and Winterization System .....</b>	<b>7-3</b>
243. Characteristics of the Kovatch R-11 electrical system .....	7-3
244. Winterization system .....	7-3
<b>7-3. Power Takeoff.....</b>	<b>7-6</b>
245. Construction and operation of the power takeoff assemblies .....	7-6
<b>7-4. Power Takeoff and Throttle Interlock.....</b>	<b>7-7</b>
246. Kovatch R-11 power takeoff and throttle interlock system.....	7-7
<b>7-5. Bottom-Loading System.....</b>	<b>7-10</b>
247. Bottom-loading system components and operation .....	7-10
<b>7-6. Bypass System .....</b>	<b>7-15</b>
248. Bypass system components and operation.....	7-15
<b>7-7. Mainline System .....</b>	<b>7-21</b>
249. Mainline system components and operation.....	7-21
<b>7-8. Defuel System.....</b>	<b>7-26</b>
250. Defuel system components and operation .....	7-26
<b>7-9. Fuel Flow Meter Testing and Calibration.....</b>	<b>7-29</b>
251. Testing the meter/register .....	7-29
252. Meter/register programming .....	7-29
<b>7-10. Fuel Hose Maintenance .....</b>	<b>7-32</b>
253. Types and inspection requirements for fuel hoses .....	7-32
254. Hydrostatic testing procedures for fuel dispensing hoses .....	7-32
<b>7-11 Refueling Maintenance Safety.....</b>	<b>7-34</b>
255. Safety hazards specific to refueling maintenance shops .....	7-35
256. Use and care of vehicle-mounted safety items on refueling vehicles .....	7-36
257. Static ground reel operation, inspection, and testing .....	7-37

**T**HE KOVATCH R-11 REFUELER is the newest R-11 model refueler in the Air Force vehicle inventory. The Kovatch R-11 can handle all types of aircraft fuels and service USAF and foreign aircraft. It is capable of high-flow and low-flow refueling, along with defueling. All equipment necessary for refueling and defueling is self-contained. The Kovatch is capable of satisfactory performance in any ambient temperature from 125°F to -40°F under normal operating conditions. The fuel servicing truck delivery systems fuel delivery rate is capable of delivering up to 625 gpm or defueling at a rate of up to 175 gpm. The fuel truck is also able to deliver fuel in adverse conditions such as 100 percent humidity, rainy, salty, or desert-like operating conditions. In full service condition, the Kovatch R-11 is capable of maintaining a max speed of 56 mph on dry, level, paved roadways, 25 mph on unimproved roads, and 10 mph on Belgian block pavement. This unit covers the bottom-loading system, bypass system, mainline system, and the defuel system.

## 7-1. Air System

The air system used on refuelers is similar to those used on heavy-duty trucks. Since you covered air brake systems in your previous course, you will not cover every component in this lesson. This lesson covers the characteristics of the Kovatch R-11 air system that are specific to it. Additionally, you cover components specific to the system.

**SAFETY NOTE:** Always wear approved personal protective equipment (PPE) to include safety goggles/glasses when working on or around vehicle air systems.

### 242. Characteristics of the Kovatch R-11 air system

The air system consists of an engine-driven compressor, four storage reservoirs, air dryer, and necessary piping and valves to supply the brake system, pumping system, air starting and all air operated accessories. The air brake system is a dual-type spring brake with separate supply systems for the front axle and rear tandem axles. The spring brakes on the rear tandem axles are used for service, parking, and emergency braking. A low air pressure warning system is provided in addition to the dual air pressure gauge, consisting of a warning light and buzzer, which activates whenever air pressure drops below 60 psi.

#### Front and rear quick air connect

The Kovatch R-11 uses a front and rear quick air connects. These connections provides for an external air source to charge the air system. The front quick air connect is on the bottom center of the front bumper. The rear quick air connect is on the cross rail just behind the center of the rear bumper.

#### Air seat

A luxury feature on the Kovatch R-11 is an air seat. The purpose of the air seat allows the operator to adjust the seat height.

#### Cab air manifold

Located under the dash to the left of the steering column is the cab air manifold. The cab air manifold provides a common connection point for all air pressure passing in and out of the cab.

#### Suspension-leveling valve (left/right)

The suspension-leveling valve automatically maintains the desired ride height throughout the unloaded and loaded range. This three-position valve is located on the left and right side of rear axles.

#### Air springs

Also located on the left and right of the rear axles are air springs. These springs are air bag-type springs. These springs raise and lower axles in accordance with changes in load and conditions as dictated by the suspension-leveling valve.

#### Height control valves

The axles mechanically control the height control valves, which are located between the two rear axles. These spool valves automatically sense varying load conditions and adjust the air ride suspension to compensate for height changes.

#### Air start tank

The air start tank is a 60-gallon fiberglass tank located on the outside left frame rail. The air start tank supplies air for the air start system.

#### Air starter

Specific to the Kovatch R-11 is the air starter. Its purpose is to turn air pressure into mechanical energy, rotating the engine for starting. The air starter is a vane-type air motor located on the lower left side of the engine. The air start switch and the Bosch® relay control the operation of the air starter.

### Air start switch

Located on the dash next to the ignition switch is the air start switch. Controlled manually, this normally open push button electrical switch sends current to the Bosch relay. The Bosch relay allows air pressure to pass to the air starter.

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## Self-Test Questions

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

### 242. Characteristics of the Kovatch R-11 air system

1. How many air reservoirs does the Kovatch R-11 have?
2. On the Kovatch R-11, at what pressure does the low air warning light and buzzer activate?
3. What is the purpose of the air seat on the Kovatch R-11?
4. What component on the Kovatch R-11 automatically maintains the desired ride height throughout the unloaded and loaded range?
5. What type of springs is used on the Kovatch R-11 rear axles?
6. Where is the air start tank located on the Kovatch R-11?
7. Which air system component on the Kovatch R-11 turns air pressure into mechanical energy?

## 7-2. Electrical and Winterization System

The following lessons cover the Kovatch R-11 electrical and winterization systems.

### 243. Characteristics of the Kovatch R-11 electrical system

The Kovatch R-11 uses a conventional 12 VDC, negative ground electrical system. A single 12 volt, 625-cold-cranking amp maintenance free battery provides the voltage. A Delco Remy® 90-amp alternator charges the battery when the engine is running. Automatic reset-type circuit breakers protect electrical components against overload.

### 244. Winterization system

The Kovatch R-11 uses 120- or 240-VAC resistance heaters. This dual-purpose system allows operation of the Kovatch winterization system in overseas areas. Operators use the winterization system when the refueler is on standby and the engine is not running during cold weather. This



system maintains the refueler in a ready-to-operate condition, permitting the refueler to satisfy mission requirements when the ambient temperature is extremely low. Refer to figure 7-1 as you cover the winterization components in this lesson.

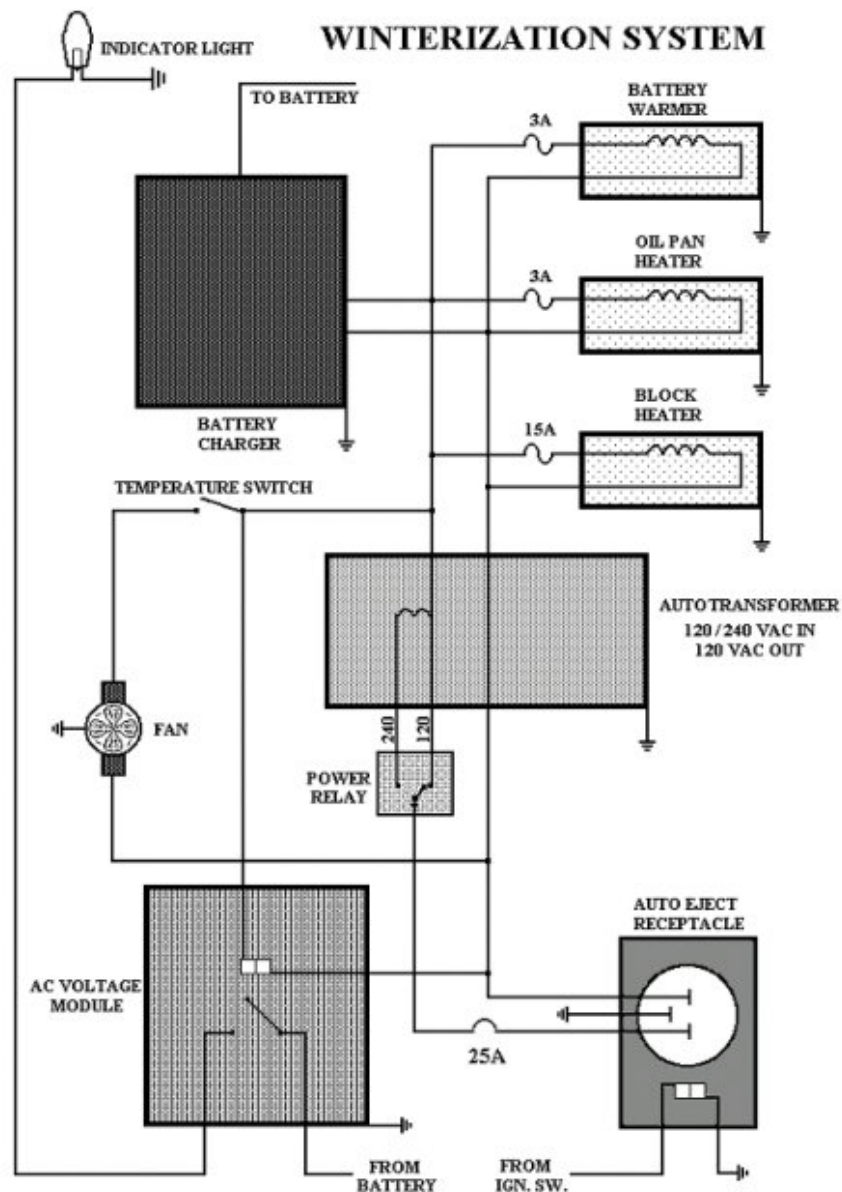


Figure 7-1. Kovatch winterization system.

The following are major components you should be aware of regarding the Kovatch R-11 winterization system.

Component	Location	Explanation
External power auto eject receptacle	On the right side of the cab above the battery box	Allows a connection for the external power cable. The receptacle automatically ejects the power cord anytime the ignition switch energizes.
Indicator light orange 12 volt	On the center of the dash	Controlled by the alternating current (AC) voltage module; Illuminates any time external power is connected.

Component	Location	Explanation
AC voltage module	Under the passenger seat in the interlock module	Allows 12-VDC to travel to the indicator light when external power is connected.
12 VDC battery charger	Under the passenger seat in the interlock module	It is a 12-volt battery charger intended to keep the battery sufficiently charged.
Battery warmer	Under the battery	It is a resistor-type heater controlled by external power that keeps the battery warm.
Engine oil heater	In the left side of the oil pan	It is a resistor-type heater probe that keeps the oil at an acceptable temperature.
Engine coolant heater	On the right rear of the engine block	Is a resistor-type heater that keeps the coolant at an above freezing temperature.
25-amp fuse	Under the passenger seat in the interlock module	Protects the winterization system components in case of an unwanted short.

### Self-Test Questions

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

#### 243. Characteristics of the Kovatch R-11 electrical system

1. What type of electrical system does the Kovatch R-11 use?
2. How many and what type battery does the Kovatch R-11 use?
3. What is the amperage rating of the alternator used on the Kovatch R-11?

#### 244. Winterization system

1. What type of power receptacle does the Kovatch R-11 use?
2. On the Kovatch R-11, what color is the winterization system ON indicator light?
3. What Kovatch R-11 winterization component allows 12 VDC to travel to the indicator light when external power is connected?
4. What type of fuse protects the Kovatch R-11 and where is it located?

### 7-3. Power Takeoff

The power takeoff (PTO) and throttle interlock systems are vital to the safe and efficient operation of refueling vehicles. The PTO acts as a power-connecting link for either driving the rear wheels or driving the main fuel pump, depending on the mode selected.

#### 245. Construction and operation of the power takeoff assemblies

This lesson covers the construction and operation of the PTO assemblies. For more in-depth technical information, reference the specific vehicle technical order.

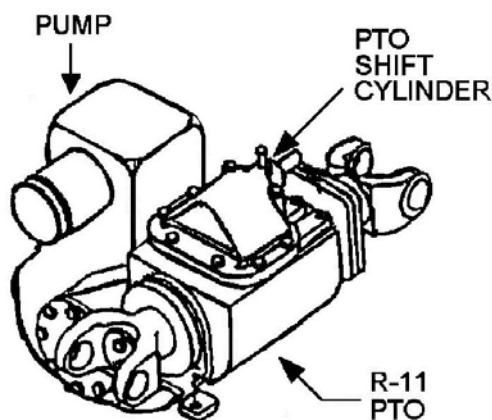


Figure 7-2. R-11 PTO and pump assembly.

#### Construction

Mounted behind the vehicle transmission is the PTO (fig. 7-2). The design of the PTO is split-shaft. This gearbox has a cast-iron case, making it extremely durable yet remarkably heavy. Use caution when removing this unit.

Ninety-weight gear oil lubricates and cools the PTO. There is a drain plug located on the bottom of the PTO as well as an inspection plug on the side of the unit. Check oil level at every scheduled inspection. The 90-weight oil level should be level with the inspection plug.

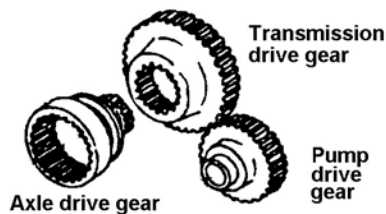
#### Operation

The PTO receives input power from the vehicle diesel engine and an automatic transmission. The PTO gearbox separates the drive shaft at a point between the transmission and the rear axle. A sliding gear unit, within the PTO, permits driving either the pump or the rear axles. The PTO is air operated and controlled by the operator from the cab.

For you to shift the PTO into and out of gear, three conditions must take place.

