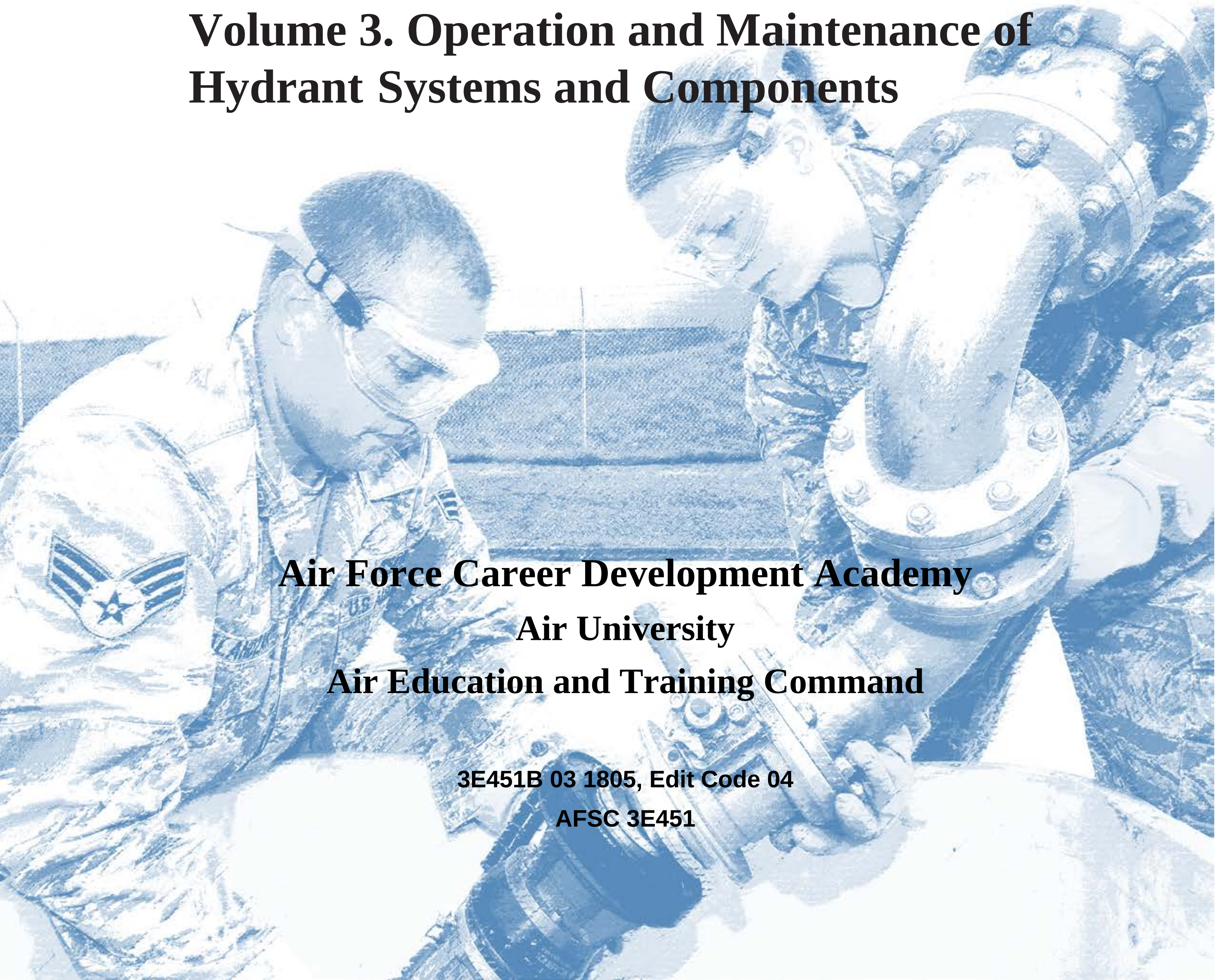
CDC 3E451B

Water and Fuel Systems Maintenance Journeyman

Volume 3. Operation and Maintenance of Hydrant Systems and Components



Air Force Career Development Academy

Air University

Air Education and Training Command

3E451B 03 1805, Edit Code 04

AFSC 3E451

Author: TSgt Roger Perez
MSgt Kevin Best
336th Training Squadron
U.S. Air Force Civil Engineer Training Center (AETC)
366 TRS/TRR
727 Missile Road
Sheppard Air Force Base, Texas 76311–2225
DSN: DSN: 736–3411
E-mail address: roger.perez.1@us.af.mil

Instructional Systems Specialist: Timothy Sackie

Editor: Sherie A. Davis

Air Force Career Development Academy (AFCDA)
Air University (AETC)
Maxwell AFB, Gunter Annex, Alabama 36114-3107

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

OUR GOAL in this third volume of Career Development Course (CDC) 3E451B, *Water and Fuel Systems Maintenance Journeyman,* is to provide you with the knowledge needed to maintain the components of Types I, II, and III hydrant systems and the Type IV hot pit system. You will need your knowledge of hydraulics and fluids to understand each component before you advance to the next objective. Valve components may be covered on more than one valve because of different adjustments or because it is being used in a different application.

Unit 1 covers the Type I hydrant system, which is also known as the modified Panero system. We look at the components and features of the modified Panero system; cover operating, adjusting the 302AF fueling and defueling valve; and the hydrant outlet features and associated repairs.

Unit 2 deals with the Type II (or Pritchard) and the Type II modified (or modified Pritchard) hydrant systems. We cover our automatic valves, found in the lateral control pit, and the hydrant outlet constructional features and maintenance, plus the valves' modifications. We also cover valves manufactured by the Cla-Val Company.

Unit 3 covers the newest hydrant systems, the Type III (or constant pressure) hydrant system. Maintenance and valve adjustment are not covered in great detail due to these valves and components' similarities to systems you have already covered. We have also included valves manufactured by the Cla-Val Company.

Unit 4 covers the fighter aircraft fueling system, which is known as the Type IV or hot pit system. The valves covered include those manufactured by the Cla-Val Company. Maintenance and valve adjustments are not covered in great detail due to the similarities with other valves and components.

A glossary of terms, abbreviations, and acronyms used in this course is included at the end of this volume.

Code numbers on figures are for preparing agency identification only.

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

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

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

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

This volume is valued at 15 hours and 5 points.

Acknowledgment

PREPARATION of this volume was aided through the cooperation and courtesy of the Cla-Val company who furnished technical materials for water and fuel systems. Permission to use this information is gratefully acknowledged. Units 1, 2, 3, and 4 of this volume uses extracts from Cla-Val Company. The figures listed below have been reproduced by permission of Cla-Val.

Title	CDC Figure Number
Modified Panero, Type I system	1–5
Three-port, two-way, refuel/defuel valve	1–6
Ejector-strainer	1–7
Pressure-reducing control (CRD)	1–8
Pressure-relief control (CRL)	1–9
CDHS–3, pressure-differential shutoff, cocked position	1–10
CDHS–3, pressure-differential shutoff, tripped position	1–11
302AF, refuel mode	1–12
302AF, pressure relief, 5 psi above NOP	1–13
302AF, pressure relief, 10 psi above NOP	1–14
302AF, excess flow	1–15
302AF, gravity defueling	1–16
Procedures for setting CDHS–3	1–17
Hydrant outlet	1–18
Pritchard, Type II hydrant system	2–1
Main valve body	2–3
Refueling control valve, 90AF–8	2–4
Cutaway view, 90AF–8	2–5
Valve position indicator (VPI)	2–6
Pressure relief valve, 50AF–2	2–7
Strainer orifice	2–8
Defueling control valve, 134AF	2–9
Defuel rate-of-flow control, 41AF	2–10
Hytrol check valve	2–11
Hydrant adapter and level control valve, 352AF	2–12
Combination rate-of-flow and solenoid shutoff valve, 41AF–10	2–14
Rapid-flow defuel (solenoid deenergized), 51AF–4	2–15
X73 Aluminum blanking cap	2–16
Filter/separator bypass hookup, 41AF–2C–22	3–2
Normal flow conditions, 41AF–2C–22	3–3
High-differential pressure shutoff, 41AF–2C–22	3–4
Excess water shutoff, 41AF–2C–22	3–5
High-level shutoff valve, 413AF–5A	3–6
Overfill valve, 2129AF	3–7
Rate-of-flow, nonsurge check valve, 41AF–1A	3–8
Filter/separator control valve, 41AF–2C	3–9
Emergency shutoff valve, 136AF–9B	3–10
Back pressure control valve, 58AF–9	3–13
Pressure control valve, 58AF–3	3–14
Defuel/flush valve, 58AF–9–1	3–15
High-level shutoff valve, 129AF–3F	4–1
Emergency shutoff valve, 136AF–9B	4–2
Hot pit hoseless pantograph	4–3
Hot pit hose end pantograph	4–4
Refueling control valve, 362AF–7	4–5
Backpressure control/flushing valve, 58AF–9–1	4–6
Flush valve, 136AF–5B	4–7
Pantograph pressure control valve, 58E–47	4–8

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.

Unit 1. Type I Hydrant System

EARLIER, we covered the components that make up a mechanical system. When you look at the pump house of the hydrant systems, you find the same pumps, tanks, filter/separators (F/S), and many of the other components we covered. What makes the hydrant system so different? The answer is simple—the pit control with automatic valves and the hydrants on the flight line. We do not cover the individual components of the pump house again, but we do discuss the hydrant system pit components and the different hydrants in some detail.

1–1. Pump Room Controls and Mechanical Drawings

The control room of any pump house is the brains of the operation. If it is not set up or operating properly, the system will not work the way it should. On the wall of the control room, or pump room, you will find schematic drawings of the entire system. These drawings are a valuable tool when troubleshooting the system.

401. Pump room controls

In this lesson, we will discuss the different types of control panels used in a pump house. The last panel will be the *defuel pump control panel* used in Pritchard fuel systems.

Electrical equipment in the hydrant system

The structure of the hydrant system pump house is the same as that described for the storage area pump house. All the piping and components in the pump room are bonded together and grounded directly to underground storage tanks. You could not ask for a better ground than a tank. The electrical equipment and conduit are grounded at the transformer located outside the building, next to the control room. The electrical conduit is also bonded to the system piping. As you can see, every precaution is taken to bring all components of the pump house to the same potential and to a common ground. This also includes the piping and components located in the fueling area. All control panels are located in the control room. The panels you are concerned with on the Type 1 system are the (1) *pump control panel* (PCP) and (2) *pump selector panel*. The Type II, or Pritchard system, has a unique third panel for controlling the *defuel pumps*. The Type III, or constant pressure system, has a very different PCP because this system is controlled by a microprocessor. The Type IV, or hot pit system PCP, is very similar to the Type III PCP, which we will cover later in this volume.

Type I and II pump control panels

Primarily, the PCPs consist of related motor controllers, pump control switches, manual reset buttons, and the main power circuit breakers for individual pumps. A separate PCP is provided for each pump motor, and they are located side-by-side. As you look at them, it may look like one long, continuous panel, but they are actually enclosed individually.

NOTE: The control room can receive emergency power from a portable generator.

The controllers (line starters) for each pump motor consist of a circuit breaker and a set of contactors. The circuit breaker serves as the “disconnect” for opening the electrical power supply line to the contactors and the associated pump motor. The circuit breaker contains a tripping device that automatically opens the power supply circuit when a short circuit occurs in the associated pump motor circuit or when the incoming power lines are overloaded. When the pump is not being operated, the contactors are spring-loaded open; when the pump motor is operating, they are closed by a solenoid. The solenoid is wired into the appropriate low-voltage control circuits for either local or the remote control of the pump motors. When the solenoid is energized by positioning the pump control switch, or by setting switches in the fueling area, the contactors close and the pump motor starts. Normally, deep-well pump motors operate on 440 volts. The low-voltage control circuits operate on voltages ranging from 24 volts to 110 volts, depending on the system design. Check your “as-built” electrical drawings to determine the control circuit voltage for your particular system.

Each low-voltage control circuit on a PCP includes a thermally actuated set of contacts. These overload contacts protect the pump motor from operating at excessive loads for an extended period. When the overload contacts open, the electrical solenoid is deenergized. When the solenoid loses its power, the main set of contacts open (they are spring-loaded open) and the pump motor turns off. The overload contacts in the control circuits connect to a manual reset button. This button is usually red and is located on each control panel. You press this button to restore the circuit to its normal operating condition after stopping it for an overload condition.

Each pump control switch on the control panels connects to the control circuit for the type of motor control desired. The switch, similar to the one used in mechanical systems, is a three-position selector switch with a pilot lamp mounted above it, which illuminates when the set of contacts in the motor controller is closed. This indicates the pump motor is running. The three positions on the pump control switch are HAND, OFF, and AUTO. The HAND position controls the pump motors locally. The OFF position, of course, turns the pump motors off. The AUTO position remotely controls the filter/meter control pits and the hydrant outlets.

Type I and II pump selector panel

The *second* major panel in the control room is the pump selector panel. A typical Type I and II pump selector panel is shown in figure 1–1. This panel enables operating personnel to select which fuel pumps control each hydrant outlet or control pit. It also indicates which hydrants are in use. As you can see, the panel has a control power disconnect switch (B). When low-voltage electrical power is required at the panel, this switch must be in the ON position. An emergency reset button (C), when pressed, restores electrical power to the panel if an emergency-stop switch in the fueling area is pressed. Press the potential indication and test push button (A) to check the hydrant lateral pilot lights (D) when you are setting up the selector panel. The pilot lights should go on to indicate when power is applied to the various pump selector switches (E) and (F). During operation, the pilot lights also indicate which control pits are in use.