1. Park brake must be set.
2. Engine must be at idle.
3. Transmission must be in neutral.

The two operation modes of the PTO are *road* and *pump*. In pump mode, the transmission drive gear meshes with the pump drive gear. The pump drive gear connects to the pump impeller with a splined shaft. In road mode, the transmission drive gear slides over the axle drive gear, which connects to the rear axles by a driveline (fig. 7-3).

**PUMP POSITION****ROAD POSITION**

97L06G14

Figure 7-3. PTO gear positions.

**Self-Test Questions**

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

**245. Construction and operation of the power takeoff assemblies**

1. What shaft design does the PTO use?
2. What PTO component permits either driving the pump or the rear axles?
3. Which conditions must be met to shift the PTO from one operating mode to the other?
4. What are the operating modes of the PTO?

**7-4. Power Takeoff and Throttle Interlock**

A PTO interlock system prevents operation of the PTO in either direction unless the truck is at idle speed and the parking brake is applied. A safety device prevents the use of the accelerator pedal when the PTO is in the pump mode.

**246. Kovatch R-11 power takeoff and throttle interlock system**

The PTO connects the engine to the pump in order to dispense fuel. The throttle interlock prevents the PTO from shifting until the parking brake is applied, the transmission is in neutral, and the engine is at idle. The auxiliary throttle interlock's purpose is to prevent operation of the auxiliary throttle when the PTO is in road mode. It is comprised of the following components.

**Body control module**

The body control module is located in the passenger compartment next to the driver's door, and determines parking brake status prior to PTO engagement by sending power to the park brake air pressure switch. If the parking brake is applied, the body control module energizes the air solenoid valve, PTO shift control, and pump shift pressure switch.

**Park brake air pressure switch**

The park brake air pressure switch is a normally closed air pressure switch located under the dash, to the right of the steering column in the delivery line. It receives 12-volts from the body control module and returns it when closed to indicate parking brake status.

**Air solenoid valve**

The air solenoid valve is a normally closed, electrically energized valve that is located in the driver's side frame rail. When the parking brake is set, the body control module energizes the air solenoid valve and provides air to the PTO shift control.

**PTO shift control**

The PTO shift control is a two position, manually operated toggle valve located on the pump shift tower. It is controlled by air received from the air solenoid valve, and directs air pressure to either the road or pump mode control port on the PTO shift cylinder.

**Pump shift pressure switch**

The pump shift pressure switch is a normally open air pressure switch located inside the pump shift tower, and connected in-line between the PTO shift control and PTO shift cylinder. It receives reference voltage from remote power module (RPM) 1. When the pressure switch is closed, it signals RPM 1 that PTO shift control has been shifted to road mode. When the PTO shift control is placed in pump mode, it is controlled by air pressure.

**PTO shift cylinder**

The PTO shift cylinder is a double-acting air cylinder located in the PTO assembly. It is controlled by air pressure from the PTO shift control, and changes PTO gearing between road and pump mode.

**PTO pilot valve V-80**

The PTO pilot valve V-80 is a normally open air valve located on the rod side of the PTO shift cylinder. It is controlled by the PTO shift cylinder, and allows air to flow from the supply tanks to the tank control valve V-44, shuttle valve V-74, and pump engaged pressure switch.

**Pump engaged pressure switch**

The pump engaged pressure switch is a normally open air pressure switch located inside the pump shift tower, mounted to the bottom passenger side toward the rear of the truck. It is controlled by air received from V-80, and receives reference voltage from RPM 1. When closed, the switch grounds, and signals RPM 1 that the pump is engaged.

**RPM 1**

The RPM 1 is located under the cab on the driver's side, above the battery box. It provides power to the fuel master, scully system, transmission lock-up relay, pump engaged light, OK TO PUMP light, and deadman air pressure switch.

**Pump engaged light**

The pump engaged light informs the operator when the PTO is engaged. It is located on the pump shift tower above the PTO shift control. It is controlled by power from RPM 1 when signal from the pump engaged pressure switch is received.

**Transmission lockup relay**

The transmission lockup relay is a four-pronged relay located in the pump shift tower. It provides fourth gear lock-up of the transmission to achieve direct drive of the PTO. It receives reference voltage from the transmission control module while in road mode, and grounds in pump mode. When shifted to pump mode, RPM 1 powers the relay, locking the transmission in fourth gear.

**OK TO PUMP light**

The OK TO PUMP light informs the operator when the PTO is engaged and fourth gear lockup is achieved. It is located on the pump shift tower, above the PTO shift control. It is controlled by RPM 1 once fourth gear lockup has been achieved and the transmission is placed in drive.

**Deadman air pressure switch**

The deadman air pressure switch is normally closed, and mounted inside the pump shift tower on the passenger's side toward the front of the vehicle. It receives 12 volts from RPM 1 via the OK to pump light when fourth gear lockup is achieved and the transmission is placed in drive. It sends 12 volts to the signal side of RPM 1 until deadman control valve V-50 is actuated.

**Auxiliary throttle control**

The auxiliary throttle control allows the operator to control engine speed from the pump panel, and permits immediate return to idle speeds by pressing the idle button. It is an electronic throttle powered by RPM 1 and the deadman air pressure switch.

---

**Self-Test Questions**

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

**246. Kovatch R-11 power takeoff and throttle interlock system**

1. What is the purpose of the Kovatch R-11 PTO and auxiliary throttle interlock system?
2. What manually operated toggle valve directs air pressure to either the road or pump control port on the PTO shift cylinder?
3. Which component is located under the cab on the driver's side above the battery box?
4. Which component receives 12 volts from RPM 1 via the OK to pump light when fourth gear lockup is achieved and the transmission is placed in drive?

## 7-5. Bottom-Loading System

In this section, you will cover the components and operation of the Kovatch R-11 bottom-loading system and some of the different features it incorporates.

**SAFETY NOTE:** Before working around or directly with fuel, wear approved PPE to include safety goggles/glasses, fuel resistant apron, and gloves.

### 247. Bottom-loading system components and operation

As you cover the bottom-loading components and operation, refer to the schematic in figure 7-4.

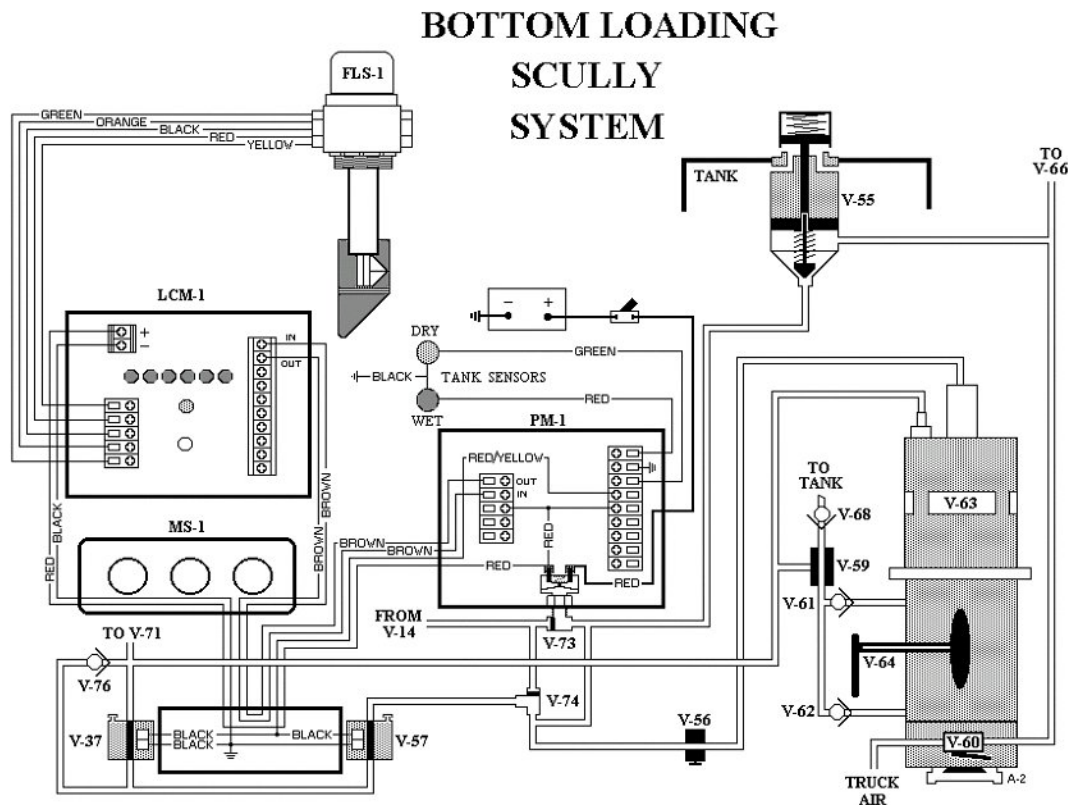


Figure 7-4. Bottom-loading system.

#### Bottom-loading adapter

The bottom-loading adapter A-2 is a single-point receptacle located on the bottom-loading valve. It provides a secure connection for the single-point nozzle that opens and closes the connection using a poppet valve.

#### Bottom-loading interlock valve

The single-point nozzle presses against the bottom loading interlock valve V-60, which sends air pressure up to the vent. This normally closed push button connects to A-2 and actuates by the connection of the hose. The mechanical actuation of the valve sends air pressure up to the V-55 ensuring the tank vents during bottom loading.

#### Bottom-loading vent valve

V-55 is normally a closed piston type with an internal check valve designed to ensure that the vent is open before sending air down to the scully system. Venting the tank provides an escape for



compressed air within the tank from compressing during bottom loading, so eruption of the tank walls will not occur.

### Shuttle valve V-73

When the hose is connected and the tank vent is open, air pressure travels down to shuttle valve V-73. This shuttle valve, located below power module (PM)-1, isolates the V-55 from the selector valve V-14. This separates the bottom-loading operations from the defuel operations. At this time, air pressure from

V-73 is applied to a pressure switch that is inside PM-1. The purpose of this switch is to ensure the tank vent is fully open before bottom-loading operations can begin.

### Power module-1

PM-1, located on the left rear bumper, is an electronic control module designed to direct electrical signals to and from the lever control module (LCM)-1. The power module allows current to flow to the LCM-1 and to solenoids V-57 and V-37. The PM-1 receives its power directly from the batteries. Control of PM-1 is through normally open V-55 during bottom loading and V-14 during defuel mode.

### On/Off switch

The on/off switch controls the power to PM-1. Located to the right of the circuit breaker panel, this 12 VDC circuit breaker protects the scully system from excessive current draw. In the event of electrical failure to the scully system, turn this switch to the OFF position to ensure no further damage to the electronics.

### Multecept sockets MS-1

The Air Force vehicle inventory does not use this component. The multitecept sockets (MS)-1 is a triple socket receptacle located under the LCM-1. The purpose of MS-1 is to allow for connection to a fill stand and incorporate a computer-controlled fuel accountability program accurate within a tenth of a gallon. This system, if incorporated, would virtually eliminate human error at the fill stands.

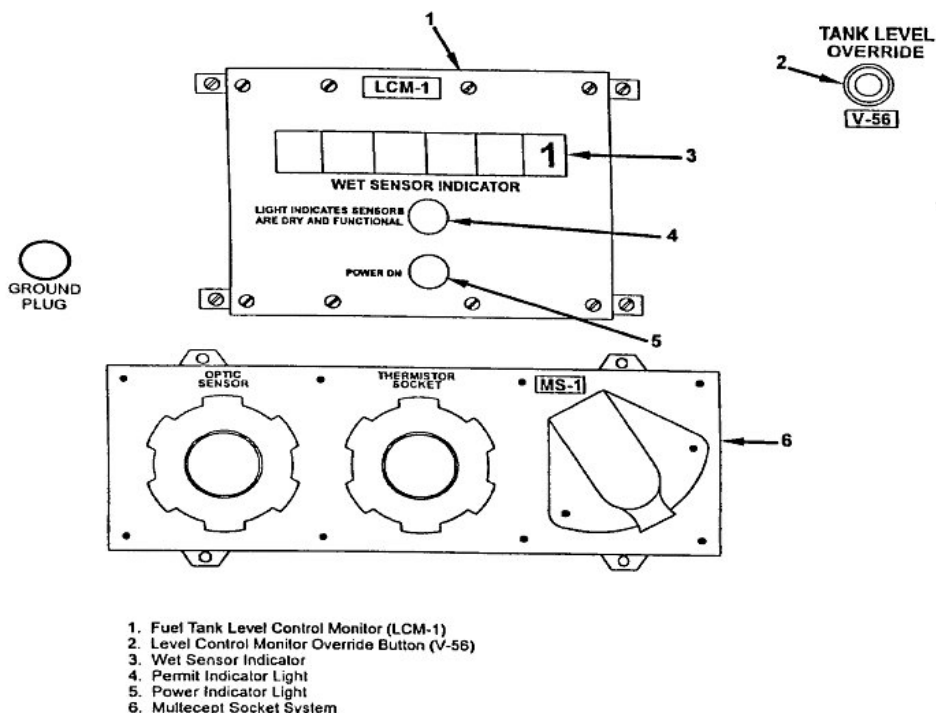


Figure 7-5. Level control module.

### Level control module LCM-1

Incorporated into the system, and located on the left rear bumper, is LCM-1. LCM-1 (fig. 7-5) sends and receives signals to the fuel level sensor (FLS), to determine fuel level within the tank. These signals are relayed back to the PM-1 to either allow or halt bottom loading.

### Fuel level sensor FLS-1

FLS-1 (fig. 7-6) is a five-wire optic probe-type sensor located to the rear of the manhole cover and controlled by fuel level in the tank. FLS-1 uses a prism-type optical diode to send electrical signals in a continuous loop until broken by fuel level higher than the prism. Once broken, this signal travels back to LCM-1 and is relayed to PM-1 indicating either a high (wet) or low (dry) fuel level on the tank sensor indicator lights located on the main control panel.