The pump selector switches, which are rotary, are used to select the pump(s) to be controlled from a particular hydrant outlet or control pit. Hydrant systems with the 300 gallons per minute (gpm) deep-well pumps installed usually have two pump selector switches provided for each control pit. Systems with the 600 gpm pumps installed have only one selector switch for each control pit. Unless the system is designed, or has been modified, for a higher rate of flow, you can only dispense the maximum 600 gpm through the control pit.

The panel shown in figure 1–1 represents a typical hydrant system, with six deep-well pumps (300 gpm) and three control pits. The control pits can be either *filter/meter* or *lateral control pits* (*LCP*). The nomenclature plates (G) identify the individual control pits, each with *only* one fueling valve. They are numbered from left to right, control pit number 1, 2, 3, and so forth. Each selector switch has six positions. The number positions on the switch correspond to the pump numbers in the pump room. For example, position number 1 on any of the six selector switches corresponds to pump number

1. Suppose you want to run pumps number 5 and number 6 to pressure-set a valve in control pit number 1. You set the two selector switches for control pit number 1 so that the pointer on one switch is at 5 and the other switch pointer is at 6. When you want to dispense fuel through control pit number 3, using only one pump, you set one switch for control pit number 3 to the OFF position. Then, set the other switch for control pit number 3 to the position for the particular pump you want to use.

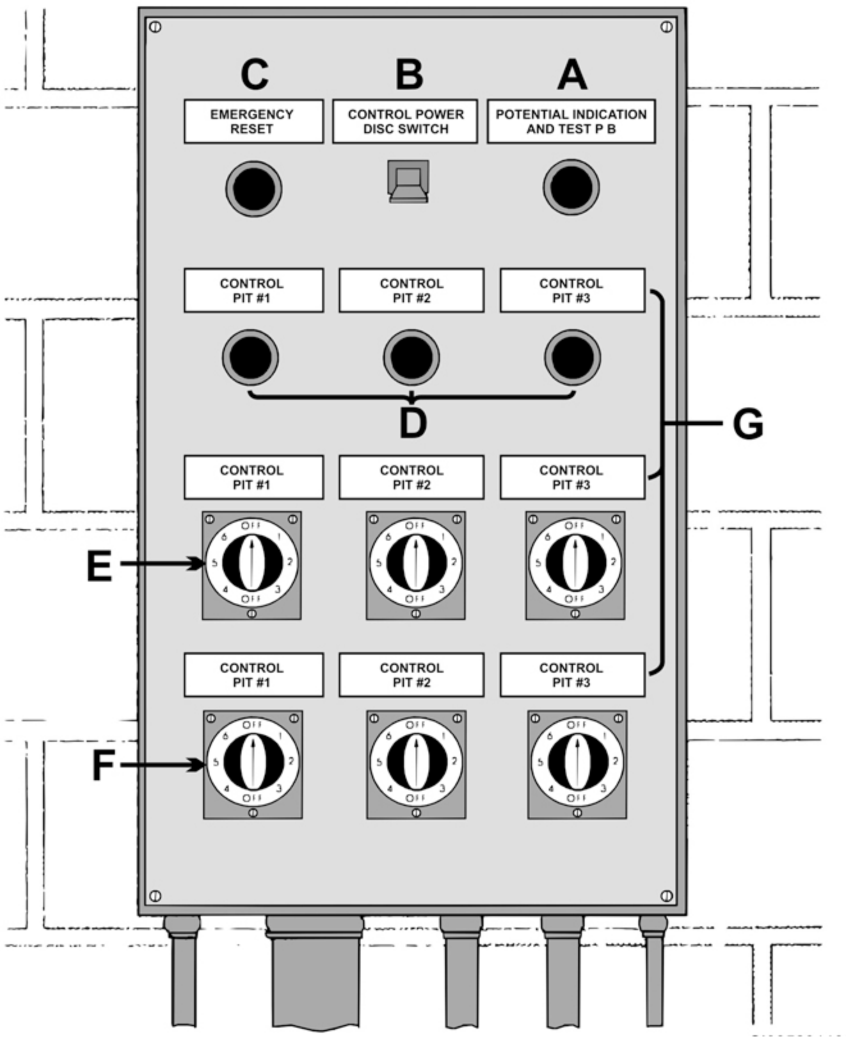


Figure 1–1. Type I and II pump selector panel.

Pritchard defuel pump control panel

The last panel we discuss is the *defuel PCP* used in Pritchard fuel systems. This panel is similar to the main PCP. There is a separate panel for each defueling pump. Each panel has a three-position HAND, OFF, and AUTO control switch and a pilot light to indicate when the pump is running. A reset button restores power to the pump control circuit. These panels are positioned side-by-side on the wall of the control room. The defuel pumps can also be operated local or remotely.

Type III pump control panel

Figure 1–2 shows the standard Type III PCP, which will be located in the control room. On some of the new installations, the graphic display can be mounted on the wall instead of on the PCP.

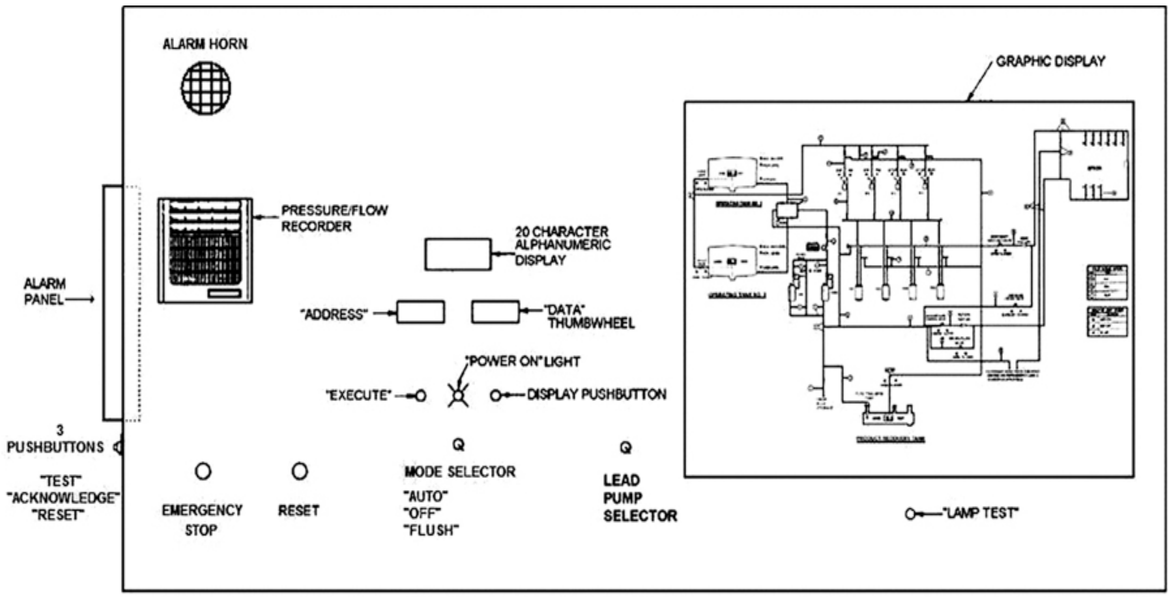


Figure 1–2. Type III PCP.

The PCP is a freestanding, National Electric Manufacturer's Association (NEMA) 250, Type I, gasket enclosure constructed of 12-gauge steel. The panel is a maximum of 90 inches high, 120 inches wide and 30 inches deep. It includes all the software programs specifying the sequence of operation. System control is done digitally by the microprocessor and converts to electrical signals, which operates motor starters, solenoids, alarms, and indicating lights. Forced-air ventilation maintains the interior air temperature no greater than 10 degrees (°) Fahrenheit (F) above the ambient temperature.

Looking at figure 1–2, the first thing you may notice is the graphic display. This is a single-line mechanical diagram of the Type III system. There are lights to indicate when certain manual and automatic valves are open or closed. A green light means a valve is open, and a red light means a valve is closed. You will also find, on this graphic, display tank level indicators and red lights for low, high, and high-high level alarms. The PCP also has an emergency-stop button (emergency shutoff [ESO] switch), a reset button, a lead pump switch, an "Auto-Off-Flush" switch, a "Power on" light, an "Execute" button, and a lamp test button listed under the graphic display. The "Address," "Data Thumbwheel," and "20 Character Alphanumeric Display" are windows used to obtain information from the microprocessor.

402. Mechanical drawings and standard designs

In the previous section we discussed electrical drawings. In this lesson, we will talk about the importance of interpreting mechanical drawings.

Being able to interpret mechanical drawings is the key to making sure the fuel goes where you intended—or not go, as in the case of opening the system for maintenance. Being able to trace the fuel system piping and locating components in the system is key to your day-to-day maintenance activities. Your shop should have a copy of all the fuel systems you maintain. If a drawing is missing, get a copy from the drafting section of your squadron.

Knowing *all* the symbols on the mechanical drawings can be helpful, but most importantly, you *must* know the valve and fitting symbols (fig. 1–3). You can apply the symbols you know to the drawing in figure 1–4 and easily understand the fuel flow through an R–12 vehicle checkout stand. It is also your responsibility to make sure drawings are accurate by submitting changes to the engineering flight.

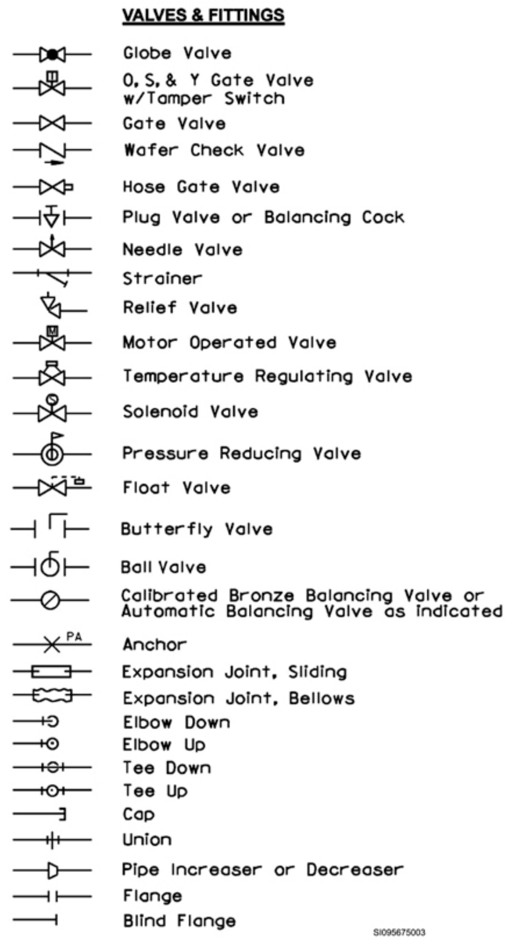


Figure 1–3. Valve and fitting symbols.

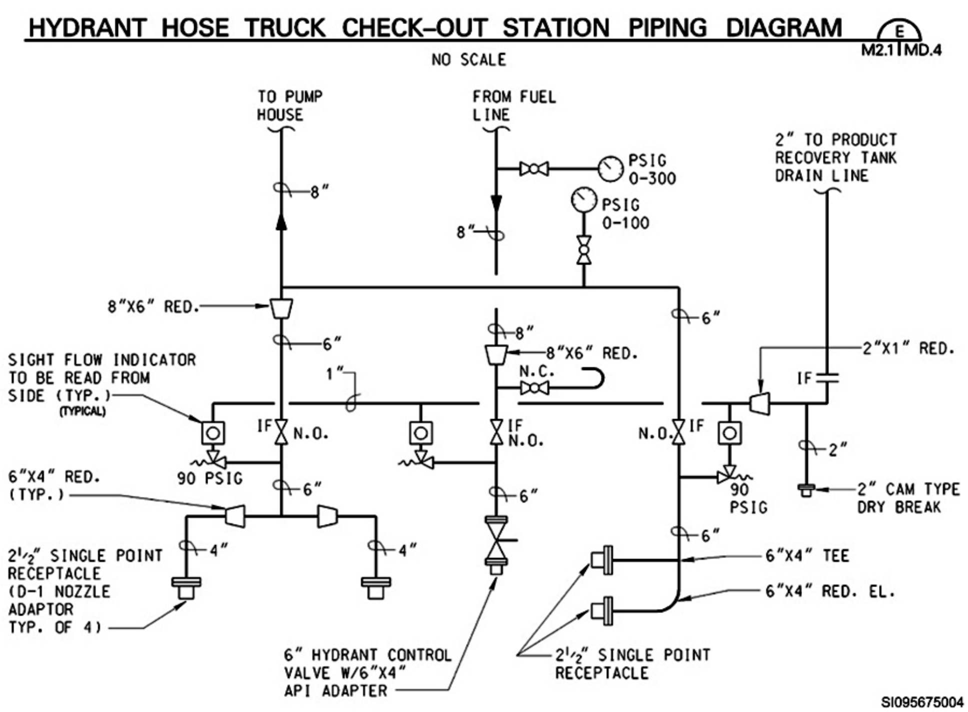


Figure 1–4. R–12 checkout stand drawing.

Most emergency service calls involve no fuel delivery. If the pump is running and no fuel is being delivered, your *first* step in diagnosing the problem is to review the as-built (mechanical) drawing located on the wall of every fueling facility. Start by making sure there is fuel in the supply tank. Then follow the piping to the delivery pump point and make sure all applicable valves are open.

The Air Force (AF) has developed uniform design drawings for its Type III, IV, V, and aboveground tanks. We call these standard designs. The Type III can be found in Air Wing (AW) 78–24–28, *DOD Pressurized Hydrant System Type III*; Type IV and V can be found in AW 78–24–29, *Pressurized Hot Fueling System;* and the standard tank in AW 78–24–27, *Standard Fueling Systems; Aboveground Vertical Fuel Tanks with Floating Pan and Fixed Roofs*. In the lower right-hand corner of mechanical drawings, you will find the standard design drawing code and specification number. When upgrading or constructing new fuel systems at your base, the work must be tailored to the specifications in the standard designs. The first step in designing upgraded or new construction is to contact the base or regional Army Corp of Engineers office along with your squadron's mechanical engineer who can help you with the design specifications.

Self-Test Questions

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

401. Pump room controls

1. What control panels on the Type I system are important to you?

2. What unique panel is found on the Type II and Prichard hydrant system?

3. What causes a PCP circuit breaker to trip?

4. What does the graphic display on the Type III PCP show?

5. What uses do the "Address," "Data Thumbwheel," and "20 Character Alphanumeric Display" windows on a Type III PCP have?

402. Mechanical drawings and standard designs

1. What is key to your day-to-day maintenance activities?

2. When troubleshooting a fuel system, you find the pump running with no fuel being delivered. What is your *first* stop in diagnosing the problem?

3. What is found in the lower right-hand corner of mechanical drawings?

1–2. Modified Panero System

The Type I hydrant system was first designed to use two automatic valves for refueling and defueling the aircraft. This system originally became known as the *original* Panero system. Since later systems used only one automatic valve, it then became known as the *modified* Panero. This section covers the modified Panero system and it is referred to as such.

403. Type I hydrant system constructional features

The Type I system consists of a pump house located over multiple underground storage tanks (UST), multiple hydrant valve pits, and multiple hydrant outlet pits. Usually the number of valve pits will equal the number of issue tanks.

Modified Panero system pump house

The basic construction of the pump house is the same from one base to another. The main difference you find in the pump house area is the make of the equipment used. All pump houses have tanks, pumps, F/Ss, manual and automatic valves, strainers, and gauges. The number and size of the tanks, pumps, and filters depends on the fuel requirement at that base. The modified Panero system typically has seven tanks—six for refueling aircraft and one separate tank for defueling aircraft.

Hydrant system pit

The hydrant LCP for the Panero system was called a filter/meter pit because it also contained a micronic filter and a meter in addition to the two automatic valves. The old hose cart had only hoses and manual valves that connected the hydrant outlet adapter to the aircraft, bridging the gap. In the modification from the original to the modified Panero system, the 302AF fueling/defueling valve replaced the two automatic valves. Later, as new equipment became available, the filter and meter were taken out of the pit and a new hose cart was introduced containing a filter and a meter, replacing the ones taken out of the pit.

Figure 1–5 shows the layout of the pump house and pit before the filter and meter were removed. If you follow the arrows of the fueling line from the pump house to the LCP, you will notice the fueling manifold contains the micronic filter, a single 302AF fueling/defueling valve, and the meter. The defuel line branches off the fueling line at the 302AF valve and was designed with a “U” bend to keep a portion of the line and the meter from draining (wet). If the meter were to drain completely, air would get into the system piping and the meter would not register the correct amount of fuel dispensed to the aircraft. Because of the pump flow rates, each Panero pit services only one hydrant outlet. The only component in the pit we will discuss is the 302AF fueling/defueling automatic valve (fig. 1–6).

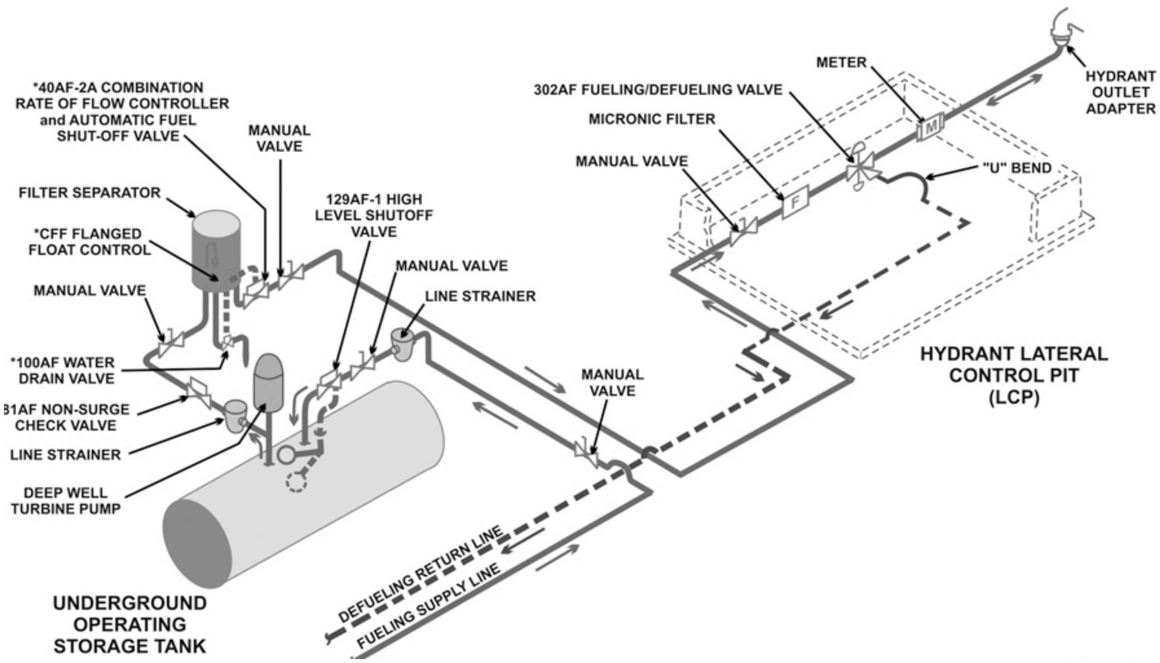


Figure 1–5. Modified Panero, Type I system. (By courtesy of Cla-Val Co.)

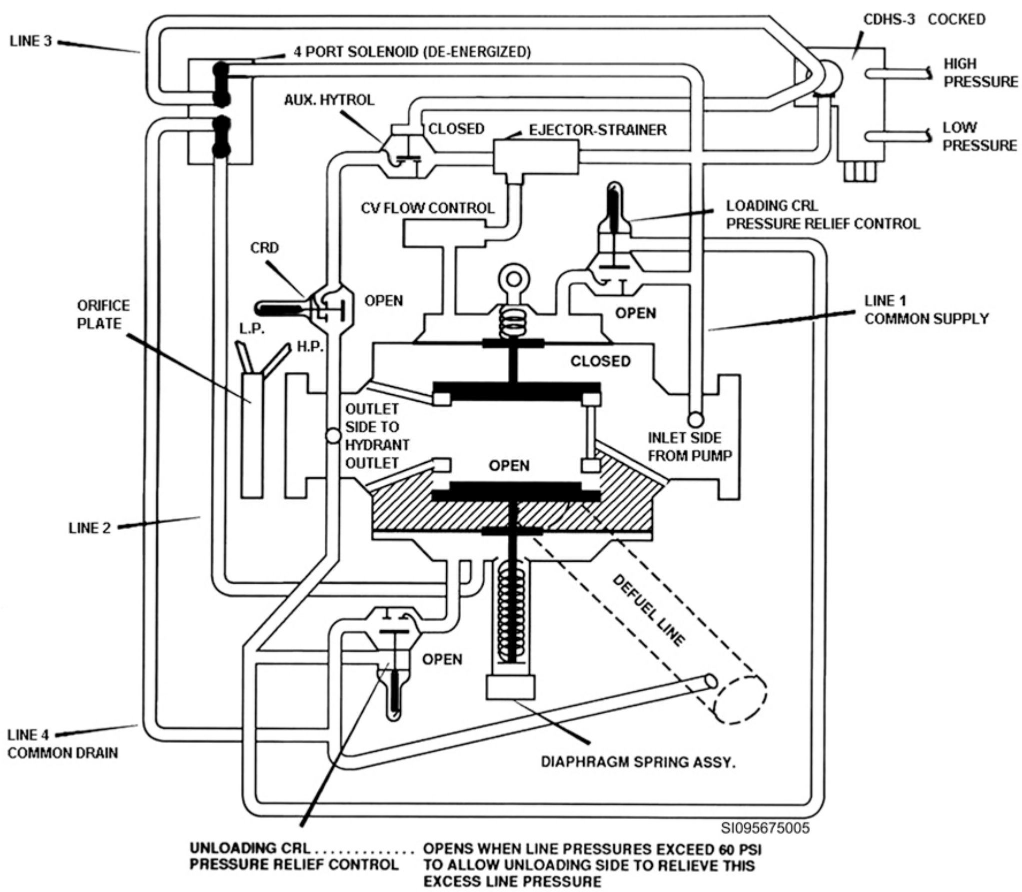


Figure 1–6. 302AF, Three-port, two-way, refuel/defuel valve. (By courtesy of Cla-Val Co.)

Remote controls

Remote controls in the Panero systems are used to remotely energize refueling and defueling operations at the hydrant outlets. The original Panero remote control system consisted of two separate cables with pushbutton switches that plugged into receptacle stations located next to the hydrant outlet. When the cables were not used, they were kept in the pump house.

The electrical plug-in remote control system was replaced with a magnetic control station consisting of separate refueling, defueling, and emergency-stop contacts. The horseshoe magnet, when either placed on the refuel or defuel contact, will complete the electrical circuit to energize the refueling or defueling operation. The spring-loaded magnetic cover, over the emergency-stop contacts, complete the circuit. By raising the spring-loaded magnetic cover, the circuit is broken thereby deenergizing operations.

To operate the refueling or defueling pumps, you must place the magnet on the two reference points (rivet heads) after the pump house is set up to operate properly. (**NOTE:** The horseshoe magnet may have a small hole to attach a cord or lanyard so the magnet can be removed quickly to immediately stop the pump.)

A small piece of wood can be used to prop open the spring-loaded covers when the magnet is used for refueling or defueling. Usually, the emergency-stop switch's magnetic cover is down and the circuit is closed. To activate the emergency-stop switch, lift the emergency-stop cover and release.

Maintaining these magnetic controls consists primarily of keeping the magnetic switch plates free of debris, water, and ice. If the magnetic switches ever fail, remove them by prying the switch plate loose with a suitable tool.

404. Operating the 302AF fueling/defueling valve

Before we discuss the operation of the 302AF fueling valve, we need to look at the operation of some of its components.

Fueling/defueling components

The components we cover are the ejector-strainer, pressure-reducing control (CRD) valve, pressure-relief control (CRL) valves, pressure-differential control, and orifice plate.

Ejector-strainer

The ejector-strainer is located at the inlet of the control tubing and aids in opening the 302AF valve. Figure 1–7 shows a cutaway of the ejector-strainer. Fuel enters the control through the holes under the 60-mesh screen, then moves to the left out of the primary jet (where the flow of fuel increases), and on through the secondary jet. (Recall that an increase in velocity creates a low pressure.)

The primary and secondary jets can be removed from the body. The O-ring prevents leakage around the primary jet. The bottom of the ejector-strainer is connected to the refueling side cover chamber.

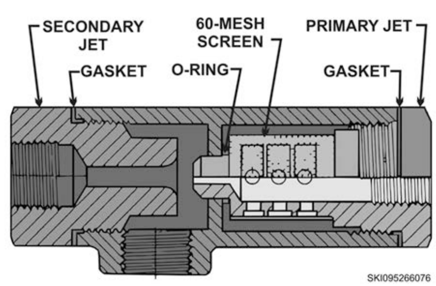


Figure 1–7. Ejector-strainer. (By courtesy of Cla-Val Co.)

Pressure-reducing control valve

The CRD valve controls the downstream pressure of the main valve during refueling. Figure 1–8 shows the CRD and its parts: a disc assembly, seat, diaphragm, diaphragm washer, spring, gasket, and adjusting screw. The CRD valve is spring loaded open. As fuel enters the control through the inlet, it passes through the seat, disc assembly, and through the outlet (discharge). As the fuel pressure increases downstream of the main valve, the pressure below the CRD diaphragm starts to overcome the spring tension and draws the yoke with the disc closer to the seat, slowing down the fuel flow in the control tubing.

Slowing the fuel flow increases the low pressure of the ejector-strainer, making the ejector-strainer less efficient, and puts slightly more pressure on top of the main valve diaphragm. This pressure increase partially closes the main valve, maintaining the desired downstream pressure. Remember, the CRD valve only *restricts* the flow of fuel in the control tubing and, when operating normally, it will not close. The vent port or weep hole is located in the cover of the CRD above the diaphragm. Fuel leaking from the vent port will indicate a damaged diaphragm.

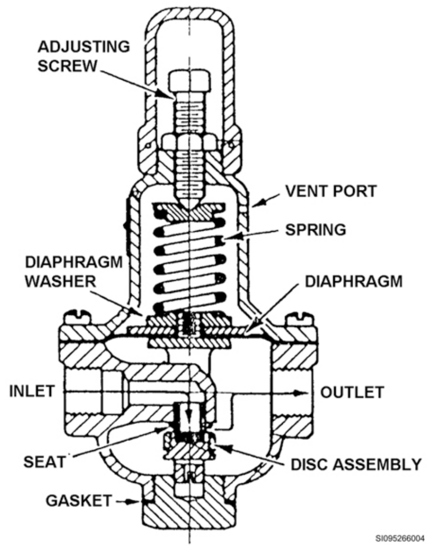


Figure 1–8. Pressure-reducing control (CRD). (By courtesy of Cla-Val Co.)

Pressure-relief control valves

Looking back on figure 1–8, locate the CRL valves. There are two of them. The unloading CRL valve is on the defuel side, and the loading CRL valve is on the refuel side of the 302AF valve. See figure 1–9, a cutaway of the CRL valve, for a clearer view of the components.