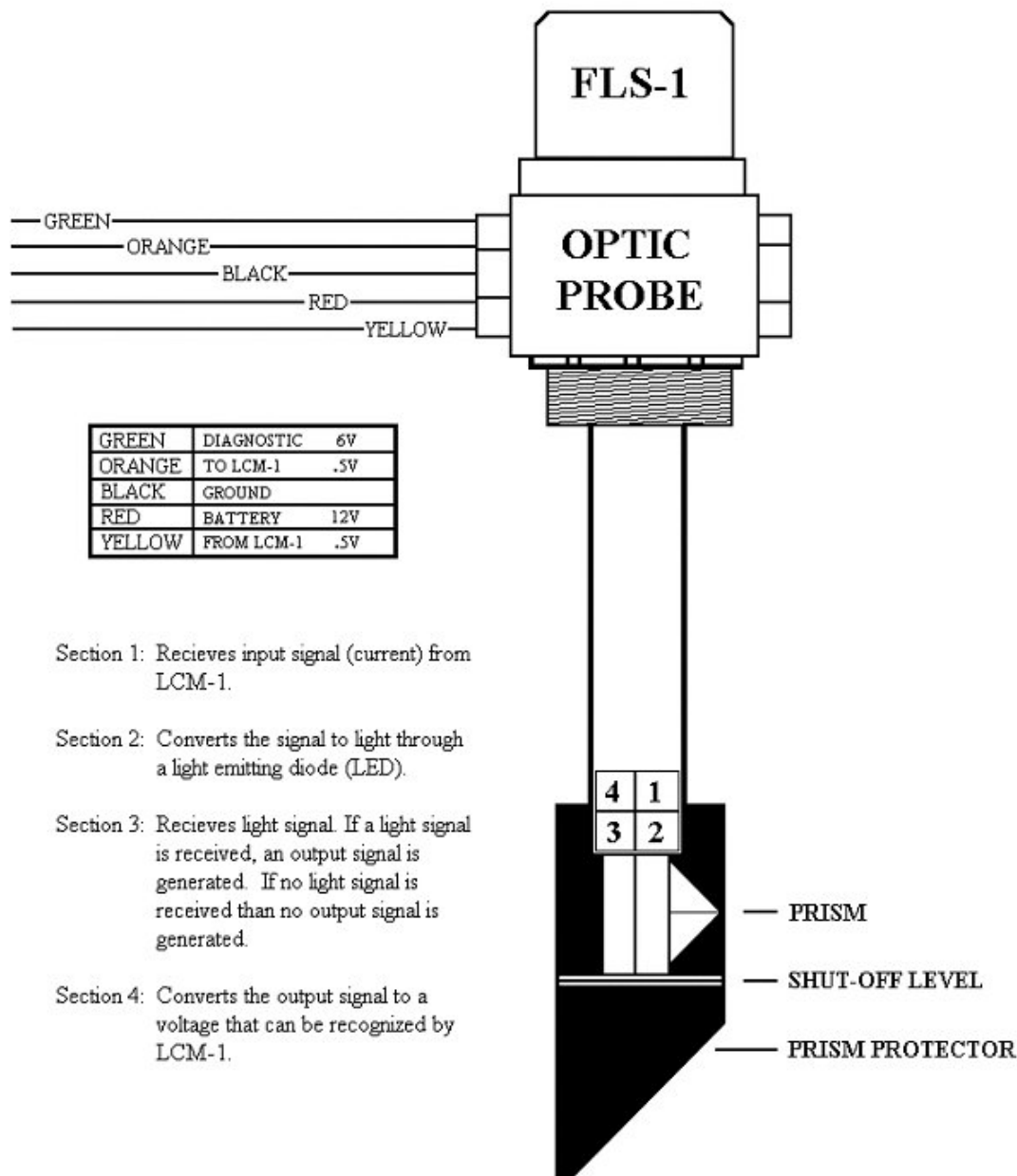


Figure 7-6. Fuel level sensor.

### Shuttle valve V-74

Once air pressure from the shuttle valve V-73 powers up the scully system, the air proceeds down to V-74. The purpose of the V-74 shuttle valve is to isolate the bottom-loading vent valve from the selector valve in defuel mode. V-74 attaches electrically to actuated air solenoid V-57

### Solenoid V-57

Normally closed V-57 allows air to flow to the supply port of V-37 when V-55 is open or when V-14 is in defuel. This solenoid attaches to the rear bumper.

### Solenoid valve V-37

V-37 is the same type of solenoid as V-57 and is located in the same area. V-37 directs air pressure to the pilot port valve on V-63, then to V-71 and V-59. PM-1 controls both V-57 and V-37.

### Bottom-loading valve V-63

Once the scully system is up and running the fuel must have a means of entering the tank from the hose. V-63 accomplishes this task. Shown in figure 7-7, the bottom-loading valve is a normally closed liquid-controlled piston valve located on the left rear of the tank. Air pressure from V-37 controls this valve and its purpose is to allow fuel to enter the tank.

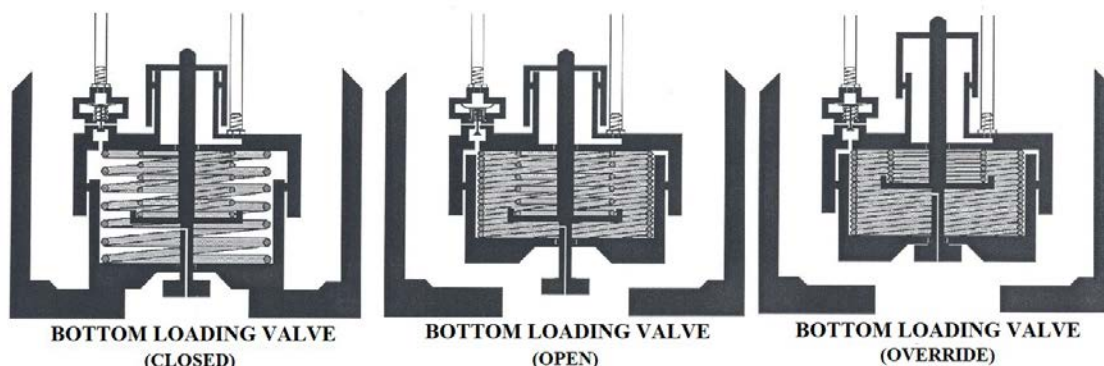


Figure 7-7. Bottom-loading valve.

### Four-inch manual butterfly valve

A four-inch manual butterfly control valve limits the amount of fuel that travels through the bottom-loading stub. This valve is manually operated to create backflow.

### Level control monitor override button V-56

In the event the tank is completely full and the scully system halted operations, a level control monitor override button V-56 allows the operator to override the bottom-loader valve. It is located on the left rear of the bumper and is a normally closed push button type. When the operator pushes the override, air pressure is directed to what is known as the “power piston” or right side of V-63. Supplying air to this side of the valve causes the air pressure on the backside of the piston to override the spring pressure, thus opening the valve.

### Thermal relief valves

Incorporated into the system are two thermal relief pilot valves and two thermal relief check valves. When the vehicle is not in use and temperatures on the outside are high, thermal pressure builds within the bottom-loading stub. Thermal relief valves ensure that the piping and seals within the stub do not rupture.

**Check valve V-76**

The bottom-loading system is full of safety features, to include a check valve V-76. V-76 provides a backup for air to exhaust if V-37 malfunctions. This check valve, connected to the delivery port of V-37, ensures the air pressure applied to V-63 during bottom-loading exhausts, so the valve closes and no accidental fuel spill occurs.

---

**Self-Test Questions**

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

**247. Bottom-loading system components and operation**

1. What does A-2 provide for?
  
  
  
  
  
  
  
  
  
  
2. Why does the refueling tank need to vent?
  
  
  
  
  
  
  
  
  
  
3. What is the purpose of the pressure switch located inside PM-1?
  
  
  
  
  
  
  
  
  
  
4. From where does PM-1 receive power?
  
  
  
  
  
  
  
  
  
  
5. How does FLS-1 sense the fuel level in the tank?
  
  
  
  
  
  
  
  
  
  
6. What controls V-63?
  
  
  
  
  
  
  
  
  
  
7. What is the purpose of the thermal relief valves?

## 7-6. Bypass System

In this section, we cover the bypass system on the Kovatch R-11 refueler. The primary purpose of any bypass system is to control system fuel pressure by returning excess fuel back to the tank during all modes of operation.

### 248. Bypass system components and operation

This lesson covers the bypass servicing system (fig. 7-8) on the Kovatch R-11 refueler. The primary purpose of any bypass system is to control system fuel pressure by returning excess fuel back to the tank during all modes of operation.

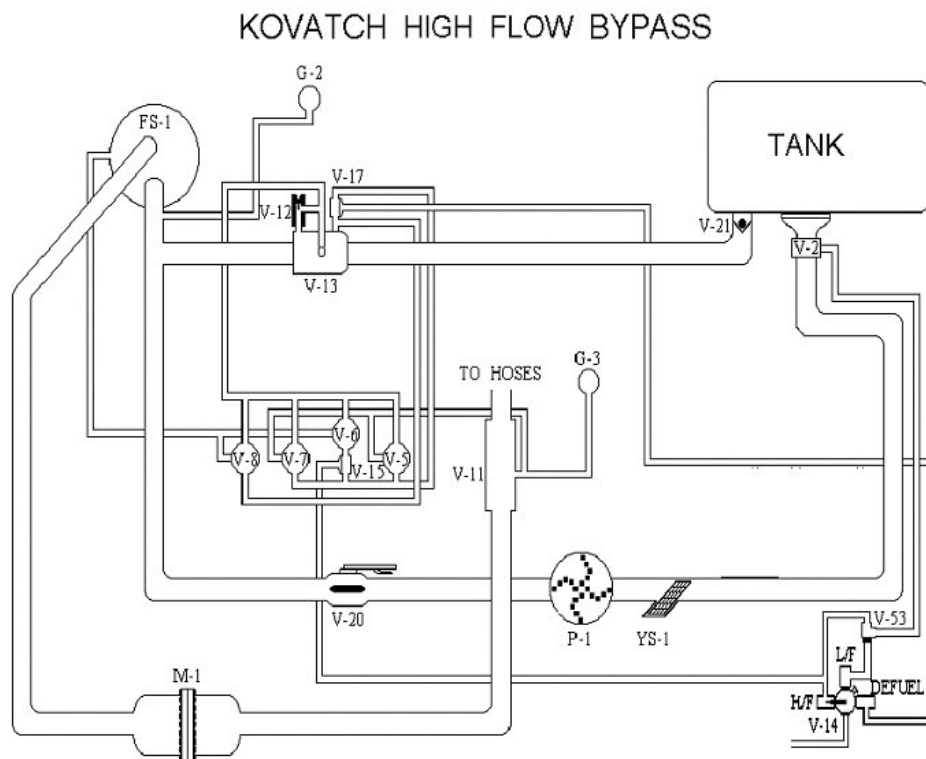


Figure 7-8. Kovatch R-11 bypass system.

#### Tank emergency shut-off valve V-2

The first component covered in the bypass system is the tank emergency shut-off valve V-2. The shut-off valve is a normally closed air operated piston valve, centered under the tank, and controlled by air pressure from V-14 when you actuate the deadman. The valve ensures fuel supply to the pump is shut off when the truck is not in use.

#### Y-strainer YS-1

From V-2 fuel travels, with contaminants that are in the fuel tank, to the Y-strainer YS-1. The 4-inch cylindrical screen is a 40-mesh filter that prevents large particles from entering the pump and damaging the impeller. The strainer is located on the suction side of the pump.

#### Pump P-1

To maintain a steady flow rate of 600 gpm, the pump P-1, attaches to the PTO. The pump is a four-inch single-stage, centrifugal impeller-type pump.

### Pump shutoff valve V-20

Sometimes it may be necessary to remove the pump for maintenance. To ensure the least amount of fuel spillage, and to add a safety feature for large spills, a pump shutoff valve V-20, attaches to the outlet side of the pump piping. Use this manually operated butterfly valve for pump maintenance.

**NOTE:** It is wise not to rely just on V-2 and V-20 to hold the 6,000 gallons of fuel in the tank. Thus, before pump removal, drain the fuel tank when possible.

### Venturi V-11

During the pumping process, you must visually check several pressures to ensure proper operations. One of these pressures is the pressure at the single-point nozzle. Since it is not feasible to connect a gauge to the nozzle, a simulated pressure is taken from the Venturi (fig. 7-9). The V-11 connects in the piping after the meter.

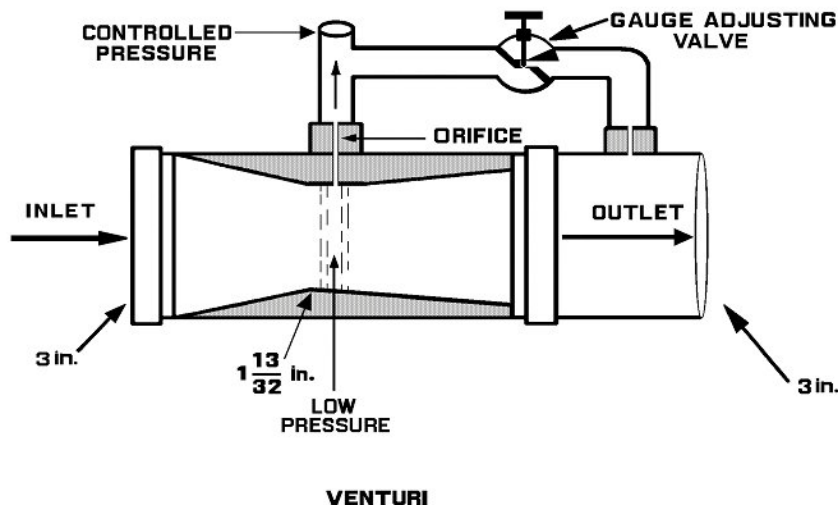


Figure 7-9. Venturi.

### Nozzle pressure gauge G-3

The nozzle pressure gauge G-3 reads the pressure taken from the V-11. Located on the main control panel, this gauge reads from 0 to 100 pounds per square inch (psi).

### Pump pressure gauge G-2

Another gauge that is important to ensure proper operations is the pump pressure gauge G-2. Located on the main control panel this gauge indicates 0 to 200 psi. It reads the pressure from the outlet side of the pump.

### Bypass control valve V-13

The bypass control valve V-13 (fig. 7-10 and fig. 7-11) maintains system pressure in all modes of operation. The valve controls pressure by providing a path for excessive pressure to return to the tank. This valve is a 4-inch liquid-controlled piston valve located in the rear of the canbox behind the filter separator. Four regulators, two pilot valves and a needle valve control this valve.