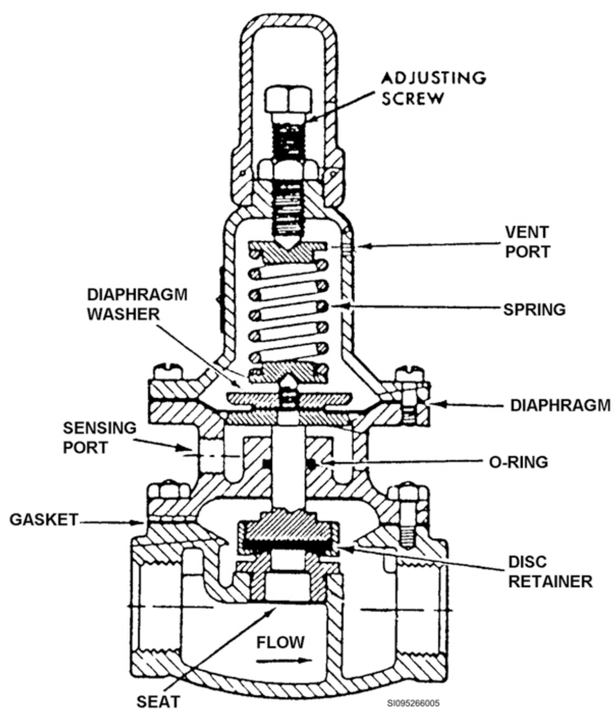


Figure 1–9. Pressure-relief control (CRL). (By courtesy of Cla-Val Co.)

The 302AF valve is really two separate valves in one valve body. One valve functions as a refueling valve, the other as a defueling valve. Both sides of the valve work in close conjunction with one another through the controlled actions of the valve components.

The major components of the CRL valve are the seat, disc, diaphragm, diaphragm washer, spring, sensing port, and "O" rings. This control is also equipped with a vent port in the cover to indicate a damaged diaphragm. Notice that many of its components are similar to the CRD valve. A main difference is that the pressure-relief valve is spring-loaded closed and opens when the diaphragm is pushed up by sensing pressure. When pressure at the sensing port is higher than the setting of the spring tension, the CRL opens. The loading CRL applies pressure to the loading (refueling) cover chamber of the 302AF, closing the refuel side of the main valve. The unloading CRL relieves pressure from the unloading (defueling) cover chamber of the 302AF, allowing the defueling side of the main valve to open.

Other components of the 302AF valve are the auxiliary hytrol valve (covered earlier), the control valve (CV) flow control (refueling valve opening rate), and the 4-port solenoid. The solenoid remotely operates the valve. When the solenoid is energized, the refueling side of the main valve opens and the defueling side closes. When the solenoid is deenergized, the opposite is true. Four lines connected to the solenoid (fig. 1–7) control the flow of pressure to the components of the main valve. Line 1 is the supply line and supplies the pressure to the solenoid control. Line 2 is the control tubing to the defueling section of the valve. Line 3 is the control tubing to the auxiliary hytrol valve cover chamber. Line 4 is the common drain line that relieves pressure to the defuel line and on back to the defuel tank.

Pressure-differential shutoff

The pressure-differential shutoff (CDHS–3) has only one purpose—to close the main valve when there is excess flow at the hydrant outlet. Figures 1–10 and 1–11 show the two operating positions of the CDHS–3. In the cocked position, (fig. 1–10) low pressure (L.P.) from the orifice plate is on the side of the diaphragm that has the spring, while high pressure (H.P.) is on the other side of the diaphragm. Spring force and L.P. keep the detent secured in the notch of the actuating stem. Line 3 is aligned with the hytrol cover chamber, venting the auxiliary hytrol to drain, and line 1 (common supply) is deadheaded.

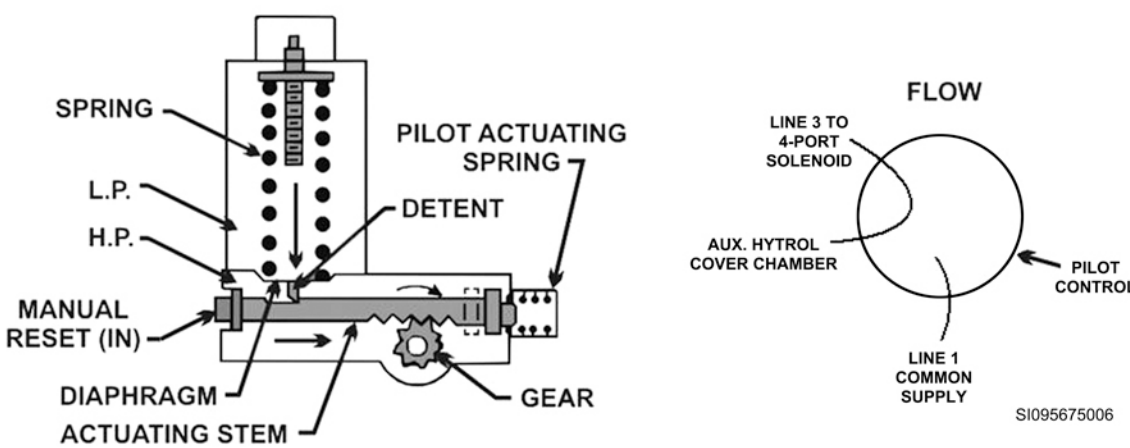


Figure 1–10. CDHS–3, pressure-differential shutoff, cocked position. (By courtesy of Cla-Val Co.)

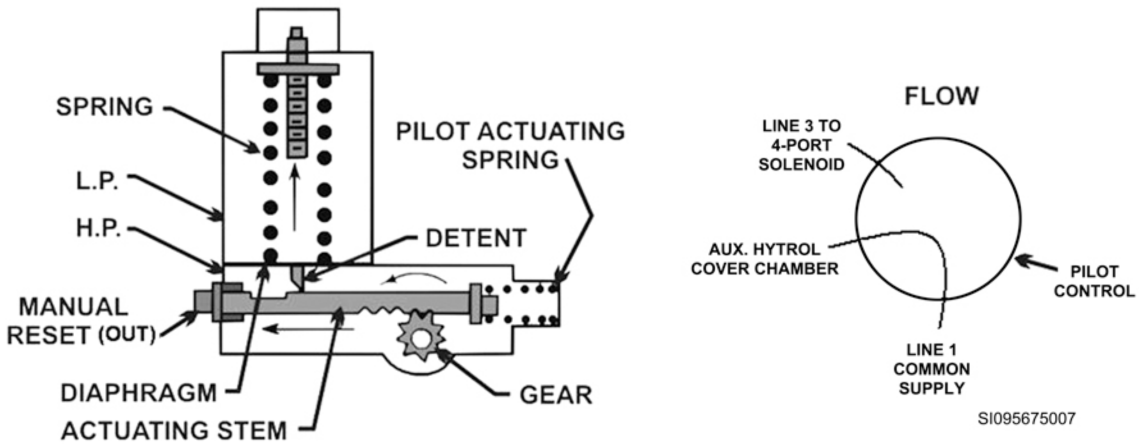


Figure 1–11. CDHS–3, pressure-differential shutoff, tripped position. (By courtesy of Cla-Val Co.)

The differential pressure changes when fuel flow increases through the orifice plate. H.P. remains the same, but L.P. gets lower. The differential pressure increase forces the diaphragm in the direction of the spring, moving the detent from the notch. The force of the pilot-actuating spring moves the actuating stem, pushing the manual reset out. The movement of the stem rotates the gear, which, in turn, rotates the rotary disc in the pilot control, putting the CDHS–3 in the tripped position, as shown in figure 1–11. When this happens, line 1 (common supply) travels through the solenoid and realigns to the auxiliary hytrol cover chamber, closing it deadheading line 3. As long as the CDHS–3 is tripped, the main valve cannot open. To reset the CDHS–3, press the manual reset button.

The normal location of the CDHS–3 is on the pit wall, but it can also be installed in the line leading from the solenoid to the hytrol valve on the 302AF valve.

Orifice plate

This component is installed on the downstream flange of the 302AF. The primary purpose of the orifice plate is to create differential pressure to operate the CDHS–3. The orifice plate assembly is the same one we covered earlier. This orifice plate is used on many automatic valves and its design is simple. The L.P. port is drilled through the housing on the downstream side of the orifice plate while the H.P. port is on the upstream side of the plate. As fuel passes through the orifice plate, a L.P. area is established on the downstream side.

Refueling

The refueling operation and flow path are shown in figure 1–12. Study the diagram as we discuss the operation of the valve. The refueling valve is spring-loaded in the normally closed (N.C.) position and the defueling valve is spring-loaded in the normally open (N.O.) position.

The 302AF (fig. 1–12) is shown in the fueling position with the solenoid energized. When a solenoid is energized, supply line 1 is common with line 2, and common drain line 4 is common with common drain line 3. The solenoid valve directs H.P. from the main valve inlet to the cover chamber of the defueling valve, holding it closed. At the same time, the solenoid valve vents the cover chamber pressure of the hytrol valve to the defueling line. This opens the hytrol valve and permits fuel flow through the control loop.

The first component in the control loop is the ejector-strainer. Fuel flowing through the ejector-strainer creates reduced pressure in the main valve cover chamber. Fuel leaves the ejector-strainer and enters the hytrol. Since the cover chamber of the hytrol is vented to the common drain, the hytrol opens and allows fuel to flow through it. Fuel continues in the control loop to the CRD. As you learned earlier, the CRD is spring-loaded open so fuel can flow through it. Fuel exits the CRD and continues in the control loop to the downstream side of the 302AF main valve body. The primary control loop is now complete.

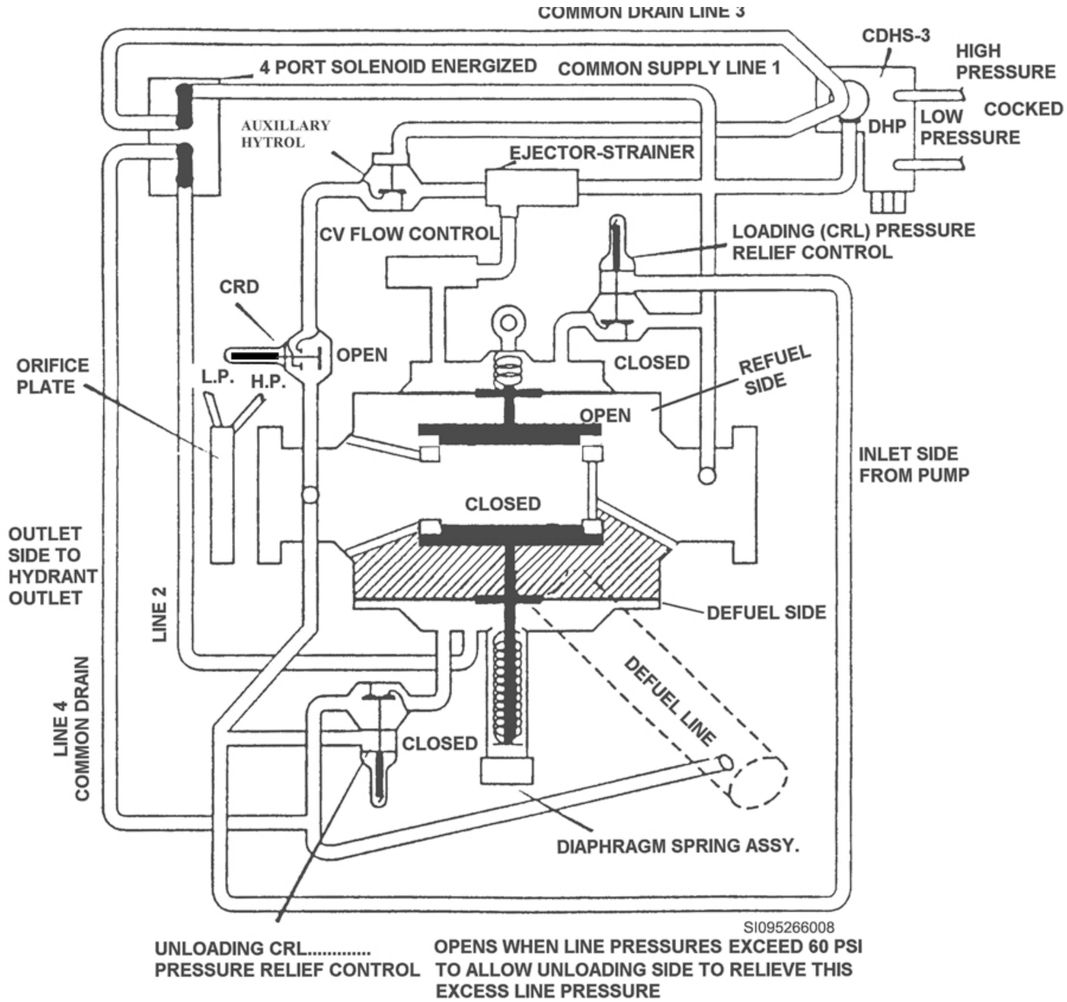


Figure 1–12. 302AF, refuel mode. (By courtesy of Cla-Val Co.)

When the pressure at the pressure-reducing valve is below the adjusted setting, maximum flow is permitted through the ejector-strainer. The L.P. created by the ejector-strainer creates reduced pressure in the main valve cover chamber. The valve then opens and builds up pressure in the downstream piping.

If you remember, Pascal said that pressure in connected vessels would be equal. Therefore, as the pressure increases in the downstream piping, it will also increase at the diaphragm of the CRD. When this happens, the increased pressure will push up on the CRD diaphragm, overcome its spring tension setting, and draw the disc closer to the seat. This restricts the flow through the CRD and the rest of the control loop. The flow restriction affects the ejector-strainer by sending less fuel through the control loop and more fuel and pressure back down to the refueling side’s main valve cover chamber. This increased pressure on top of the diaphragm forces the refueling side’s disc closer to its seat, restricting flow, and consequently, downstream pressure. Therefore, as you can see, any modulation (change) at the CRD will also modulate the refueling side’s main valve until the downstream piping’s pressure, acting on the CRD’s spring tension, finds the balance to providing a constant downstream pressure.

Any change in the rate of fuel dispensed causes a slight change in the downstream pressure, making the CRD and the main valve assume new positions to supply the new demands. If the pressure suddenly increases, two actions occur: (1) the fueling valve closes rapidly and (2) the defueling valve opens. When this happens, the pressure-relief valves are used. Figure 1–14 shows the delivery pressure directed under the diaphragm of the loading CRL valve, which opposes the force of the springs.

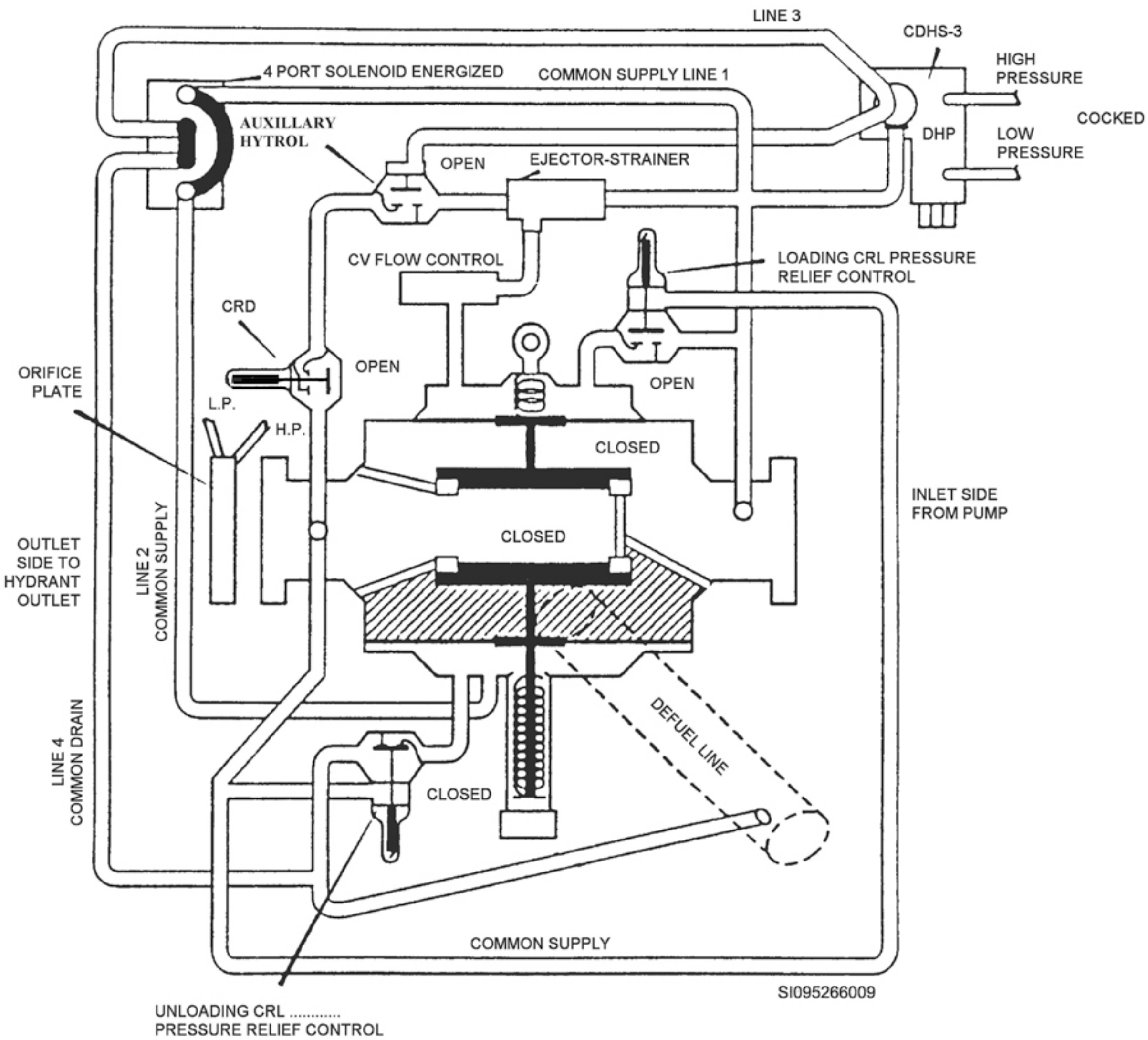


Figure 1–13. 302AF, pressure relief, 5 psi above NOP. (By courtesy of Cla-Val Co.)

When downstream pressure increases to 5 pounds per square inch (psi) above normal operating pressure (NOP), the CRL opens and the full-pump pressure is applied to the refueling side diaphragm, closing the refueling side of the main valve. This prevents any further pressure from building at the hydrant outlet. If the loading pressure relief fails to relieve excess pressure and downstream pressure continues to build to 10 psi above NOP, the unloading pressure relief opens (fig. 1–14) and relieves pressure from the cover chamber of the defueling side. The defueling side opens and relieves excessive line pressure into the defuel line.

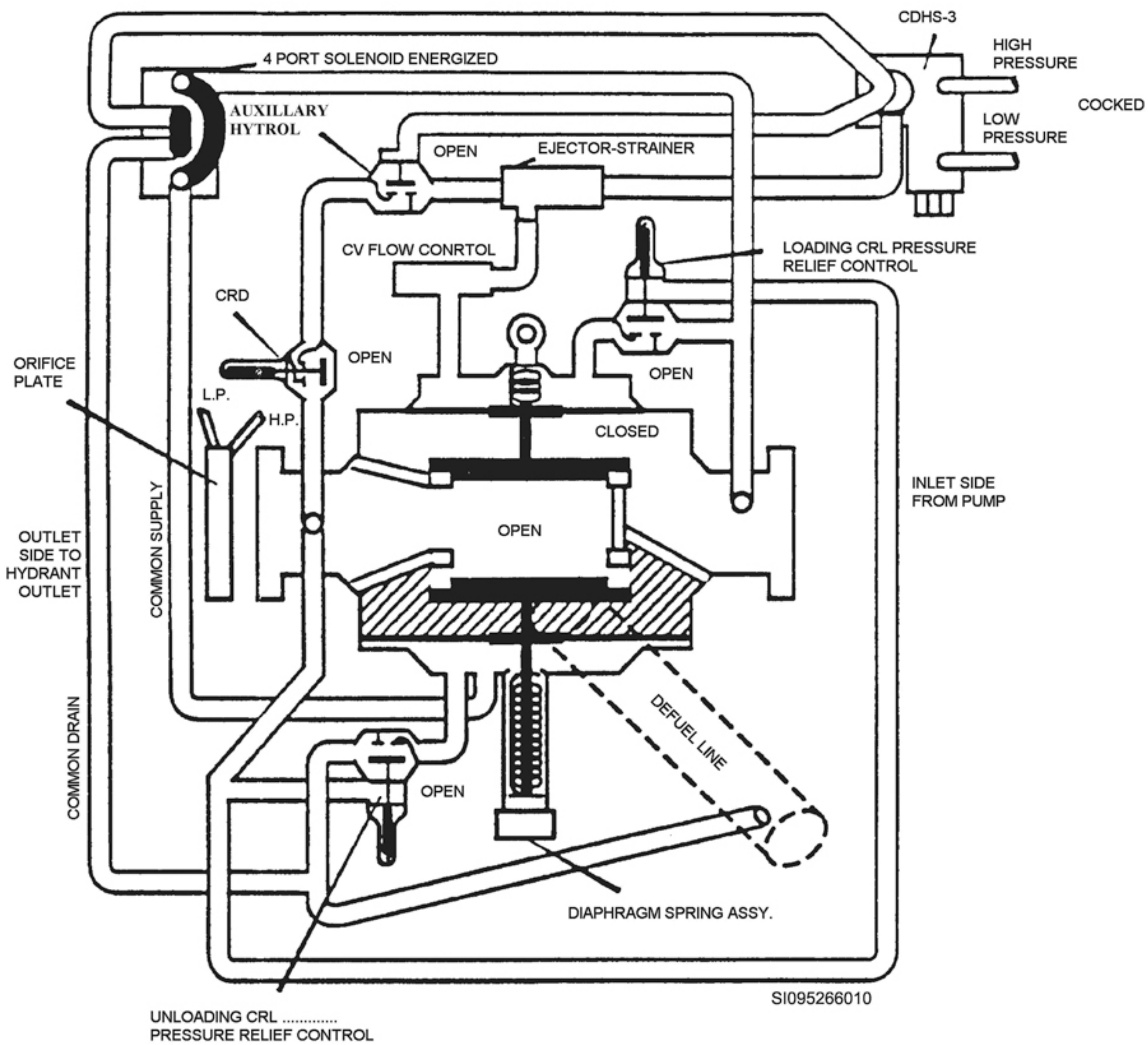


Figure 1–14. 302AF, pressure relief, 10 psi above NOP. (By courtesy of Cla-Val Co.)

If a hose breaks while refueling an aircraft, an excess flow condition exists. The excess flow then creates L.P. at the orifice plate, tripping the CDHS–3 and closing the refueling valve. Let us look at each step using figure 1–15. When excess flow creates a L.P. drop at the orifice plate, the CDHS–3 trips (fig. 1–15) and the rotary disc rotates. Line 3 is deadheaded and line 1 realigns with the hytrol cover chamber, sending pressure to the top of the hytrol diaphragm, which closes it. With the hytrol valve closed, all the fuel pressure previously going through the ejector-strainer now directs downward on top of the refueling valve diaphragm, closing the valve.

With the CDHS–3 cocked, fuel being forced off the top of the hytrol diaphragm goes through the CDHS–3, to line 3, through an energized 4-port solenoid, then out the common drain tubing to the defuel line.

All 302AF valves *must* have a CDHS–3, an orifice plate, and a CV flow control. The CV flow control *must* regulate the opening speed of the fueling valve to keep the CDHS–3 from inadvertently tripping.

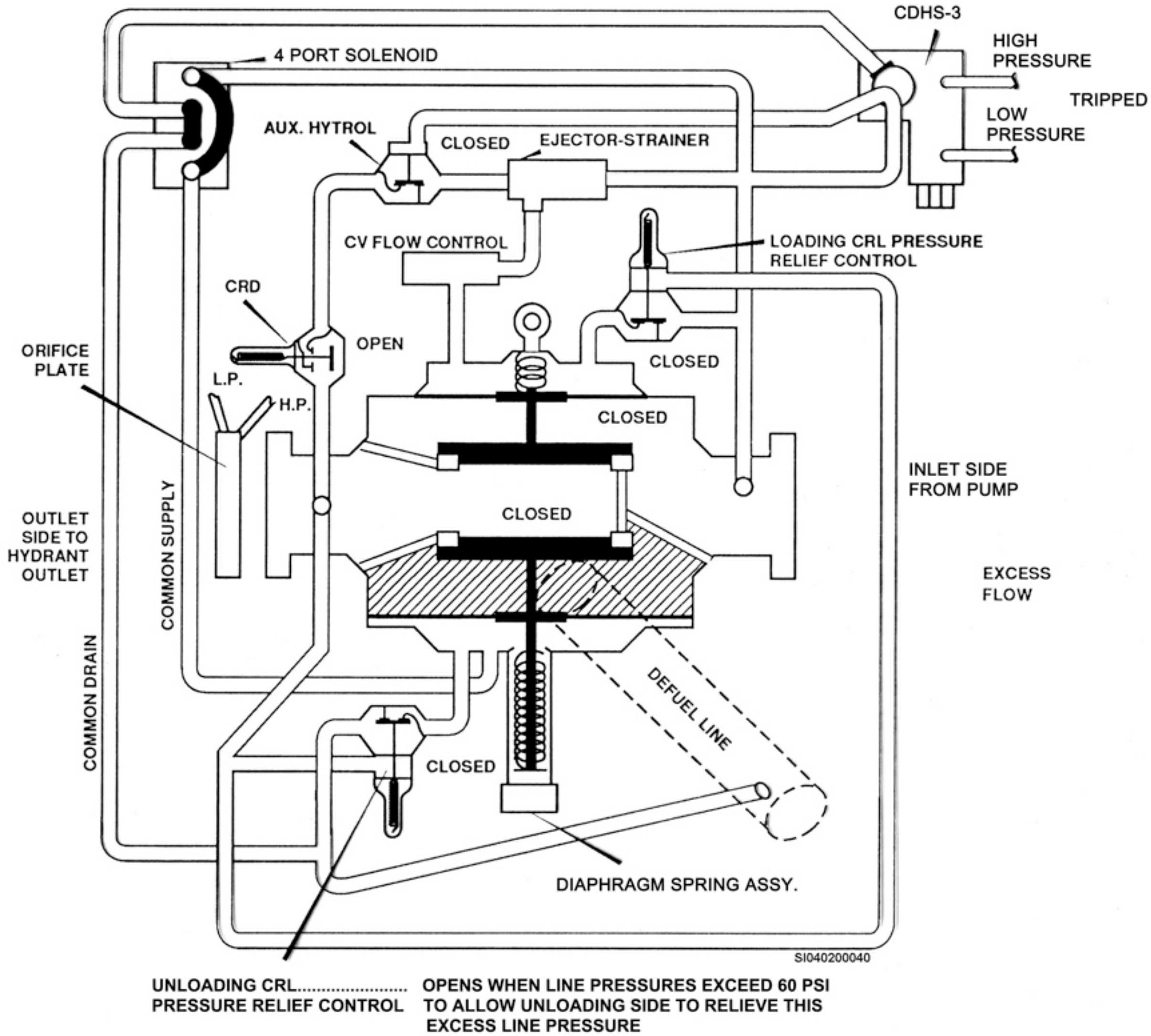


Figure 1–15. 302AF, excess flow. (By courtesy of Cla-Val Co.)