### Bypass control needle valve V-12

The bypass control needle valve V-12 (fig. 7-12) is a variable orifice needle valve that controls the closing speed of V-13. This manually adjusted needle valve is set at a standard two and one-half turns out, once fully seated. The needle valve controls the closing speed by allowing a certain amount of fuel trapped on the backside of the piston valve to relieve through the needle valve, thus causing the spring pressure within the valve to close it.

The bypass system controls pressures in many ways. It is essential that pressures within the system maintain steady rates. Serious damage or spillage can occur if the bypass system does not maintain operating pressures. The nozzle pressure is one of the most crucial pressures to regulate. Too high pressure at the nozzle could damage it or even worse, damage the aircraft being serviced. Too low pressure will not provide the needed pressures to service the aircraft properly.

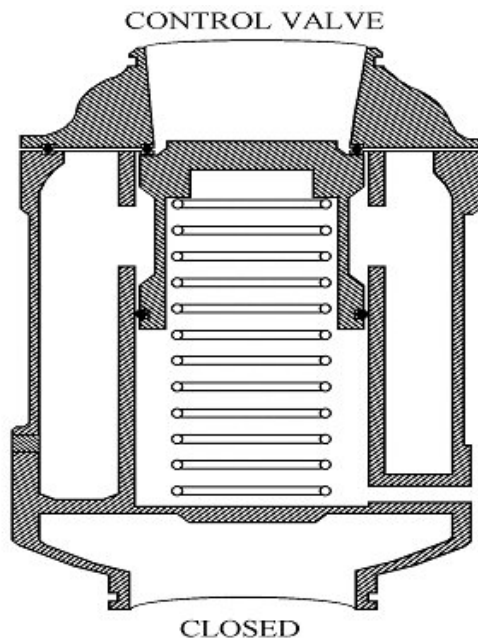


Figure 7-10. Bypass control valve closed.

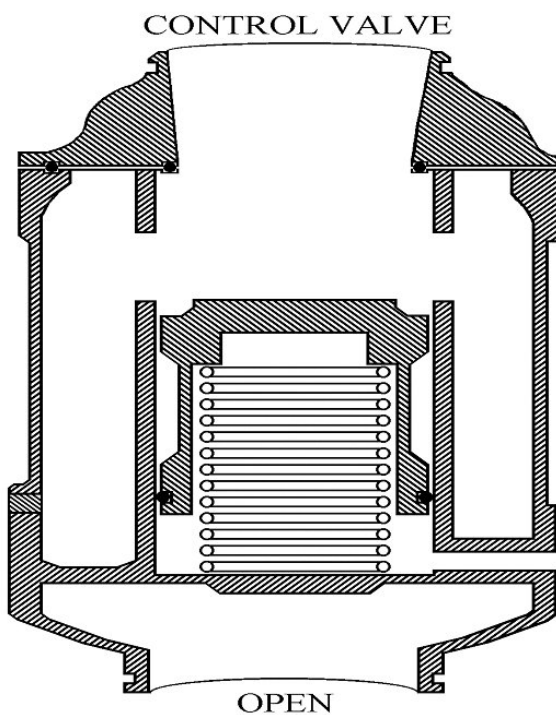
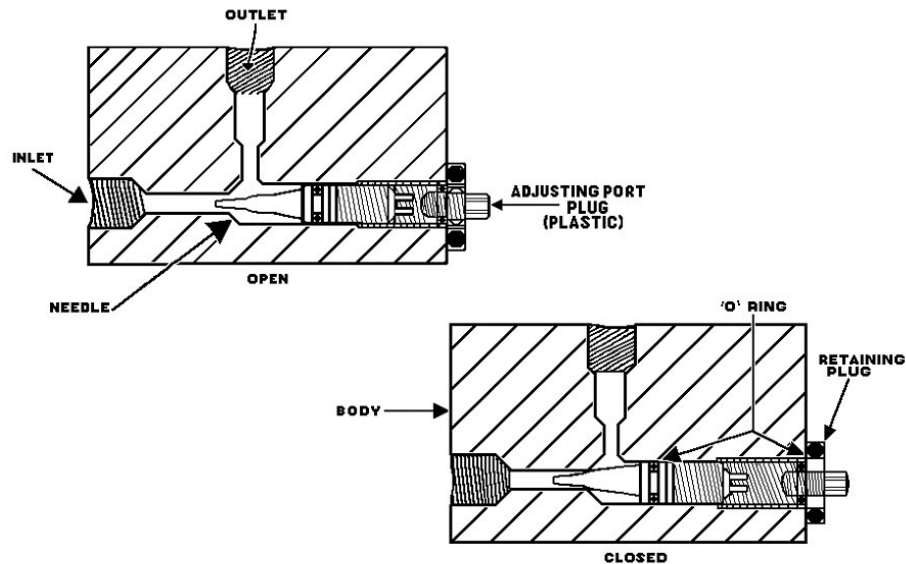


Figure 7-11. Bypass control valve open.





VARIABLE ORIFICE (NEEDLE) VALVE

Figure 7-12. Bypass control needle valve.

### Nozzle pressure regulating pilot valve V-5

Shown in figure 7-13, the truck has a nozzle pressure regulating pilot valve V-5 to control the nozzle pressure. This regulator controls the nozzle pressure by opening V-13 when pressure sensed at the Venturi reaches 50–51. Located under the main control panel, this regulator is a normally closed adjustable type valve.

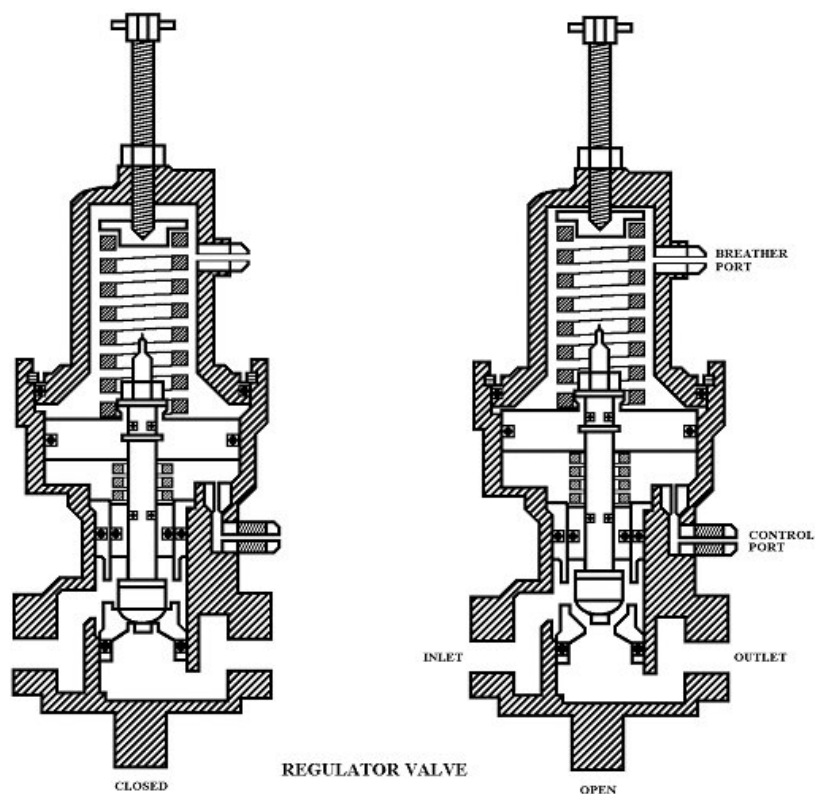
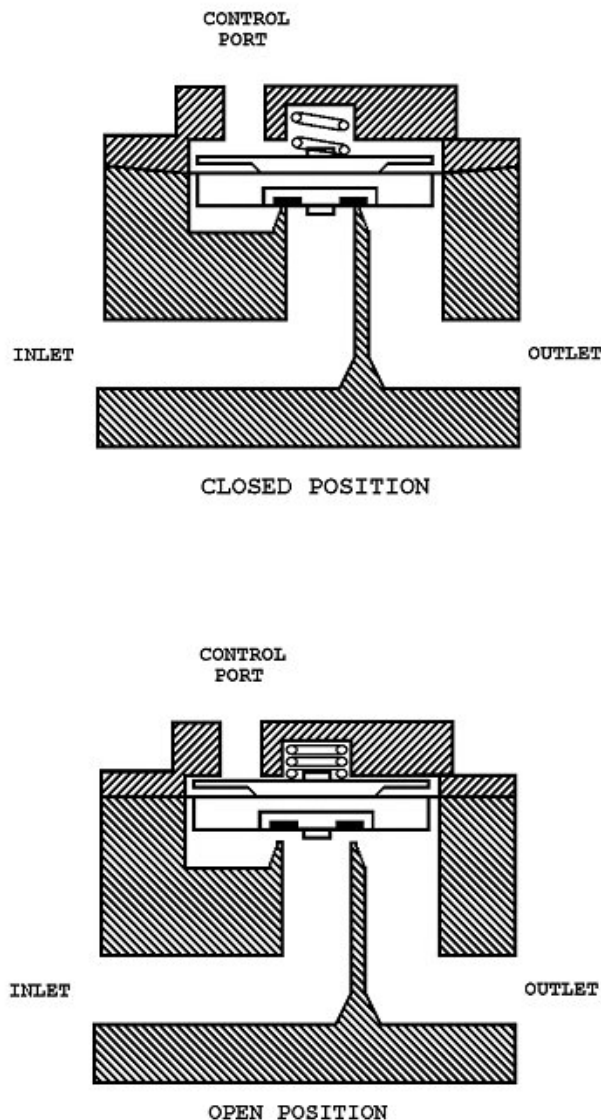


Figure 7-13. Regulating valve.



TYPE NORMALLY OPEN PILOT VALVE

Figure 7-14. Normally open pilot valve.

#### Secondary nozzle pressure regulating pilot valve V-7

In the event V-5 fails, a secondary nozzle pressure regulating pilot valve V-7 takes over. This too, is a normally closed adjustable regulator, located behind the main control panel. The purpose of the valve is to backup V-5 and open V-13 when pressure sensed at the Venturi reaches 53 to 54 psi.

#### Low-flow pressure regulating pilot valve V-6

The low-flow pressure regulating pilot valve V-6 regulates pump pressure to 60 psi during low-flow operations. This regulator is a normally closed adjustable regulator and senses pump pressure at the outlet side of the pump.

#### Low-flow lockout pilot valve V-15

The low-flow lockout pilot valve V-15 (fig. 7-14) locks out V-6 to guarantee the system does not operate at low-flow conditions while in high-flow mode. This valve is a normally open pilot valve

that closes by air pressure from V-14 during high flow and its purpose is to prevent V-6 from operating in high-flow mode.

#### **High-pressure regulating pilot valve V-8**

Located next to V-7 under the main control panel, the normally closed, adjustable high-pressure regulating pilot valve V-8, regulates the pressures in high-flow mode. It controls maximum pump pressure anytime it senses 160 psi at the outlet of the pump.

#### **Check valve V-20**

Located in the bottom front of the tank, check valve V-20 ensures fuel does not reenter the bypass system. The check valve is a four-inch inline swing gate-type check valve.

#### **Defuel lockout pilot valve V-17**

The final component of the bypass system is the defuel lockout pilot valve V-17. This valve attaches to V-13. Air pressure from V-14 controls this valve during defuel mode. The purpose of this valve is to apply a hydrostatic lock on V-13 by blocking the bleed off path in defuel mode.

---

### **Self-Test Questions**

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

#### **248. Bypass system components and operation**

1. What is the purpose of the bypass system?
2. Which valve ensures fuel supply to the pump is shut off when the truck is not in use?
3. List the two gauges located on the main control panel.
4. What component controls the closing speed of V-13?
5. What is the standard adjustment on V-12?
6. Why is it important for the bypass system to maintain steady operating pressures?
7. The secondary nozzle pressure V-7 is the backup for which valve?

8. Which valve locks out V-6?
9. Which valve controls maximum pump pressure anytime it senses 160 psi at the outlet of the pump?

## 7-7. Mainline System

The mainline system controls the fuel flow from the filter separator to the hose reel system in all modes of operation. As discussed earlier, the bypass system controls the pressure in all modes; this system controls the flow of that pressure. Reference figure 5-13, as you cover each component of the mainline system.

### 249. Mainline system components and operation

This lesson covers the mainline system associated with the Kovatch R-11 refueler. Knowing these components and how they operate will help you determine causes of malfunctions in the mainline system.

#### Filter separator FS-1

The filter separator (FS)-1 is a large, cylindrical aluminum shaped canister with a four-inch inlet and a four-inch outlet. The purpose of the filter separator FS-1 is to house the first- and-second stage filter assemblies and collect water from the fuel. The first-stage filter is known as the *coalescer*. It is a replaceable paper element with a chemically treated paper outside. Its purpose is to filter solid contaminants from the fuel and treat the water to form it into water globules. The separator is the second-stage filter located inside of the filter housing. The filter is a Teflon coated, 100-mesh screen that separates the water globules from the fuel.

#### Air eliminator valve V-25

The air eliminator valve V-25, located on top of the filter separator, relieves trapped air inside the filter separator, when fuel flows into the filter housing. Relieving the trapped air prevents surging in the system. This valve is a float-type valve with a return line directly to the tank.

#### Water slug valve V-24

It is imperative that water does not enter the fuel system of an aircraft serviced by the R-11. To ensure this, the chemicals on the filter separator cause water to form globules and drop to the bottom of the filter housing. The water collects in the bottom of the filter separator and when the water level rises, this raises the float water slug valve V-24, which is a two-position rotary air valve. When the float is in the top position, it stops airflow to the water slug pilot valve V-30, placing a hydrostatic lock on flow control valve V-27. The slug valve has a manual override that operators and mechanics use to test float operation.

#### Filter separator drain valve V-49

Once the water in the filter separator is full, you can manually drain the water through the filter separator drain valve V-49. The drain valve is a manually controlled ball valve located on the bottom of the filter separator.