Defueling

Figure 1–16 shows the automatic refueling and defueling valve in the defueling position with the solenoid deenergized. With the solenoid deenergized, line 1, common supply becomes part of line 3's common supply and closes the hytrol valve. The line 4 common drain becomes part of the line 2 common drain, which opens the defueling valve. You can see that the solenoid valve directs pressure from the main valve inlet onto the cover chamber of the auxiliary hytrol valve, holding it closed. This causes pressure in the control loop to flow through the ejector-strainer into the cover chamber of the refueling side of the valve, holding it closed. The solenoid also vents the cover chamber of the defueling valve to the defueling line. With the pressure relieved from the defuel cover chamber, the diaphragm spring assembly pulls the valve open for gravity defueling.

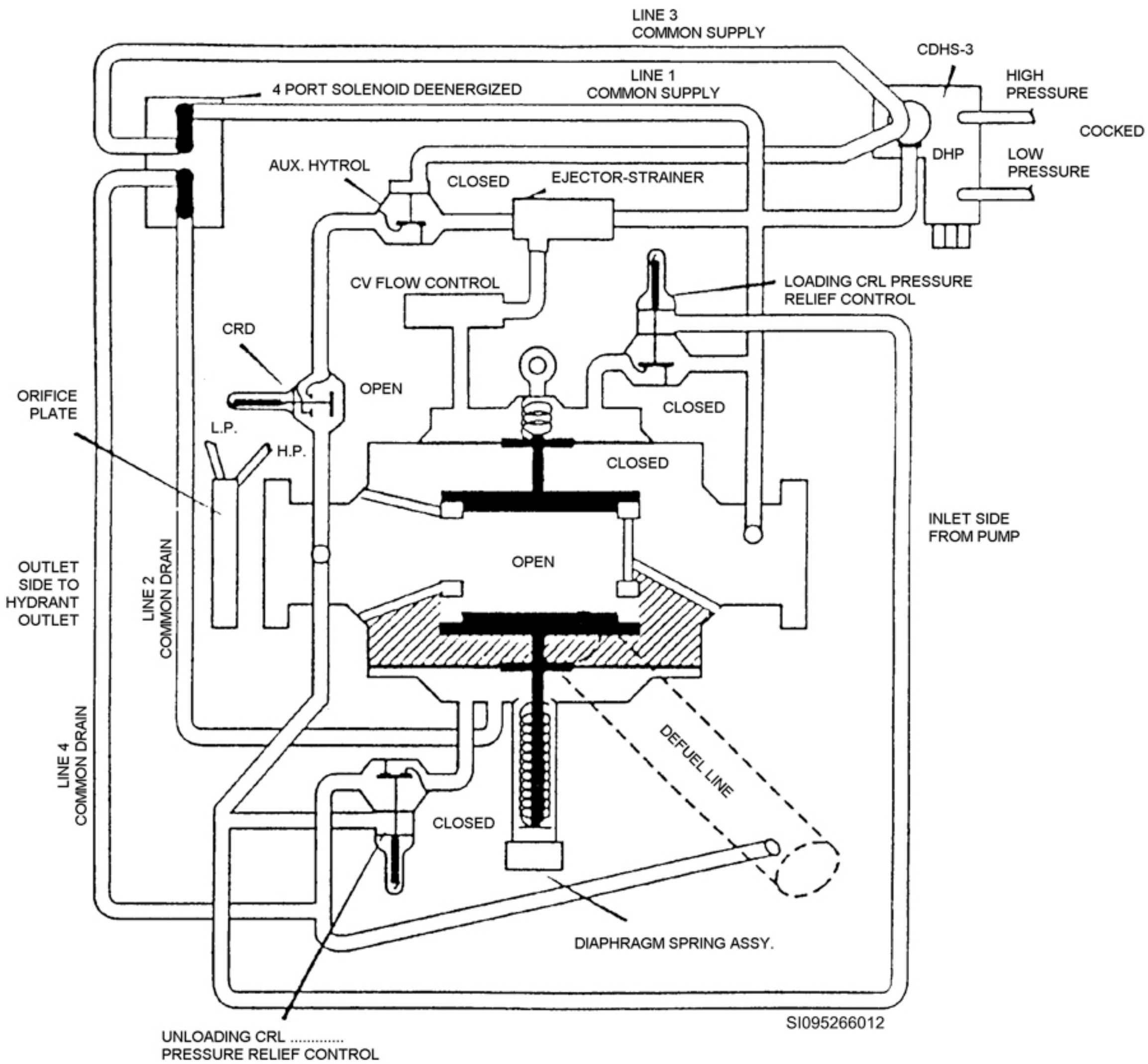


Figure 1–16. 302AF, gravity defueling. (By courtesy of Cla-Val Co.)

405. Inspecting and adjusting the 302AF

Operationally inspect the 302AF valve every 3 months (quarterly). In addition to checking for leaks, check the condition of all valve components including the proper downstream pressure (CRD), the pressure relief (loading and unloading CRLs), and for excess flow by way of the CDHS–3. In addition, check the opening rate (CV flow) of the refueling side to make sure it opens at a rate that will not cause the CDHS–3 to trip. When the solenoid is energized, you read the pressure gauge downstream of the 302AF to verify the pressure-reducing and pressure-relief settings.

Most 302AF valves operate correctly under normal conditions for long periods. However, you may have to work on one of the components and adjust it after you finish. The possible adjustments include pressure, the opening rate, and the excess flow shutoff.

Pressure adjustment

Three components can be adjusted: the *loading-pressure relief, unloading-pressure relief,* and the *CRD.* The 302AF is designed to maintain a constant downstream pressure. To set the pressure, you connect a fueling truck to the hydrant and turn the adjusting screws on both CRLs clockwise. Do not turn the screws past the point where they bottom! This may damage the threads or the seats of the component. The *first* adjustment you make, after starting the pump and while fueling, is to turn the adjusting screw on the CRD clockwise until you get a pressure gauge reading of 10 psi above the desired delivery pressure. Slowly turn the unloading CRL adjusting screw counterclockwise until the pressure begins to drop. This causes the defueling side to open at 10 psi above NOP. Then turn the CRD screw counterclockwise until the pressure drops to 5 psi above NOP. Turn the adjusting screw on the loading CRL counterclockwise until the pressure just begins to drop on the gauge. The fueling side closes when delivery pressure reaches 5 psi above the NOP. Finally, turn the CRD screw counterclockwise until you get the desired delivery pressure. Stop and restart the pump to check the settings, then tighten all jam nuts and replace the caps and seal the three controls.

Adjusting the CV flow control

Adjust the CV flow control when the valve has been taken apart or when the main valve is opening too fast and tripping the CDHS–3. Adjust the opening speed of the fueling valve the same way you do the 81AF valve, by turning the adjusting screw on the CV flow control clockwise to increase the time it takes the valve to open. When you adjust this control on the 302AF valve, you want the fueling valve to open in about 20 seconds. This should be the fastest rate that will not trip the CDHS–3. Should the fueling valve open too fast, a flow surge across the orifice plate will trip the CDHS–3.

Testing the pressure-differential shutoff

The CDHS–3 shutoff operates from differential pressure produced by the orifice plate on the outlet of the main valve. The orifice plate's bore size is located on the flange of the orifice plate. Once you identify the orifice plate bore size, you can calculate its differential pressure at a given gpm flow rate (fig. 1–17). Once you know this differential pressure, testing becomes a matter of producing the differential pressure across the diaphragm of the CDHS–3 shutoff and adjusting the control until it trips. For this method, you add shutoff valves in the CDHS–3 sensing lines to shut off the fuel supply. Then you add external pressure equal to the pressure produced by the differential across the orifice plate, and make the adjustment.

Shutoff valves (1 and 2) are in the H.P. and L.P. sensing lines between the orifice plate and the CDHS–3. Install valve 3 on a "T" in the H.P. sensing line on the CDHS–3 side of valve 1 to connect the air pump and pressure gauge. Install valve 4 on a "T" in the L.P. sensing line to vent the L.P. side of the diaphragm to atmosphere. Now you can set the excess flow control without flowing fuel through the system.

To find the correct differential pressure on the flow chart in figure 1–17, move to the right across the bottom line of the chart to locate the gpm flow rate your system normally operates within. Then move up towards the top of the chart until the gpm flow line intersects the line drawn from the orifice bore size. From this intersection, follow the line to the left of the chart and read the differential pressure in psi. Use the differential pressure figure from the chart in the following procedure.

Close valves 1 and 2. Open valve 4 to vent the L.P. side of the diaphragm to atmosphere. Connect a 0 to15 psi gauge and air pump to shutoff valve 3. Turn the adjustment screw on the CDHS–3 clockwise until it bottoms out.

Apply the pressure (psi) obtained from the flow chart to the H.P. sensing connection. Turn the adjustment screw on the CDHS–3 counterclockwise until the control trips. Once the control trips, open valve 5 to bleed the pressure to zero, and reset the control. Repeat the procedure several times to make sure the control trips at the correct pressure.

To return the system to normal operation, remove the air pump and gauge, close and plug off valves 3 and 4, and open valves 1 and 2. To prevent tampering, remove the valve handles or safety-wire them to their proper position.

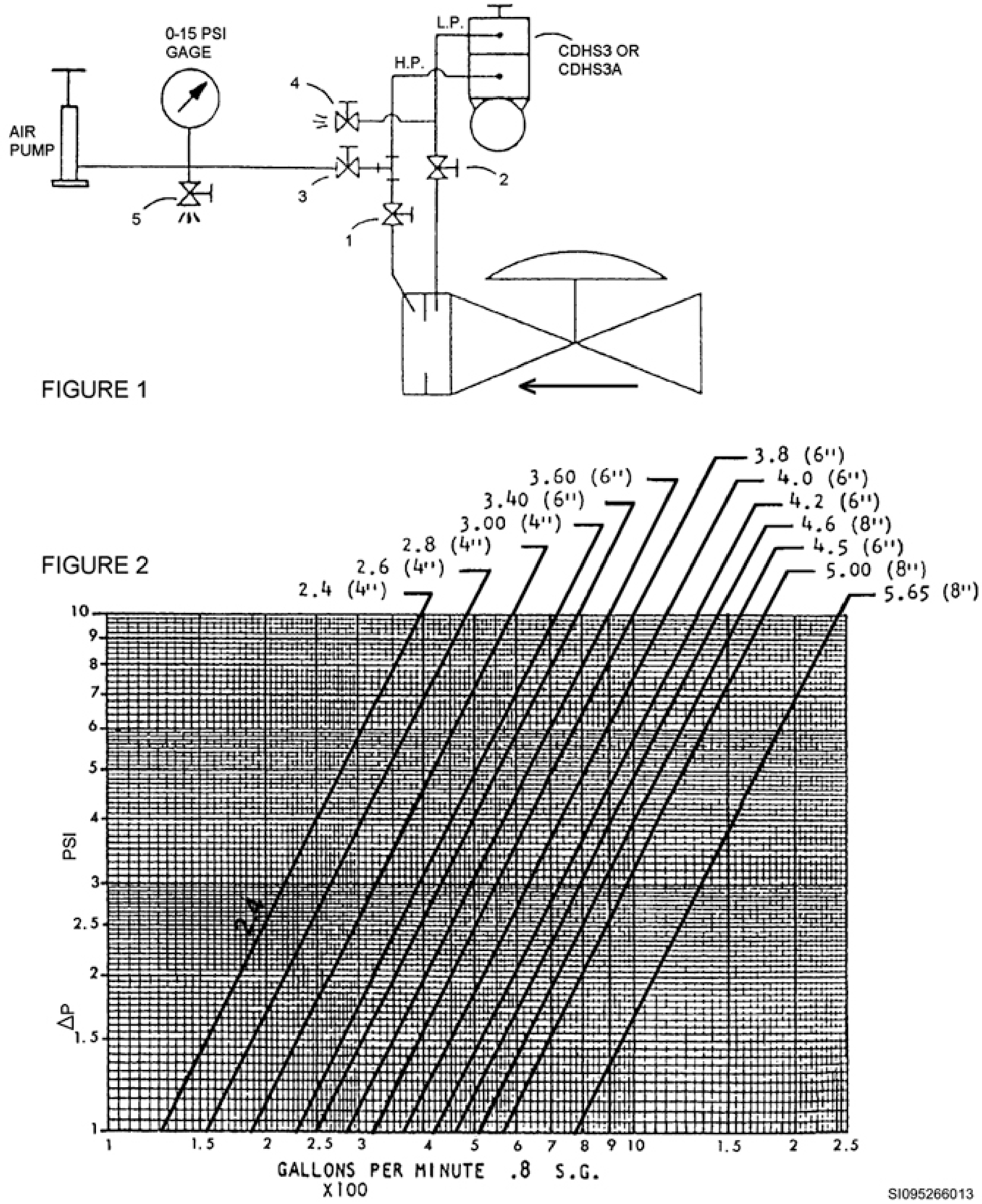


Figure 1–17. Procedures for setting CDHS–3. (By courtesy of Cla-Val Co.)

Repair automatic valves

Repairing automatic valves consist of replacing parts listed by the manufacturer in their maintenance literature, and this is usually limited to the removable portions of the main valve and components. Order replacement parts either individually or as a kit.

Once you have the replacement parts, most automatic fuel valves and components disassemble similarly. First, the following precautions *must* be followed to perform the work safely:

- Notify the petroleum, oil, and lubricants (POL) people to let them know the system will be temporarily out of service.
- Use lock-out/tag-out procedures to isolate valves and pump motors; electrically isolate any solenoids or limit switches on the valve.
- Use a multimeter to ensure the power is off.

- You must shut off the cathodic system if it is cathodically protected through impressed current.
- Bleed any pressure off the connected piping and valve, to include the control tubing.
- Have the proper personal protective equipment (PPE) to do the job.
- Adequately ventilate the area to prevent vapor from building up.
- Use drip pans to catch any leaking fuel and bond it to the pipe.
- Use the proper tools for the job.

Once these items are accomplished and are in place, you can proceed with disassembling the valve to make any necessary repairs. When you are not sure of the procedures, and to prevent damage to valve parts that cannot be replaced, use the manufacturer's instructions, if necessary. If there is damage to the valve body such as cracks or splits, you must replace it. Any attempt to repair a valve body may result in the catastrophic failure or rupture of the valve when under pressure.

When you complete repairs and reassemble the valve, you must then put the valve under pressure to check for leaks. Run the fuel system and operationally check all valve functions; make adjustments as needed. Clean up the area and return the system back to its original condition. Return any fuel collected to the product recovery tank or similar collection point.

Electric pump motors

Besides problems with the electrical components and wiring that we have already discussed in electrical circuits, here are some common and easy problem areas to begin troubleshooting pump motors before it gets complicated. Make sure the control panel is set up properly and check the pump switch next to the pump to see if it is on. Also, check for activated emergency-stop switches and low tank fuel levels. Remember, the low-level control will prevent a motor from starting if the fuel level is low.

Emergency-stop switches

Normally, when you depress an emergency-stop switch, all control circuits become inoperable. When a pump cannot operate, either automatically or by hand, and you are certain that the electrical controls are set up properly, it may be that one of these emergency-stop switches has been activated. Reset the control panel first. If this does not restore power, check each emergency-stop switch. You may find one stuck open. Internal corrosion in these switches is the biggest cause of malfunctions. To prevent moisture from entering, make sure the cover gasket is sealing properly on all switches. Once you detect an emergency-stop switch that may be malfunctioning, repair it.

Self-Test Questions

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

403. Type I hydrant system constructional features

1. The modified Panero system has seven tanks. How many are used for refueling aircraft?

2. What was removed and replaced in the hydrant pit and is now used on the hose cart?

3. What, in the Type I filter/meter pit, was put in the defueling line to keep a portion of the line and meter from draining?

4. How many hydrant outlets are normally installed on each 302AF valve?

5. Which automatic valve is located in the pit?

404. Operating the 302AF fueling/defueling valve

1. What component aids in opening the 302AF valve?

2. What prevents leakage around the 302AF valve ejector-strainer’s primary jet?

3. During refueling, which component controls downstream pressure of the main valve?

4. How does the CRD operate?

5. On the CRD, what indicates a damaged diaphragm?

6. How many CRLs are on the 302AF valve and what are they called?

7. Which CRL applies pressure to the top of the refueling cover chamber of the 302AF?

8. What happens to the defueling side of the 302AF when the 4-port solenoid is deenergized?

9. What positions are the 302AF refueling and defueling valves normally spring-loaded?

10. What component vents the cover chamber pressure of the hytrol valve to the defueling line?

11. What component restricts flow through the ejector-strainer, and what impact does it have on the refueling side of the main valve?

12. Explain what happens if the downstream pressure builds to 10 psi above NOP.

13. What happens at the 302AF valve when an excess flow condition exists?

14. Which component on the 302AF valve *must* regulate the opening speed of the fuel valve, and why is the component necessary?

15. How does the 302AF refueling and defueling valve operate during defueling?

405. Inspecting and adjusting the 302AF

1. To make sure the 302AF valve operates properly, how often do you inspect it?

2. What do you check when operationally inspecting the 302AF valve?

3. How do you adjust the CRD and CRL pressure settings?

4. How do you adjust the opening speed of the fueling valve?

5. How do you adjust the CDHS–3 excess flow control?

1–3. Hydrant Outlets

Hydrant outlets are small recessed pits topped with hinged cover plates that are located on the aircraft-parking ramp. Each outlet has a 4-inch hydrant adapter attached to the pipeline extending from the filter/meter pit. Panero systems use two types of hydrant adapters: the “Buckeye” and the “Philadelphia.” We discuss the Philadelphia adapter in this section.

406. Constructional features and repair

The Philadelphia hydrant adapter (fig. 1–18) includes a flanged housing and a spring-loaded closed poppet assembly to keep fuel from leaking if the adapter pressurizes when the hose coupling is not connected.

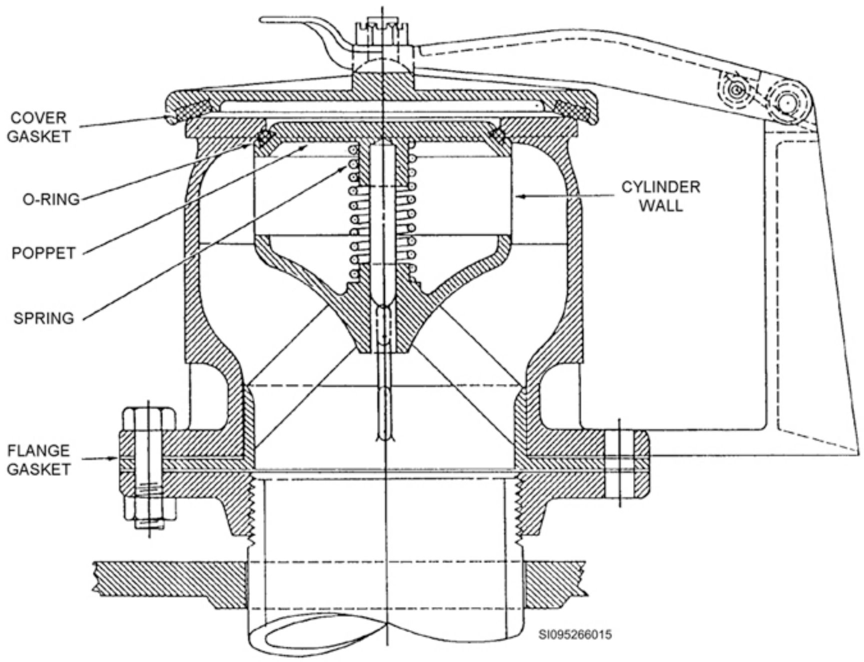


Figure 1–18. Hydrant outlet. (By courtesy of Cla-Val Co.)

Components

It is important for you to know how fuel flowing back into the defuel pipe after a fueling operation is assisted by gravity. Each hose coupling uses a vacuum breaker. When the coupling is mated to the adapter, the poppet valve in the coupling opens the poppet in the adapter and allows fuel to flow. When the coupling is pressurized, the vacuum breaker stays closed until the fueling stops. At this point, fuel entering the defuel pipe creates a slight vacuum at the hose coupling and opens the vacuum breaker. Opening the vacuum breaker allows air to enter the coupling. Fuel then flows, in a smooth gravity flow, back to the delivery tank. If the vacuum breaker on the hose coupling fails to open, the fuel from the hydrant outlet and fueling hose will not drain properly.

A remote electrical control station is adjacent to each hydrant outlet. Recall that three magnetic switch plates (refuel, defuel, and an emergency-stop) replaced the push-button remote electrical control cables. After you properly set up the controls in the pump house, by placing a magnet on the refuel contact points, you will energize the deep-well turbine pump and the electrical solenoid on the 302AF valve during fueling.

When you place a magnet on the refuel switch, the relay in the low-voltage control circuit closes and energizes the electrical solenoid on the 302AF valve. At the same time, the relay also energizes the control circuit from the filter/meter pit to the pump selector panel. The selected control circuit is completed to the selected motor controller and energizes the motor controller and contactor based on the setting of the panel selector switch. This, in turn, starts the deep-well pump. When you remove the magnet, the relay opens to deenergize the 302AF valve solenoid and the deep-well pump. You use these magnetic switches to operationally check and troubleshoot the system components. Remember, for the remote magnetic switches to work, you must place the main pump switch on the PCP in the AUTO position.

There is also an electrical static ground connection (ground rod) at each hydrant outlet. The installed pipeline system is connected to the static ground. This connection is also used for grounding the aircraft and hose cart to eliminate static charge buildup.

Maintenance

The Philadelphia hydrant adapter is a simple hydrant adapter. It has just one function to join with the hose cart’s hose coupling. It gives little trouble, but whenever there is a leakage, it is usually remedied by replacing the cover gasket, the flange gasket, or the O-ring on the poppet. One other trouble that seldom occurs is the poppet binding. This calls for dressing away any burrs on the poppet, stem guide, stem, and cylinder wall. If this does not fix the problem, or if the stem is bent, replace the faulty parts. To check for binding, push the poppet down with your fingers while the system is idle. It should move easily against the spring force until it bottoms. When you let go, the poppet should rise and instantly seat securely. Finally, make sure the cover fits well enough to keep out dirt and water.

Inspection

Inspecting the hydrant outlet consists of checking for leaks, pit cleanliness, and a properly operating poppet. You may also have to check the condition and proper operation of the electrical cord.

Self-Test Questions

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

406. Constructional features and repair

1. How is the Philadelphia adapter’s poppet assembly spring-loaded? Why?

2. What opens the poppet in the hydrant outlet adapter?

3. What feature allows air to enter the coupling and provide a smooth gravity flow back to the delivery tank?

4. What components are energized by placing a magnet on the refuel contact points?

5. What position must the PCP switch be placed in for the remote magnetic switches to work?

6. Usually, how is leakage remedied on the hydrant outlet adapter?

7. What would you need to do if the poppet binds?

8. What inspections are required for the Philadelphia hydrant adapter?

Answers to Self-Test Questions

401

1. PCP and pump selector panel.
2. A defuel PCP.
3. The circuit breaker contains a tripping device that automatically opens the power supply circuit when a short circuit occurs in the associated pump motor circuit or when the incoming power lines are overloaded.
4. A single-line mechanical diagram of the Type III system.
5. To obtain information from the microprocessor.

402

1. Being able to trace the fuel system piping and locate the components in the system.
2. Review as-built (mechanical) drawing.
3. The standard design drawing code and specification number.

403

1. Six.
2. A new filter and meter.
3. A “U” bend.
4. One.
5. The 302AF fueling/defueling valve.

404

1. Ejector-strainer.
2. O-ring.
3. CRD valve.
4. As fuel enters the control through the inlet, seat, disc assembly and outlet, pressure increases downstream of the main valve. The pressure below the CRD diaphragm overcomes the spring tension and draws the yoke with the disc closer to the seat, slowing down the fuel flow in the control tubing, increasing the low pressure on top of the ejector-strainer. This makes the ejector-strainer less efficient and puts slightly more pressure on top of the main valve diaphragm.
5. Fuel leakage from the vent port.
6. Two, the loading and unloading pressure-relief CRL.
7. The loading CRL.
8. Does the opposite and opens.
9. The refueling side is normally spring-loaded closed and the defueling side is normally spring-loaded open.

10. The solenoid.
11. The CRD, through modulation, causes the refueling side's main valve to eventually provide constant downstream pressure.
12. The unloading pressure relief opens and relieves pressure on the defueling side; the defueling side opens and relieves pressure into the defuel line.
13. The excess flow creates L.P. at the orifice plate, tripping the CDHS–3 and closing the refueling valve.
14. The CV flow control, and it is important because it keeps the CDHS–3 from inadvertently tripping.
15. The solenoid is deenergized during defueling and the line 1 common supply becomes part of line 3's common supply and closes the hytrol valve.

405

1. Every three months.
2. You check for leaks and the condition of all valve components including the proper downstream pressure (CRD), the pressure relief (loading and unloading CRLs), and for excess flow by way of the CDHS–3. In addition, check the opening rate (CV flow) of the refueling side to make sure it opens at a rate that will not cause the CDHS–3 to trip.
3. Turn the CRD clockwise until you get a pressure gauge reading of 10 psi above the desired delivery pressure; slowly turn the unloading CRL adjusting screw counterclockwise until the pressure begins to drop, which causes the fuel to open at 10 psi above NOP. Then turn the CRD screw counterclockwise until the pressure drops to 5 psi above NOP. Turn the adjusting screw on the loading CRL counterclockwise until the pressure just begins to drop on the gauge. Finally, stop and restart the pump to check settings, tighten all jam nuts and replace the caps and seal the three controls.
4. By turning the adjusting screw on the CV flow control clockwise to increase the time it takes the valve to open.
5. Once you know the orifice plate's bore size, located on the flange of the orifice plate, calculate its differential pressure, using the CDHS–3 chart, at a given gpm flow rate. Test it by producing the differential pressure across the diaphragm of the CDHS–3 shutoff and adjust the control until it trips. Add shutoff valves in the CDHS–3 sensing lines to shut off the fuel supply. Finally, add external pressure equal to the pressure produced by the differential across the orifice plate and make the adjustment.

406

1. It is spring-loaded closed to keep fuel from leaking if the adapter pressurizes when the hose coupling is not connected.
2. The poppet valve in the coupling.
3. The vacuum breaker.
4. The deep-well turbine pump and the electrical solenoid.
5. AUTO.
6. By replacing the cover gasket, the flange gasket, or the O-ring on the poppet.
7. Either dress away any burrs on the poppet, stem guide, stem, and cylinder wall or replace the faulty parts.
8. Check for leaks, pit cleanliness, and the condition and proper operation of the poppet. Also, check the condition and proper operation of the electrical cord.

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

Unit Review Exercises

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

Do not return your answer sheet to AFCDA.