### Differential pressure gauge G-1

The system has a DP gauge G-1 incorporated in the system that indicates the condition of the coalescer (first stage) elements. The gauge, located on the main control panel, is controlled by fuel pressure from the inlet and outlet of the filter separator.

### Tank vent valve V-4

The tank vent valve V-4 is a normally closed air operated piston valve, with an internal check valve that vents the tank in all modes of operation. Located on top of the manhole cover, the tank vent valve is controlled by air pressure from V-44.

### Flow control valve V-27

The flow control valve V-27 (fig. 7-16) is a four-inch, normally closed, liquid-controlled piston. The flow control valve controls fuel flow during all modes of operation. Located below the servicing hose reel, this valve is controlled by three pilot valves, two regulators and a needle valve.

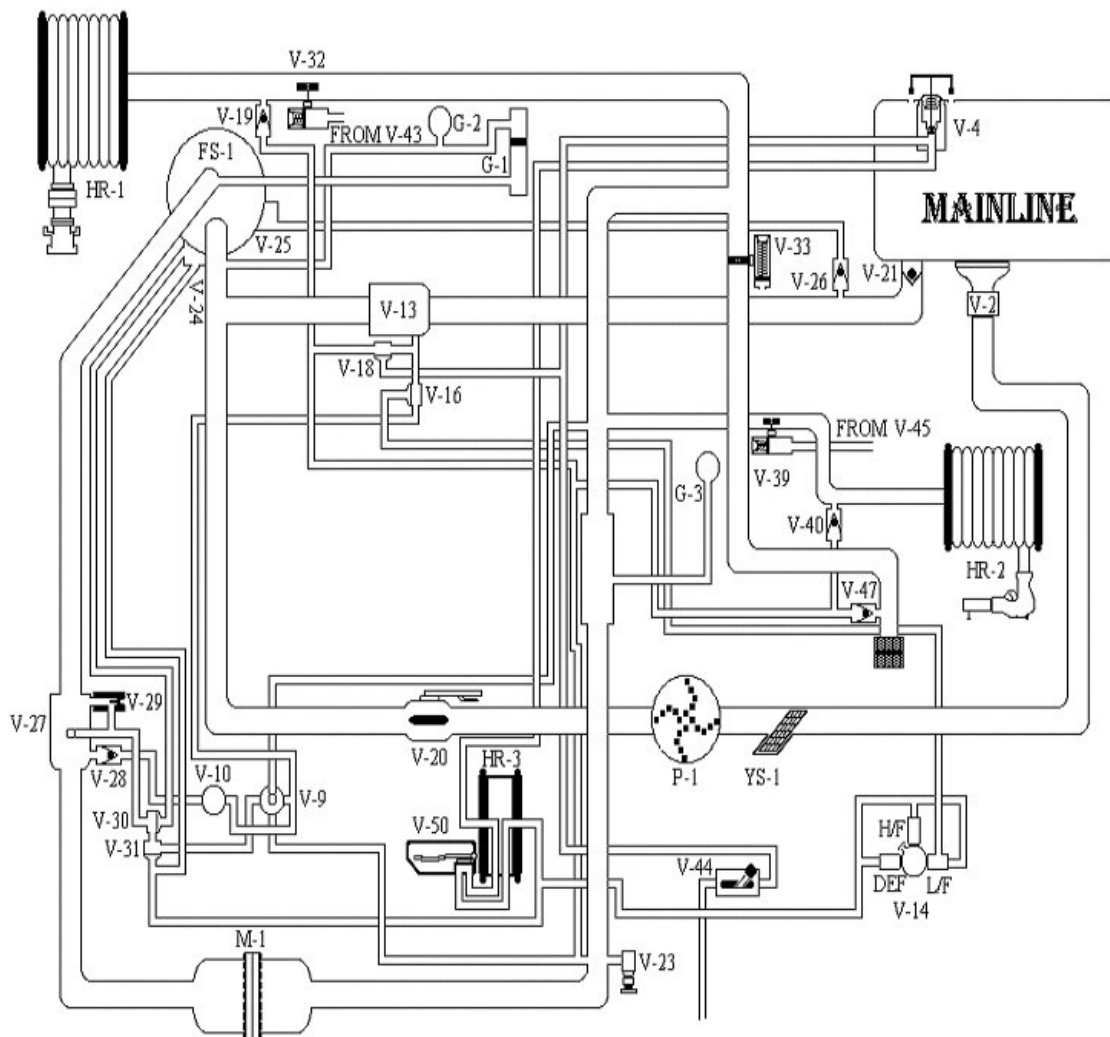


Figure 7-15. Kovatch R-11 mainline system.

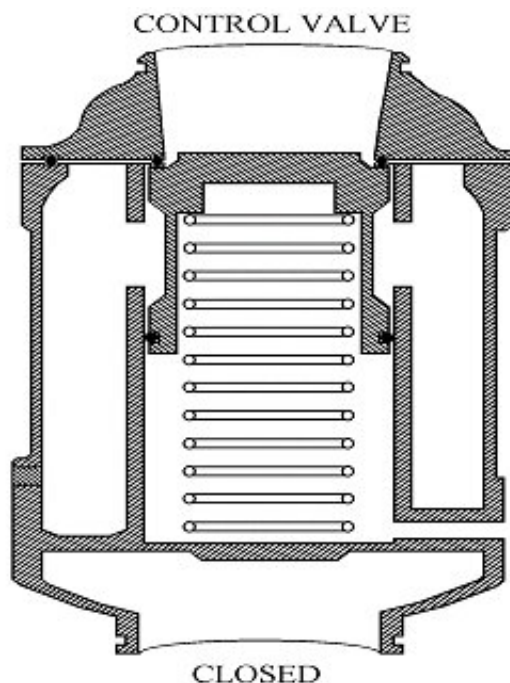


Figure 7-16. Flow control valve.

#### **Water slug pilot valve V-30**

During operations, if the slug valve closes and stops air pressure to the water slug pilot valve, the water slug pilot valve V-30, which is normally closed, will open, causing a hydrostatic lock to be applied to V-27. The water slug pilot valve is located below and to the right of the servicing hose reel.

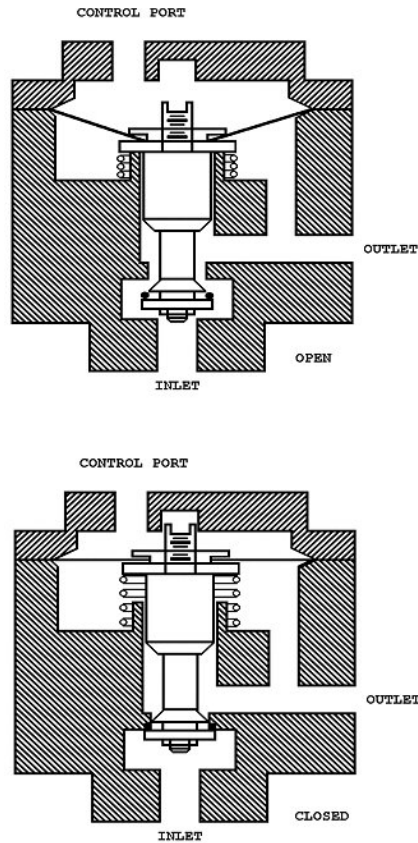
#### **Interlock pilot valve V-31**

To ensure there is no fuel flow in the system before the tank vent valve V-4 opens and deadman actuates, the interlock pilot valve V-31 (fig. 7-17) holds a hydrostatic lock on the V-27. This is a normally closed pilot valve controlled by deadman air pressure.

#### **High-flow regulator V-9**

The high-flow regulator V-9 (fig. 7-18) regulates fuel flow rate to 625 gpm during high-flow mode. Controlled by fuel pressure from the inlet and outlet of the Venturi, the high-flow regulator is a DP regulator. This regulator is different from all of the rest because it is always open. When pressure is lost at the outlet of the Venturi, the high-flow regulator closes, allowing the reaction time to release the deadman stopping fueling operations. When the high-flow regulator closes, the fuel bleed off from flow control valve V-27 stops, thus causing the flow control valve to lock hydrostatically.





## G2 TYPE NORMALLY CLOSED

Figure 7-17. Normally closed pilot valve.

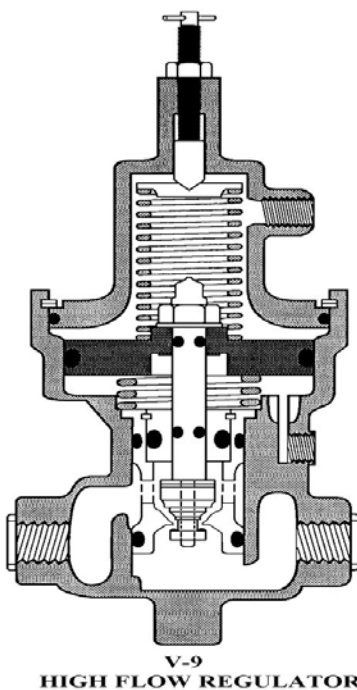


Figure 7-18. High-flow regulator (V-9).



**Low-flow regulator V-10**

The low-flow regulator V-10 controls the low-flow rate to 100 gpm per hose. Located below the meter, the low-flow regulator is controlled by the closing of the high-flow V-16, in the low-flow mode.

**High-flow lock-out pilot valve V-16**

The high-flow lock-out pilot valve V-16 is a normally open pilot valve, attached to V-13. This valve forces a controlled bleed-off of the hydrostatic lock, on V-27, through low-flow regulator V-10, in the low-flow mode. The high-flow lock-out pilot valve is controlled by deadman air pressure from the selector valve in low-flow mode.

**Check valves V-26 and V-28**

Installed on the bypass piping is a 3/4-inch check valve V-26. This check valve prevents fuel from traveling back into the filter separator. Another check valve V-28, located on V-27, prevents fuel from traveling back into the mainline system.

**Flow control needle valve V-29**

An adjustable orifice flow control needle valve V-29, controls the closing speed of the V-27 and adjusts to a standard two and one-half turns out, once fully seated. The flow control needle valve is attached to V-27.

**Thermal relief pilot valve V-18**

Thermal relief pilot valve V-18 is a normally open pilot valve attached to V-27. The thermal relief pilot valve prevents operation of the thermal relief check valves, during pumping operations. Air pressure from the tank vent V-44 controls this valve.

**Thermal relief check valve V-19**

The thermal relief check valve V-19 is a 1/8-inch, one-way check valve, located to the right of the servicing hose reel. This thermal relief check valve relieves thermal buildup within the servicing hose and hose reel when the truck is not in use.

**Thermal relief check valve V-40**

The thermal relief check valve V-40 is a 1/8-inch, one-way check valve, located just below V-39. This thermal relief check valve relieves thermal buildup within the auxiliary hose and hose reel when the truck is not in use.

**Thermal relief check valve V-47**

The thermal relief check valve V-47 is a 1/8-inch, one-way check valve, located behind the main control panel. This valve relieves thermal buildup in the supply piping when the vehicle is not in use.

---

## Self-Test Questions

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

**249. Mainline system components and operation**

1. What is the purpose of FS-1?

2. How is G-1 controlled?
3. What type of valve is V-27?
4. What is the purpose of V-9?
5. What type of regulator is V-9?
6. What is the purpose of V-10?
7. What does V-16 do?
8. Which check valve prevents fuel from traveling back into the mainline system?
9. What valve prevents operation of the thermal relief valves, during pumping operations?

## **7-8. Defuel System**

The defuel system on the Kovatch R-11 removes fuel from an aircraft. The system filters fuel, removing contaminants that could be re-dispensed into another aircraft. The fuel is accounted for by passing through the meter.

### **250. Defuel system components and operation**

Many of the same components of the bottom-loading system are part of the defuel system. These components include FLS-1, LCM-1, MS-1, PM-1, solenoid valve V-37, solenoid valve V-57, shuttle valve V-73, and shuttle valve V-7. For more information on these components, refer back to the bottom-loading lesson. Reference the defuel system, shown in figure 7-19, when covering the following components.



## Defuel actuator V-70

## Defuel pilot valve V-71

### Defuel shutoff butterfly valve V-34

### Defuel return butterfly valve V-35

## Shuttle valve V-36

For Official Use Only

**Shuttle valve V-54**

The shuttle valve V-54 purpose is to isolate the defuel system from the high-flow and low-flow modes. It is located behind the control panel attached to V-53.

**Defuel override control valve V-38**

When refueling specialists, also known as petroleum, oils, and lubricants (POL) operators, require taking samples of fuel within the vehicle, they must rotate the fuel internally to take an accurate sample. The defuel override control valve V-38 directs air pressure to the defuel return butterfly valve to provide a means of rotating fuel for sampling. Additionally, this normally closed, manually operated toggle valve, is located on the main control panel. It directs air pressure to V-35, providing a means of rotating fuel when the tank is full.

**Defuel suction butterfly valve V-33**

The defuel suction butterfly valve V-33 provides a path for fuel from the servicing hose to the suction side of the pump during defuel. This is necessary because defueling fuel from the aircraft requires the same hose and piping as the servicing modes. This valve is a normally closed, three-inch butterfly valve, located on the rear of the canbox and is controlled by the air pressure from the V-14 in defuel.

**Defuel lockout pilot valve V-17**

Attached to the side of bypass control valve V-13 is V-17. In defuel mode, V-17 blocks bleed-off path of the hydrostatic lock on V-13. This ensures all fuel is filtered and metered before returning to the tank. Air pressure from the selector valve controls this normally open pilot valve.

**Defuel priming control valve V-1**

The defuel priming control valve V-1 is a normally closed, manually operated, toggle valve located on the main control panel. In defuel mode, when actuated, it directs air pressure to open V-2, to prime the pump.

**Check valve V-3**

The last component in the defuel system is the four-inch check valve V-3. This inline swing gate valve is between the emergency shutoff and the suction side of the pump. It prevents the fuel from bypassing the pump when aircraft assist pumps are used.

---

**Self-Test Questions**

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

**250. Defuel system components and operation**

1. What is the purpose of V-70?
2. What does V-34 ensure?

3. Why does V-38 direct air pressure to the defuel return butterfly valve?
4. What is the purpose of V-33?
5. What component prevents the fuel from bypassing the pump when aircraft assist pumps are being used?

## 7-9. Fuel Flow Meter Testing and Calibration

The fuel meter (or register) assembly measures the amount of fuel being put into or taken out of an aircraft. Testing and calibrating the meter are contained in this section.

### 251. Testing the meter/register

Perform the following procedures to prepare the refueler for testing of the meter/register assembly:

- a. Have a qualified operator fill the cargo tank through the bottom loading adapter with 1500 gallons of fuel, then disconnect the external fueling source from the bottom loading adapter.
- b. Perform the following procedures to slowly fill filter/separator and allow internal pressure to rise to normal operating pressure.
- c. Connect the fuel servicing nozzle to the bottom loading adapter.
- d. With engine at *idle* speed, activate the deadman switch and observe the meter. When the meter starts to register flow, the filter/separator is full.
- e. Use the bottom-loading butterfly valve V-64 to throttle down flow until normal operating pressure is indicated on nozzle pressure gauge, G-3.
- f. Check piping connections for leaks.
- g. To test the accuracy of the meter/register, dispense a set amount of fuel and compare it to the same amount of fuel dispensed through another meter of known accuracy.

### 252. Meter/register programming

If testing indicates the need for adjustment of the register, refer to figure 7-20 and follow these steps to access the programming menu.

- a. Rotate the program mode selector switch (16) 90 degrees clockwise to the program position. "CAL 0" will appear on the register display. The two push buttons (17 and 18) can then be used to enter programming information.

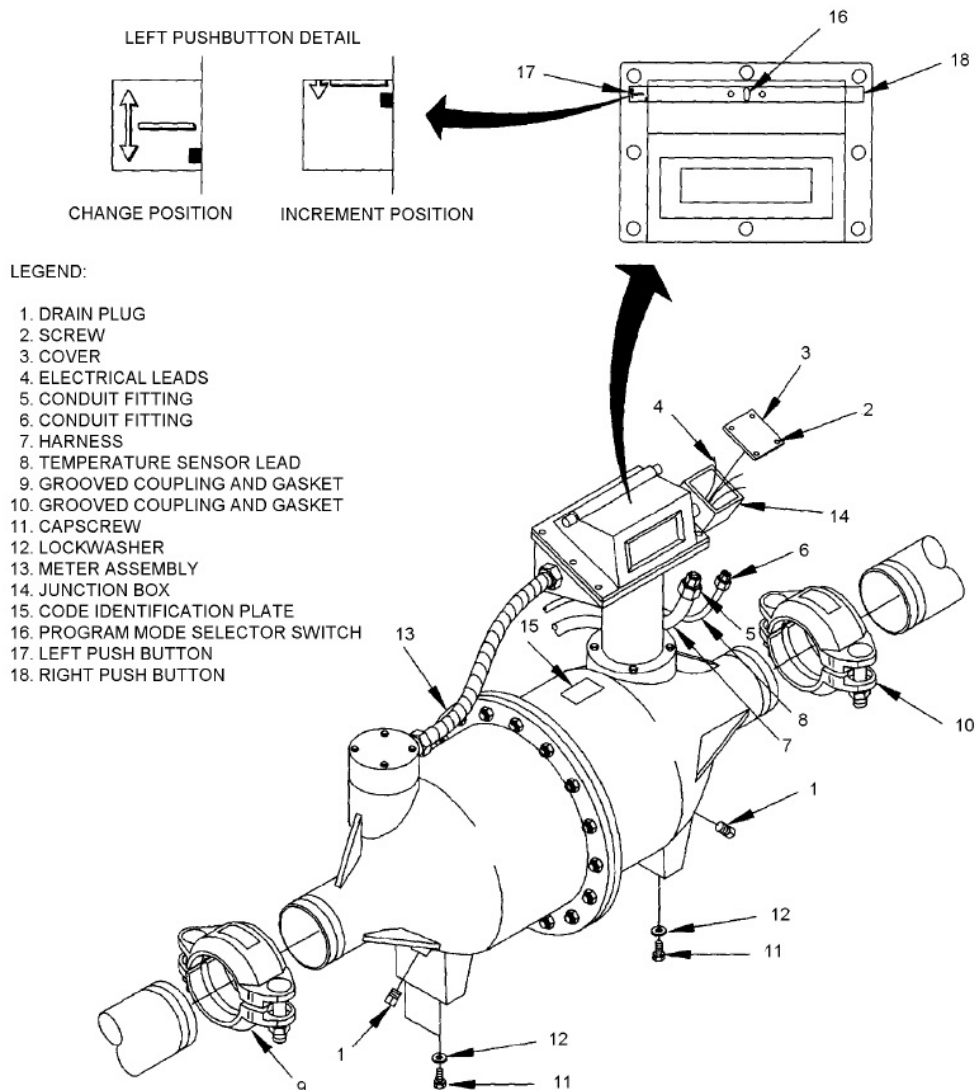


Figure 7-20. Meter/register.

- b. The left push button (17) functions as two switches. Push the button in to change and increment flashing digits. The button can also be rotated 90 degrees. There is a marking on the push button to indicate whether it is in the 0- degree position (rotated up) or the 90-degree position (rotated toward the operator). When the left push button (17) is rotated to the 0-degree position, depressing the button moves the cursor to the right one digit. When the push button is rotated to the 90-degree position, depressing the button will increment the flashing digit.

Item	Description	Parameter Value
CAL 00	Scaled pulse output	1
CAL 01	Scaling factor	Whole numbers before K-factor decimal point
CAL 02	Scaling factor	Number after K-factor decimal point
CAL 03	Cutoff frequency	0.25
CAL 04	Rate decimal position	1

CAL 05	Time base for rate	1
CAL 06	Filter	21
CAL 07	Decimal point for total display	1
CAL 08	Total conversion factor	1
CAL 09	Total conversion factor-numbers after decimal	0
CAL 10	Low alarm-whole numbers	0
CAL 11	Low alarm-digits after decimal point	0
CAL 12	High alarm-whole numbers	0
CAL 13	High alarm-digits after decimal point	50,000
CAL 14	4 milli-amps direct current (MADC) output	0
CAL 15	4 MADC output	0
CAL 16	20 MADC output	0
CAL 17 SOFT	20 MADC output Software version	0

- c. The right push button (18) functions only as one switch. Depressing the push button (18) saves the displayed CAL step and moves on the next CAL step. All the parameter values listed below are programmed into the registers at the factory with the exception of CAL 01 and CAL 02. Obtain these parameter values from the data plate (15) attached to the meter assembly.

### Meter calibration

To ensure accurate fuel flow measurement, a corrected scaling factor (or K-factor) must be calculated and programmed into the unit parameters CAL 01 and CAL 02. The amount of correction can be determined by the ratio of the known volume (prover or master meter) to the actual volume (meter) and correcting the existing meter K-factor by this amount. The example formula has an existing K-factor of 96.35. Be sure to verify the existing K-factor of the meter you are adjusting.

Example:

Prover Volume: 1000.00 gallons

Meter Volume: 999.50 gallons

Ratio: divide Meter volume (999.5) by Prover volume (1000) = 0.9995 or 99.95%

Existing K-Factor - 96.35 pulses per gallon

Ratio % x K-factor = (99.95%) x (96.35) = New K-Factor of 96.30

## Self-Test Questions

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

### 251. Testing the meter/register

1. How much fuel should be loaded in the cargo tank when testing the meter?
2. How do you verify the accuracy of the meter?



**252. Meter/register programming**

1. On the meter programming menu, what does CAL 01 represent?
2. What should you verify when calibrating the meter?

**7-10. Fuel Hose Maintenance**

The American Petroleum Institute rates fuel hoses. All refueler hoses must be American Petroleum Institute rated.

**253. Types and inspection requirements for fuel hoses**

There are two types of hoses used on refueling vehicles, collapsible and noncollapsible.

**Collapsible**

Some refuelers use collapsible hoses for dispensing fuel from the refueler to the aircraft. They are relatively lightweight and require careful handling. The use of a collapsible hose is convenient because it allows the hose reel to store a longer hose.

**Noncollapsible**

Normally, defueling operations use noncollapsible hose. However, you may find a 1 1/2-inch noncollapsible hose used as a dispensing hose for overwing operations. Defueling operations use noncollapsible hoses primarily because there is suction involved. Hose carts and hydrant service vehicles that connect to a fixed hydrant system use noncollapsible hoses. The standard hose, supplied on the Oshkosh® and Kovatch R-11 refueler, is a three-inch noncollapsible-type hose.

**Inspections**

Visually inspect hoses before and after each operation. Inspect for cracks, tears, worn spots, bulging, and leaks. Also, check for abnormal damage, such as crushing, kinking, and excessive end pull. Identify superficial damage to the outside of a hose with red paint. Direct special attention to the area immediately behind the hose couplings for indications of structure weakness, soft spots, and coupling slippage. Repair or replace the hose if you encounter any of these malfunctions. After repair or replacement of hose, you must perform a hydrostatic hose test.

**NOTE:** You must comply with all inspection and testing requirements and procedures outlined in TO 37A-1-101, *Operation and Service-General Instructions, USAF Fuel, Water, and Lubricant Dispensing Equipment*.

**254. Hydrostatic testing procedures for fuel dispensing hoses**

To prevent hose failure during a refueling operation, you must hydrostatically test refueling hoses before installation on a refueling unit, hydrant hose cart or hydrant hose truck. New hoses usually come certified by the hose manufacture. Test any hose, new or used, that appears defective or repaired by cutting and replacement of couplings. A vehicle or cart with two or more hoses should have all hoses tested on the same date. Record hose inspections on AF Form 1830, Refueling Equipment Hose Installation and Hydrostatic Test Data Record.

**NOTE:** Only qualified personnel can perform hydrostatic testing.

Applications where the working pressure is less than 30 psi need not be hydrostatic pressure tested. An example of this is a demineralized water truck. However, if you remove a hose from a water truck

for installation on a refueler, you must perform a hydrostatic test. Refer to the appropriate technical order for testing intervals for different hoses.

**WARNING:** Personnel conducting hose testing should wear protective clothing and goggles/face shield to protect them from hazards of spraying liquids. Be aware of hose movement when pressurizing hoses.

You must remove the hose from the refueling vehicle before hydrostatic testing. For additional information refer to TO 33A2-2-36-1, Instructions and Parts Breakdown-Hydrostatic Hose Tester, Model S-817, PN 79842 (Sprague)(FSN 4940-546-3551 and 4940-290-9331) and PN 033086-1 (NSN 490-00-290-9331)(Missile Systems). Always refer to the technical manual before any testing. Here are the hydrostatic testing procedures.

1. Connect the hose to a hydrostatic hose tester.
2. Water is the test fluid used for hydrostatic testing of fuel dispensing hoses.
3. According to TO 37A-1-101, do not use demineralized water for hydrostatic testing, due to the lack of lubrication for the tester.
4. Attach one end of the hose to the tester; place a cap on the other end that has a bleed valve to bleed the air from the hose. The cap on the end will need to withstand extremely high pressures.
5. Fill the hose through the pump with the capped end elevated and the bleed valve open to allow air to escape from the hose.
6. Place the hose in a straight position with the hose end couplers caged and pressurize it to the prescribed pressure for that particular hose.
7. If the couplings leak, release the pressure and repair them as necessary; then resume testing.
8. If the hose leaks or balloons, remove it from service and condemn it in accordance with the applicable directives.
9. If the hose proves satisfactory, return it to service.
10. Drain any residual fluid from the hose after testing is complete.
11. Flush or circulate 100 gallons of fuel through the hose after installation.

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### Self-Test Questions

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

#### 253. Types and inspection requirements for fuel hoses

1. How are fuel hoses classified?
2. Why is hose collapsibility more convenient?
3. Normally, how are noncollapsible hoses used?

4. What size and type of hose does the Oshkosh and Kovatch refuelers use?
5. What do you look for during visual hose inspections?
6. How do you identify superficial damage to the outside of a hose?
7. What action do you take if you find a soft spot behind the hose coupling?

#### **254. Hydrostatic testing procedures for fuel dispensing hoses**

1. On what type of hose do you hydrostatically test before installing the hose on a refueler?
2. What fluid do you use when you hydrostatic test hoses?
3. What position do you place the hose in for hydrostatic testing?

### **7-11 Refueling Maintenance Safety**

Due to the nature of refueling maintenance, safety is paramount. Safety is a full-time job. Safety affects you 24 hours a day, every day, on and off duty. There are many published safety manuals and standards used by the Air Force and civilian organizations to ensure people are aware of safety hazards. The challenge is for people to realize that safety is a never-ending process that everyone must practice at all times, especially so, during refueling maintenance. Please take the time to familiarize yourself with the safety hazards within a refueling maintenance shop. First in this section, you will learn about the safety hazards specific to refueling maintenance shops. Next, we cover the use and care of vehicle-mounted safety equipment on refueling vehicles. Finally, we cover static ground reel operation, inspection and testing requirements.

## 255. Safety hazards specific to refueling maintenance shops

You must learn the safety hazards specific to refueling maintenance shops before you attempt working on refueling vehicles. Accidents can happen in a flash and you can prevent them if you have the understanding that working around fuel is dangerous. Therefore, it is in your best interest and your responsibility to know the hazards.

### Static electricity

Almost everyone has experienced the shock of static electricity from touching such items as doorknobs, chairs, and cars. A small static discharge is enough to ignite fumes present around refueling equipment. Static electricity is the most dangerous hazard a refueling mechanic faces. The reason is that you cannot see, feel, or hear static electricity until it is too late.

The best precaution against static electricity is to ground yourself and the piece of equipment you are servicing. Grounding yourself neutralizes any accumulation of static electricity that has built up on your body. You can get rid of this accumulated static by touching the ground with your hands or by touching an approved grounding connection.

**SAFETY NOTE:** Your shoes are insulators; so, you must ground yourself by touching a grounded object.

Static electricity can accumulate in the refueler by simply driving the truck. Additionally, static electricity is generated during refueling operations. Grounding the refueler provides a safe path to ground for static electricity. *Always* ground the refueler before working on the truck. *Always* use an authorized grounding connection when grounding a refueler. When grounding the refueler, *do not* connect the grounding clip to another grounding clip. This is known as a “piggy back.”

All personnel assigned to a refueling maintenance work center must be thoroughly familiar with, TO 00-25-172, *Ground Servicing of Aircraft and Static Grounding Bonding*.

**SAFETY NOTE:** TO 00-25-172 is in a constant state of change. All refueling shops should have a current, up-to-date copy on hand. Review it often and note all changes. Your safety depends on it.

### Adverse weather

Performing maintenance on the fuel systems during adverse weather is hazardous. The installation weather officer notifies the base fuels management officer of adverse weather such as thunderstorms, lightning, strong winds, heavy rain, and freezing precipitation. During adverse weather, do not perform maintenance on fuel systems of fuel servicing vehicles, when outside. You may not always know the conditions just by looking up at the sky. Therefore, it is a good idea to have a close relationship with base fuels management to help determine when adverse weather conditions exist.

### Smoking

You cannot smoke within 50 feet of the refueling maintenance shop or any fuel servicing equipment. The smoking hazard is ever present so you must comply with and enforce all instructions and policies. *YOUR safety and the safety of OTHERS depend on it!* You must strictly control smoking materials. Storing smoking materials outside of the work area takes away the opportunity for an unfortunate incident. These items include devices such as lighters and matches. Place properly labeled and approved disposal containers, for smoking materials, only in approved locations. As an extra precaution, partially fill the container with water to ensure smoking materials extinguish thoroughly.

Open flames and spark-producing devices are prohibited within 25 feet of the refueling maintenance shop, when a refueling vehicle is undergoing maintenance and fuel vapors are likely to be present.

**Fuel volatility**

Flammable vapors exist over the surface of aviation fuels. A spark or flame causes ignition of these vapors. If the proper ratio of fuel vapor and air is present, an explosion can result. Energy levels associated with a static discharge are sufficient to ignite fuel vapors.

**SAFETY NOTE:** The liquid fuel does not burn—it is the vapors. The potential for explosive fuel vapors are ever present in all refueling areas.

**Power tools**

If you have ever used an electric drill, power saw, or sander, you've probably noticed the many sparks produced at the motor brushes. For this reason, *never* use electric power tools. Use pneumatic power tools only. *Never* use an electrical power tool as a substitute while awaiting repair or replacement of the pneumatic tool.

**Electrical units**

Most shop lighting and electrical outlets used within the refueling maintenance shop are of the explosion-proof type. Refueling maintenance shops do not use conventional light switches and receptacles unless the mounting of the switches or receptacles is at least 4 feet from the floor. Trouble lights must be of the explosion-proof type. Constantly inspect the cords of all electrical units for fraying and cracking of the insulation. Immediately remove any deteriorated cord from service.

**Two-person policy**

The two-person policy is simple, and is explained in AFMAN 91-203, paragraph 32.15.7.8 as follows:

A minimum of two (2) persons, one qualified in the task to be performed and the other a safety observer to provide assistance, shall be available in the refueling maintenance site whenever repairs are done on a vehicle fuel system. For minor maintenance after duty hours, the vehicle flight commander may waive, in writing, the two-person policy if all safety precautions are taken and a qualified 5-skill level mechanic does the work.

**NOTE:** A vehicle operator for the type of equipment being repaired may be the second person. Refer to AFI 24-302, *Vehicle Management*, for additional guidance.

**Jacks and stands**

Always use hydraulic jacks with a rating of no less than 10 tons when lifting refueling vehicles. You must consider the weight of the truck and the fuel before lifting the refueler. Since you must use a hydraulic jack with a rating of no less than 10 tons to lift refueling vehicles, it makes sense to use a pair of jack stands with a minimum rating of 10 tons.

**256. Use and care of vehicle-mounted safety items on refueling vehicles**

The use and care of vehicle-mounted safety items is another important safety aspect of refueling maintenance. Knowing where and what these items are can save lives.

**Work lights/floodlights**

Mounted on the side and/or rear of refueling vehicles are work lights. Used during the hours of darkness, work lights illuminate the work area during a refueling or defueling operation. Using work lights help to eliminate personnel injury.

**Fire extinguishers**

Refueling vehicles have two hand-operated fire extinguishers, one on each side of the vehicle. The fire extinguishers are the general-purpose, dry-chemical type. These fire extinguishers put out small fuel fires. Make sure these fire extinguishers are properly sealed and charged at all times.

Additionally, ensure the discharge hose is free from debris. Failure to do so could cost someone their life.

### **Static ground reels**

There are two static ground reels mounted on refueling trucks. Using two reels satisfies the special ground requirements for refueling and defueling aircraft. Ensure the reels operate properly and perform a resistance test. If static ground reels are not serviceable, a spark from static electricity could result in extensive equipment damage and personnel injury.

### **Sealed electrical system**

Refuelers use sealed electrical wiring and components to eliminate the possibility of sparking. Conduit and sealed junction boxes keep the electrical wiring sealed. Check for deterioration of the insulation on exposed wiring during inspections and repairs. Also, make sure all engine wiring is a safe distance from exhaust system components. Carefully inspect the wiring harnesses running from the chassis into the cab. A sharp edge will cause fraying or cut the wiring harness.

### **Emergency switch**

Mounted on the main control side panel of refueling vehicles is an engine emergency switch. This switch allows the operator to shut the engine off without entering the cab in case of an emergency. Refuelers have different emergency shutdown procedures. Refer to the appropriate technical order and become thoroughly familiar with the shutdown procedures for each vehicle.

### **Spark arrestor**

All refuelers use a spark arrestor-type muffler. A spark arrestor-type muffler contains sparks within the muffler instead of discharging them. Installed on the muffler is a plug or band. Removal of the drain plug or band allows you to clean out carbon deposits and accumulated moisture. This cleaning is critical for proper operation. Accomplish this cleaning at intervals prescribed by TO 36-1-191, *Technical and Managerial Reference for Motor Vehicle Maintenance*.

### **Safety decals**

Safety decals on refueling vehicles serve as constant reminders of hazardous cargo. These decals include "No smoking within 50 feet," "Cargo fire-avoid water," and the fuel type and grade. Replace decals when they become excessively faded. Use a stencil with approved paint if decals are not available. For additional reference, refer to TO 36-1-191.

## **257. Static ground reel operation, inspection, and testing**

Proper static ground reel operation, inspection, and testing is critical. Grounding the refueler provides a safe path to ground for static electricity. If a refueling vehicle does not have the proper ground, the unthinkable can happen.

### **Operation and construction**

Grounding is the most practical way to control static electricity. Grounding provides a path of least resistance through low-resistance grounding wires, 10 ohms or less, through which static charges can flow easily. Grounding harmlessly removes the static charges that build up within an object, neutralizing the difference in electric potential. Grounding points are clean, unpainted metal surfaces that ensure a low-resistance connection.

For proper grounding procedures, refer to TO 00-25-172. The design of the static reel (fig. 7-21) and cable assembly provides for a minimum amount of resistance. The reel end of the cable connects directly on the inside of the reel. A *set of contacts* allows a movable connection between the reel and the housing, similar to a steering wheel horn button. You must bolt the housing to a clean, unpainted surface of the refueler. With the clip attached to the end of the cable, there should be no more than 10 ohms of resistance from the clip to the refueler.

**NOTE:** Do not use ordinary battery-type (alligator) spring clips. Use only the clips specifically authorized by TO 00-25-172.

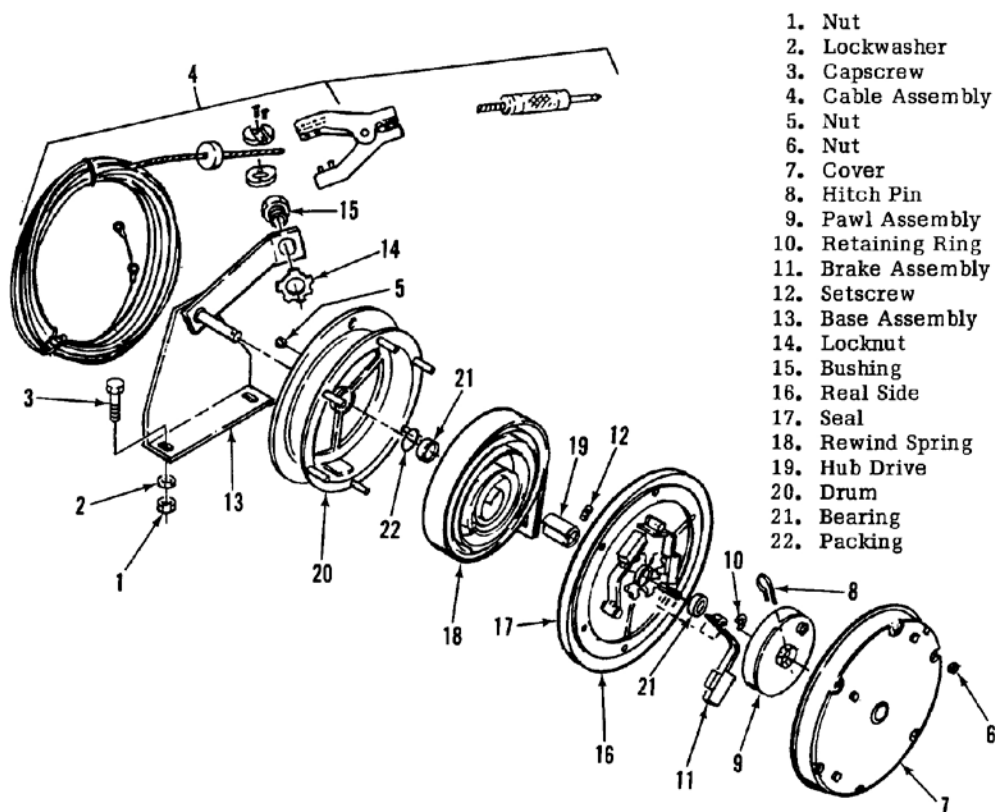


Figure 7-21. Static ground reel.

### Inspection

A good, clean, metal-to-metal contact between the mounting bracket and the vehicle is necessary. First, make a visual check to ensure the static ground reel is in serviceable condition. Next, use a multimeter to check for a proper ground between the clip or plug and a bare metal point on the vehicle frame. If continuity is within 10 ohms, the reel is serviceable. If continuity is not within 10 ohms, continue the inspection. The static reel should be free of paint, grease and so forth, on the underside of the mounting bracket. Additionally, check the mounting area on the vehicle to ensure that it, too, is free of paint, grease, and so forth. Next, inspect the static cable. Check for any cuts or fraying. Be sure to look at the plastic coating—minor cuts or abrasions in the plastic coating are serviceable. The last check is that of the ground clips or plugs. Replace bent, broken, or rusted ground clips and plugs. Remember, the clips or plugs make the final ground connection. Do *not* take their condition for granted.

### Resistance test

The resistance test ensures that any static electricity accumulated on the refueler has a low-resistance path to ground. Use a digital multimeter to measure resistance of the static reel assembly. The first step is to configure the multimeter to measure resistance. Begin by placing the black lead in the communication port, and the red lead in the port labeled for voltage (V) and ohms ( $\Omega$ ). Next, turn the dial to the  $\Omega$  setting. Now, connect one meter lead to the static reel ground clip and the other lead to bare metal on the truck chassis. Be sure that the meter lead is touching bare metal. An excellent location is the ladder of the refueler at the rear of the tank. If paint, grease, corrosion, or any other



factors do not allow a good contact, the resistance reading can be too high. The maximum allowable resistance for this test is 10 ohms. If the meter is connected properly between the truck-mounted static reel and the truck chassis, an indication of more than 10 ohms requires corrective action. Any indication under 10 ohms indicates a serviceable static reel. If the meter reads outside limits or OL, it is an indication of an open connection. This also requires corrective action.

### **Corrective action**

If the static reel resistance exceeds 10 ohms or reads OL, your first step is to check the entire static reel assembly for loose connections, corrosion, parts wear, or any defect that could put resistance or a break in the path you have tested. Pay particular attention to the area of metal contact between the reel mounting bracket and the truck chassis. Stainless steel star washers between reel and truck mounting have a better grounding effect. Do not use steel washers as they will rust and increase resistance. Correct any poor connections you may find and recheck resistance. If you cannot bring the resistance below 10 ohms, replace the static reel assembly.

**CAUTION:** Disassembling the static reel assembly, if not done properly can injure or even kill. The reel (fig. 1-1) can come apart or explode. Always consult the appropriate technical order.

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## **Self-Test Questions**

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

### **255. Safety hazards specific to refueling maintenance shops**

1. Why is static electricity the most dangerous hazard to a refueling mechanic?
2. What is the best precaution against static electricity?
3. With which technical order must you be thoroughly familiar?
4. Why is it important to have a good relationship with base fuel management?
5. At what distance from a refueling vehicle can personnel smoke?
6. Why should you store smoking materials outside of the work area?
7. Where are disposal containers for smoking materials kept, and why should you partially fill containers with water?
8. Why do you not use electric power tools in a refueling maintenance shop?

9. What continual inspection is required for electrical units?
10. When can you perform minor maintenance after duty hours by yourself?
11. What rating must a jack stand and hydraulic jack have when lifting a refueling vehicle?

**256. Use and care of vehicle-mounted safety items on refueling vehicles**

1. Why are work lights used on refueling vehicles?
2. For what must you check the hand-operated fire extinguishers?
3. Why do refueling vehicles have two static ground reels?
4. Why do refueling vehicles use sealed electrical units?
5. What component allows the operator to shut the engine off without entering the cab, and where is it located?
6. What action ensures proper spark arrestor operation? Why?
7. Why do refueling vehicles use safety decals?

**257. Static ground reel operation, inspection, and testing**

1. What type of grounding wire do static ground reels use?
2. What allows for a rotating connection between the reel and the housing?
3. Where do you bolt static ground reels on the refueler?

4. What technical order specifies the use of special spring clips?
5. What is necessary for a good ground?
6. What do you check for when inspecting the static reel cable?
7. What is the last item to check when inspecting the static reel?
8. Why must you check the ground clip or plug so thoroughly?
9. What test ensures static electricity has a low-resistance path to ground at the static reel?
10. What equipment is required for testing the static reel assembly?
11. How do you prepare the test equipment to perform the test?
12. Describe the connections required for the test.
13. If after repairing the static reel the resistance is still too high, what is your next step?

---

### Answers to Self-Test Questions

**242**

1. Four.
2. 60 psi.
3. Allows the operator to adjust the seat height.
4. Suspension-leveling valve.
5. Air bag-type springs.
6. Outside left frame rail.
7. Air starter.

**243**

1. Conventional 12 VDC, negative ground.
2. One 12 volt, 625 cold cranking amps, maintenance free.
3. 90 amp.

**244**

1. Auto eject.
2. Orange.
3. AC voltage module.
4. 25 amp fuse located under the passenger seat in the interlock module.

**245**

1. Split-shaft.
2. Sliding gear unit.
3. Parking brake set, the engine at idle and the transmission in neutral.
4. Road and pump.

**246**

1. It prevents the PTO from shifting until the parking brake is applied, the transmission is in neutral, and the engine is at idle, and prevents operation of the auxiliary throttle when the PTO is in the road mode.
2. PTO shift control.
3. RPM 1.
4. Deadman air pressure switch.

**247**

1. A secure connection for the single-point nozzle that opens and closes the connection using a poppet valve.
2. So eruption of the tank walls will not occur.
3. Control of PM-1 during bottom loading and defuel modes.
4. The on/off switch.
5. A prism-type optical diode sends electrical signals in a continuous loop until broken by fuel level higher than the prism.
6. Solenoid valve V-37.
7. Ensure that the piping and seals within the stub do not rupture.

**248**

1. To control system fuel pressure by returning excess fuel back to the tank during all modes of operation.
2. Tank emergency shut-off valve V-2.
3. Nozzle pressure gauge and pump pressure gauge.
4. Bypass control needle valve V-12.
5. Two and one-half turns out, once fully seated.
6. Serious damage or spillage can occur.
7. Nozzle pressure regulating pilot valve V-5.
8. Low-flow lockout pilot valve V-15.
9. High pressure regulating pilot valve V-8.

**249**

1. To house the first and second stage filter assemblies and collect water from the fuel.

2. By fuel pressure from the inlet and outlet of the filter separator.
3. A four-inch, normally closed, liquid-controlled piston.
4. Regulates fuel flow rate to 625 gpm during high-flow mode.
5. DP regulator.
6. Controls the low-flow rate to 100 gpm per hose.
7. Forces a controlled bleed-off of the hydrostatic lock, on flow control valve V-27, through low-flow regulator V-10, in the low-flow mode.
8. Check valve V-2.
9. Thermal relief pilot valve V-18.

**250**

1. To open defuel pilot valve V-71.
2. That the fuel makes its way back to the tank and not back to the servicing hose reel.
3. To provide a means of rotating fuel for sampling.
4. Provides a path for fuel from the servicing hose to the suction side of the pump during defuel.
5. Check valve V-3.

**251**

1. 1500 gallons.
2. Dispense a set amount of fuel and compare it to the same amount of fuel dispensed through another meter of known accuracy.

**252**

1. Whole numbers before the K-factor decimal point.
2. The existing K-factor of the meter you are adjusting.

**253**

1. Collapsible and noncollapsible.
2. It allows the hose reel to store a longer hose.
3. For defueling operations.
4. Three-inch noncollapsible-type hose.
5. Cracks, tears, worn spots, bulging, and leaks. Also, check for abnormal damage, such as crushing, kinking and excessive end pull.
6. With red paint.
7. Repair or replace the hose.

**254**

1. Any hose, new or used, that appears defective or repaired by cutting and replacement of couplings.
2. Water.
3. In a straight position.

**255**

1. Because you cannot see, feel, or hear the static electricity until it is too late.
2. Ground yourself and the piece of equipment you are servicing.
3. TO 00-25-172.
4. To help determine if adverse weather conditions exist.
5. 50 feet.
6. To take away the opportunity for an unfortunate incident.
7. Only in approved locations; to ensure smoking materials are thoroughly extinguished.

8. Because of sparks produced at the motor brushes.
9. Inspection of the cords for fraying and cracking of the insulation.
10. The vehicle flight commander may waive, in writing, the two-person policy if all safety precautions are taken and a qualified 5-skill level mechanic does the work.
11. Not less than 10 ton.

**256**

1. To illuminate the work area helping to eliminate personal injury.
2. To ensure they are properly sealed and charged and the discharge hose is free of debris.
3. To satisfy the special grounding requirements.
4. To prevent the possibility of sparking.
5. An emergency switch on the main control panel.
6. Removing the drain plug or band on the muffler. This allows the cleaning out of carbon deposit and accumulated moisture.
7. To serve as constant reminders of hazardous cargo.

**257**

1. Low resistance.
2. Set of contacts.
3. At any clean, unpainted area of the refueler.
4. TO 00-25-172.
5. A good clean, metal-to-metal contact.
6. Cut or frayed cable and ensure the cable is encased in a plastic coating.
7. The ground clips or plugs.
8. They are the final connection to the ground.
9. A resistance test.
10. A digital multimeter.
11. Place the black lead in the communication port, and the red lead in the port labeled for voltage (V) and ohms ( $\Omega$ ). Next, turn the dial to the  $\Omega$  setting.
12. Connect one meter lead to the static reel ground clip and connect the other lead to bare metal on the truck chassis.
13. Replace the static reel assembly.

## 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 AFCDA.**

98. (242) The Kovatch R-11 right and left suspension leveling valves automatically maintain desired
- a. load range.
  - b. ride height.
  - c. load height.
  - d. spring height.
99. (243) How many 12-volt batteries does the Kovatch R-11 use?
- a. One.
  - b. Two.
  - c. Four.
  - d. Six.
100. (244) Which type of winterization system heaters does the Kovatch R-11 use?
- a. 110 or 120 volt direct current (VDC) resistance heaters.
  - b. 110 or 240 VDC resistance heaters.
  - c. 120 or 240 volt alternating current (VAC) resistance heaters.
  - d. 110 or 120 VAC resistance heaters.
101. (244) Which Kovatch R-11 winterization system component allows 12 volt direct current (VDC) to travel to the indicator light?
- a. Toggle switch.
  - b. Indicator relay.
  - c. Battery charger.
  - d. Alternating current (AC) voltage module.
102. (245) Which type of power takeoff (PTO) assembly is used on Kovatch R-11 refueling vehicles?
- a. Universal design.
  - b. Split-shaft design.
  - c. One-piece shaft design.
  - d. Constant velocity design.
103. (245) Before shifting a Kovatch R-11 refueling vehicle's power takeoff (PTO) into or out of gear, the park brake must be set, the engine must be at idle, and the transmission must be in
- a. drive.
  - b. neutral.
  - c. low gear.
  - d. reverse.
104. (246) Which Kovatch R-11 throttle interlock component energizes the air solenoid valve after determining parking brake status?
- a. Power takeoff (PTO) shift control.
  - b. Body control module.
  - c. Remote power module.
  - d. Deadman air pressure switch.



105. (247) What Kovatch R-11 *bottom-loading* component provides a secure connection for the single-point nozzle?
- a. Adapter A-2.
  - b. Interlock valve.
  - c. Vent valve.
  - d. Check valve.
106. (247) Which Kovatch R-11 valve isolates the bottom-loading vent valve from the selector valve?
- a. Shuttle valve V-73.
  - b. Bottom-loading interlock valve V-60.
  - c. Solenoid valve V-57.
  - d. Solenoid valve V-37.
107. (247) Which Kovatch R-11 component is a five-wire optic probe-type sensor?
- a. On/off switch.
  - b. Power module.
  - c. Fuel level sensor.
  - d. Multicept sockets.
108. (248) Which Kovatch R-11 bypass component controls the closing speed of the bypass control valve V-13?
- a. Secondary nozzle pressure regulating pilot valve V-7.
  - b. Nozzle pressure regulating pilot valve V-5.
  - c. Bypass control needle valve V-12.
  - d. Venturi V-11.
109. (248) What does the Kovatch R-11 bypass system use to prevent fuel from reentering the bypass system?
- a. Ball valve.
  - b. Butterfly valve.
  - c. Check valve.
  - d. Thermal valve.
110. (249) Which Kovatch R-11 mainline system component relieves trapped air inside the filter separator?
- a. Air eliminator.
  - b. Air separator.
  - c. Air slug valve.
  - d. Air drain valve.
111. (249) Which Kovatch R-11 mainline system component holds a hydrostatic lock on flow control valve V-27?
- a. Tank vent valve V-4.
  - b. Water slug valve V-24.
  - c. Interlock pilot valve V-31.
  - d. Filter separator drain valve V-49.
112. (250) Which Kovatch R-11 defuel system component directs air pressure to the shuttle valve V-36?
- a. Defuel pilot valve V-71.
  - b. Defuel butterfly valve V-34.
  - c. Defuel return butterfly valve V-35.
  - d. Defuel override control valve V-38.

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113. (250) Which Kovatch R-11 defuel system component ensures fuel is filtered and metered before returning to the tank?
- a. Defuel lockout pilot valve V-17.
  - b. Defuel override valve V-38.
  - c. Defuel suction butterfly valve V-33.
  - d. Defuel priming control valve V-1.
114. (251) When testing meter accuracy on the Kovatch R-11, compare the meter readings to
- a. technical order specifications.
  - b. meter specifications.
  - c. readings from another meter of known accuracy.
  - d. readings from a similar truck.
115. (252) Which Kovatch R-11 meter programming item represents whole numbers before the K-factor decimal point?
- a. CAL 01.
  - b. CAL 02.
  - c. CAL 03.
  - d. CAL 04.
116. (252) What should you verify before adjusting the meter on an Kovatch R-11?
- a. Year and model of the truck.
  - b. Type of fuel being dispensed.
  - c. Date of last meter adjustment.
  - d. Existing K-factor of the meter.
117. (253) Which types of fuel dispensing hoses do refueling vehicles use?
- a. Collapsible and noncollapsible.
  - b. Collapsible and rigid.
  - c. Noncollapsible and rigid.
  - d. Noncollapsible and flexible.
118. (254) Which type of fluid is preferred for hydrostatic testing of fuel dispensing hoses?
- a. Water.
  - b. JP-4 jet fuel.
  - c. P.D. 680 type II solvent.
  - d. The same fluid used when dispensing.
119. (254) After you complete hydrostatic hose testing, how many gallons of fuel is flushed or circulated through the hose?
- a. 100.
  - b. 200.
  - c. 400.
  - d. 500.
120. (255) Which is the most dangerous safety hazard you will encounter working in refueling maintenance?
- a. Unstable fuels.
  - b. Static electricity.
  - c. Faulty grounding.
  - d. Smoking material.

121. (255) What extra precaution do you take in the refueling work center to safeguard smoking material disposal containers?
- a. Seal container lids tightly.
  - b. Empty containers weekly.
  - c. Partially fill containers with water.
  - d. Place containers outside of the work center only.
122. (256) Why are safety decals used on refueling vehicles?
- a. To enhance vehicle appearance.
  - b. As identification for the aircraft.
  - c. As a constant reminder of fuel type.
  - d. As a constant reminder of hazardous cargo.
123. (256) How many static ground reels must be used to satisfy the special ground requirements for refueling and defueling aircraft?
- a. 1.
  - b. 2.
  - c. 3.
  - d. 4.
124. (257) Which mechanism allows for a rotating connection between the static ground reel and the housing?
- a. A friction disc.
  - b. A set of contacts.
  - c. Low resistance wire.
  - d. A spring-loaded carbon tip.

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## Glossary

<b>°F</b>	degrees Fahrenheit
<b>Ω</b>	ohms
<b>A2B</b>	anti-two-block
<b>ABFDS</b>	Aerial Bulk Fuel Delivery System
<b>AC</b>	Alternating current
<b>ACE</b>	alternate capability equipment
<b>ADDS</b>	Aerial Delivery and Dispensing System
<b>AFI</b>	Air Force instruction
<b>APECS</b>	A Proportional Engine Control System
<b>ATHRS</b>	Air Transportable Hydrant Fueling System
<b>BTU</b>	British thermal unit
<b>CAD</b>	cadmium
<b>CAT</b>	Caterpillar
<b>DC</b>	direct current
<b>DP</b>	differential pressure
<b>ECM</b>	electronic control module
<b>EPR</b>	electronic pressure regulator
<b>ERR</b>	engine run relay
<b>FAM</b>	forward area manifold
<b>FARP</b>	forward area rearming and refueling point
<b>FEDS</b>	Fluid Efficient Delivery System
<b>FLS</b>	fuel level sensor
<b>FMSE</b>	fuels mobility support equipment
<b>FORCE</b>	fuels operational readiness capability equipment
<b>FSII</b>	fuel system icing inhibitor
<b>gpm</b>	gallons per minute
<b>HL</b>	hydraulic low
<b>hp</b>	horsepower
<b>HTO</b>	heat transfer oil
<b>Hz</b>	hertz
<b>JP</b>	jet propulsion
<b>LCD</b>	liquid crystal display
<b>LCM</b>	level control module

<b>LED</b>	light emitting diode
<b>mph</b>	miles per hour
<b>MRSP</b>	mobility readiness spares package
<b>MS</b>	multiecept
<b>NATO</b>	North Atlantic Treaty Organization
<b>OL</b>	outside limit
<b>PM</b>	power module
<b>POL</b>	petroleum, oil, and lubricant
<b>PPE</b>	personal protective equipment
<b>psi</b>	pounds per square inch
<b>PTO</b>	power takeoff
<b>PWM</b>	pulse width modulated
<b>RCI</b>	rated capacity indicator
<b>RIV</b>	rapid intervention vehicle
<b>rpm</b>	revolutions per minute; remote power module
<b>RTD</b>	remote temperature detector
<b>TD</b>	time delay
<b>TO</b>	technical order
<b>TYMCO</b>	The Young Manufacturing Company
<b>UHP</b>	ultra-high pressure
<b>USAF</b>	United States Air Force
<b>USMC</b>	United States Marine Corp
<b>V</b>	voltage
<b>VAC</b>	volt alternating current
<b>VDB</b>	valve driver board
<b>VDC</b>	volt direct current
<b>WRM</b>	war reserve materiel

## **Student Notes**

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