1. (401) What are the positions on the pump control switch?
   a. HAND/OFF.
   b. HAND/AUTO.
   c. HAND/OFF/AUTO.
   d. HAND/OFF/MANUAL.

2. (401) The graphic display on the Type III pump control panel (PCP) is a single line
   a. diagram of the electrical wiring.
   b. diagram of the pump control system.
   c. mechanical diagram of the Type II system.
   d. mechanical diagram of the Type III system.

3. (402) *Most* emergency service calls involve
   a. electrical shorts.
   b. no fuel delivery.
   c. minor leaks.
   d. jammed valves.

4. (402) The pump is running, but no fuel is delivered. What is your *first* step in diagnosing the problem?
   a. Check the pump.
   b. Check all valves.
   c. Review the as-built drawing.
   d. Check the Fuel storage tank.

5. (403) In the modified Panero system, how many tanks are used for defueling aircraft?
   a. 1.
   b. 3.
   c. 5.
   d. 7.

6. (403) The “U” bend in the Panero hydrant system pit defuel line
   a. allows the line to expand.
   b. absorbs the hydraulic shock.
   c. keeps a portion of the line and meter from draining.
   d. provides a place for priming the pump.

7. (403) How many hydrant outlets are served by each Panero pit?
   a. 1.
   b. 2.
   c. 3.
   d. 4.

8. (404) When operating normally, what part on the 302AF fueling/defueling valve *restricts* the flow of fuel in the control tubing and will not close?
   a. Ejector-strainer.
   b. Control valve (CV) flow control.
   c. Pressure-relief control (CRL).
   d. Pressure-reducing control (CRD).

9. (404) Which component closes the main valve of the 302AF fueling/defueling valve when there is excess flow at the hydrant outlet?
   a. Pressure-reducing control (CRD).
   b. Pressure-differential shutoff (CDHS–3).
   c. Loading pressure-relief control (CRL).
   d. Control valve (CV) flow control.

10. (404) When the pressure-differential shutoff (CDHS–3) on the 302AF fueling and defueling valve trips, pressure in the common supply line travels through the solenoid and goes
    a. directly to the refueling section of the valve.
    b. directly to the diaphragm chamber of the auxiliary hytrol valve.
    c. through the CDHS–3 to the refueling section of the valve.
    d. through the CDHS–3 to the auxiliary hytrol cover chamber valve.

11. (404) The *primary* purpose of the orifice plate on the 302AF fueling and defueling valve is to create differential
    a. pressure to operate the pressure-differential control (CDHS–2).
    b. pressure to operate the pressure-differential shutoff (CDHS–3).
    c. flow to operate the CDHS–2.
    d. flow to operate the CDHS–3.

12. (404) During refueling, which 302AF fueling and defueling valve component holds the defuel side of the main valve inlet closed?
    a. Loading pressure-relief control (CRL).
    b. Pressure-differential shutoff (CDHS–3).
    c. Solenoid.
    d. Hytrol.

13. (405) Which delivery pressure causes the fueling side of the 302AF fueling and defueling valve to close when turning the adjusting screw on the loading pressure-relief control (CRL) counterclockwise?
    a. 5 pounds per square inch (psi) above normal inlet pressure.
    b. 5 psi above normal operating pressure (NOP).
    c. 10 psi above normal inlet pressure.
    d. 10 psi above NOP.

14. (405) Approximately how many seconds do you want it to take the fueling valve to open when you adjust the control valve (CV) flow control on the 302AF fueling and defueling valve?
    a. 10.
    b. 20.
    c. 30.
    d. 40.

15. (405) You can begin to properly calculate the differential pressure required to adjust the pressure-differential shutoff (CDHS–3), by identifying the
    a. upstream and downstream pressure.
    b. upstream pressure and flow rate.
    c. downstream pressure.
    d. orifice plate bore size.

16. (406) To remedy a leakage on the Philadelphia hydrant adapter, you *may* need to replace the
    a. coupling poppet.
    b. vacuum breaker.
    c. flange gasket.
    d. solenoid.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Type II Hydrant System

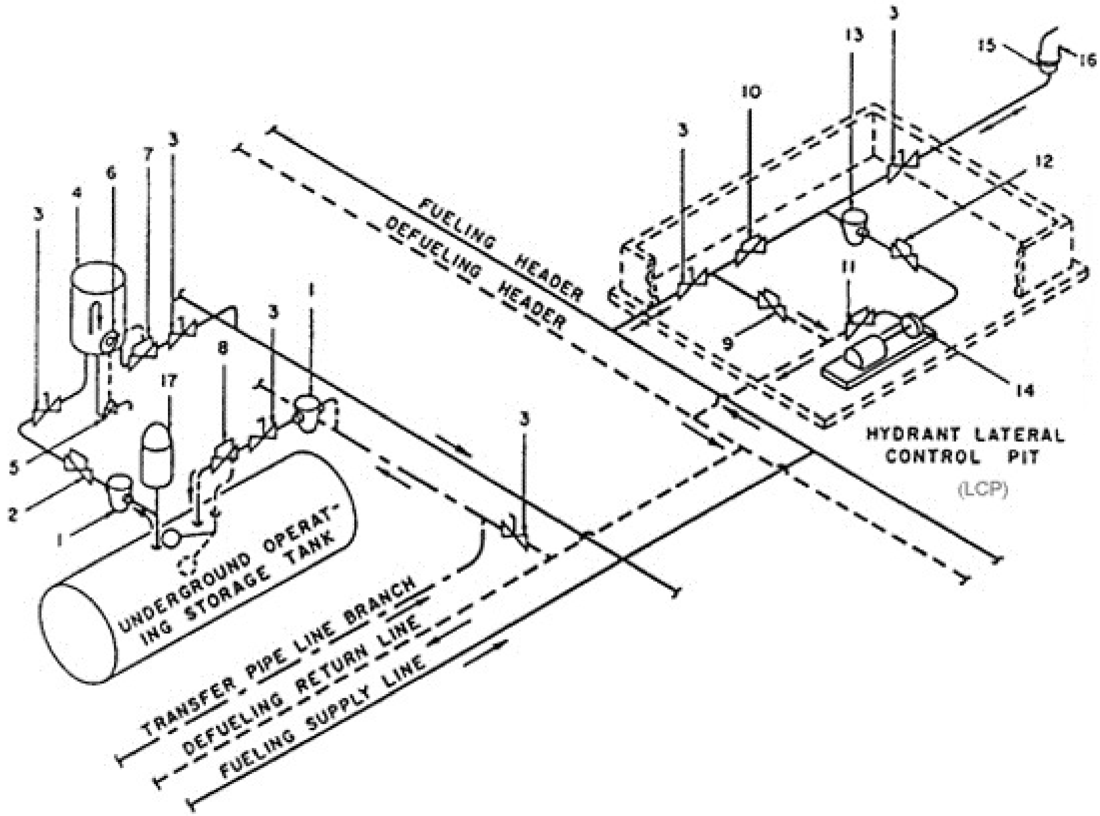
PREVIOUSLY, we learned about the Type I system. Essentially, it is a pump house with four to six hydrant valve pits with one hydrant outlet per lateral pit. In the past, the aircraft was usually towed to the hydrant outlet location, which increased a plane's turnaround time in a high tempo operation. The Panero system was clearly not working for many bases and the mission demanded a system that fit the bill. The design and construction of the Type II hydrant system became the solution.

2–1. Pritchard Hydrant System

The Type II hydrant system, more commonly known as the Pritchard hydrant system, is designed to service up to six hydrant outlets for every LCP. This system usually has two tanks in the immediate storage area for each pit. If there are eight immediate operating storage tanks at the pump house, you will normally have four pits, for a total of up to 24 hydrant outlets. You can see the big advantage this system gives to the base refueling mission—more aircraft can be simultaneously refueled by the hydrant system at 600 gpm without towing.

The pump house of the Pritchard hydrant system is very similar to that used for the Panero system. One major change is the elimination of the extra defueling tank found in most Panero systems. One of the Pritchard's operating tanks is used for defueling an aircraft. The tank used for defueling can be changed daily or on a schedule set up by the hydrant supervisor.

When you get out to the pit of the Pritchard system, you find many differences as indicated by figure 2–1. One of them is its name—the hydrant LCP rather than the filter/meter pit. In this section, we cover the equipment in the hydrant LCP.



ITEM NO.	DESCRIPTION
1	Line Strainer
2	81AF Non-Surge Check Valve
3	Manual Valve
4	Filter Separator
5	*100AF Water Drain Valve
6	*CFF Flanged Float control
7	*40AF-2A Combination Rate of Flow Controller and Automatic Fuel Shutoff valve
8	129AF-1 high Level Shutoff Valve
9	50AF-2 Pressure Relief Valve
1	90AF-8 refueling Control Valve
11	41AF Rate of Flow Control Valve
12	134AF Defueling control Valve
13	Line Strainer
14	Defueling Pump
15	352AF Adapter and Level Control Valve
16	351AF Quick Coupler Valve Located on Hose Cart
17	Deepwell Turbine Pump
	* Part of Fuel and Water Separator

Figure 2–1. Pritchard, Type II hydrant system. (By courtesy of Cla-Val Co.)

407. Type II hydrant system operational features

The LCP of the Pritchard system is different from the filter/meter pit of the Panero system. Four different automatic valves replaced the 302AF valve, and the filter and meter are located on the hose cart. Figure 2–2 shows a typical hydrant LCP. Use this figure as you study the operation of the LCP. One drawback of this system is, even with the added hydrant outlets per LCP and with each LCP being capable of a refuel and defuel function, at any given LCP a refuel and defuel operation cannot occur simultaneously. If aircraft refueling is progressing at one LCP, any defuel operation has to occur at a different LCP. The LCP has three manual valves for isolating pit sections and maintenance and four automatic valves for refueling/defueling operations.

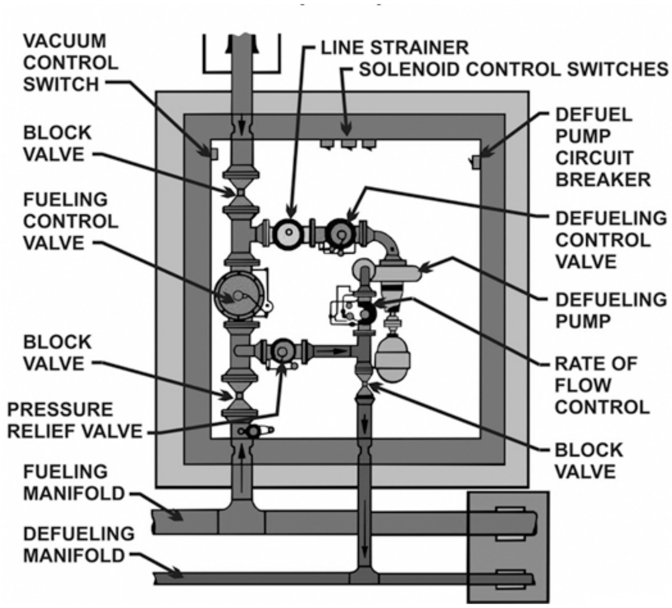


Figure 2–2. Hydrant LCP.

Refueling

When fuel is required at a hydrant outlet, a magnet is placed on the refueling contacts of the magnetic control station, also called the keep it simple, system (KISS) switch, next to the hydrant outlet. This is the same system that replaced the push-button/cable system in the Type I hydrant system. This switch starts the pumps in the pump house and energizes the solenoid on the refueling control valve (RCV) (90AF–8) in the LCP. Fuel enters the pit by way of the fueling manifold and the branch line leading into the pit. Pump pressure and flow passes through a manual valve, reaches the upstream side of the RCV (90AF–8), forces the valve open, then passes through a second manual valve and continues to the hydrant outlet. The manual valves in the LCP are non-lubricated plug valves or ball valves.

During fueling, the 134AF defueling CV solenoid is deenergized, and the valve is held closed. The 41AF rate-of-flow CV on the defuel line will remain closed because the 134AF is doing its job by isolating the defuel line. The 50AF–2 pressure-relief valve relieves any excess pressure from the upstream side of the 90AF–8 to the defuel line.

Defueling

During a defueling operation the 134AF, 41AF, and defuel pump are used, while the 90AF–8 and the 50AF–2 remain closed. When you have to evacuate the hose cart or defuel an aircraft, place a magnet on the defuel KISS switch. This energizes the solenoids on the 134AF defueling CV and the defuel pump. Fuel is then pulled through the line by the defuel pump and forced through the 41AF rate-of-flow CV, through a manual valve and into the defuel line at a rate of 200 gpm.

Three solenoid control switches in the pit isolate the solenoids on the valve; however, after the KISS-switch modification, only two are used: 90AF–8 and 134AF. The defuel pump can be isolated by opening the defuel pump circuit breaker. The remaining control in the pit is the vacuum control switch. It automatically cuts off the defuel pump when a vacuum, sensed in the line between the defuel pump and the hydrant outlet, reaches a predetermined amount of inches of mercury. The defuel pump used in the hydrant LCP is a self-priming, centrifugal pump.

408. Operating the 90AF–8 refueling control valve

The 90AF–8 serves five functions: pressure-reducing control, nonsurge, pressure relief, excess flow shutoff, and ESO. The 90AF–8 valve uses some of the same auxiliary components the 302AF valve uses.

Components

Before you can learn more about automatic valves (also called diaphragm-operated valves), you have to understand the main valve body (fig. 2–3). It is the heart of all automatic valves. Another name for it is “hytrol main valve.” In the figure, note that its stem, disc, and seat are arranged much like the parts of a manual globe valve. It is actually a spring-loaded globe valve of sorts, but it is usually installed so the inlet pressure or flow is over the disc and under the diaphragm. Inlet pressure only acts on the bottom of the disc when the main valve body is used as a relief valve (as in the 50AF–2).

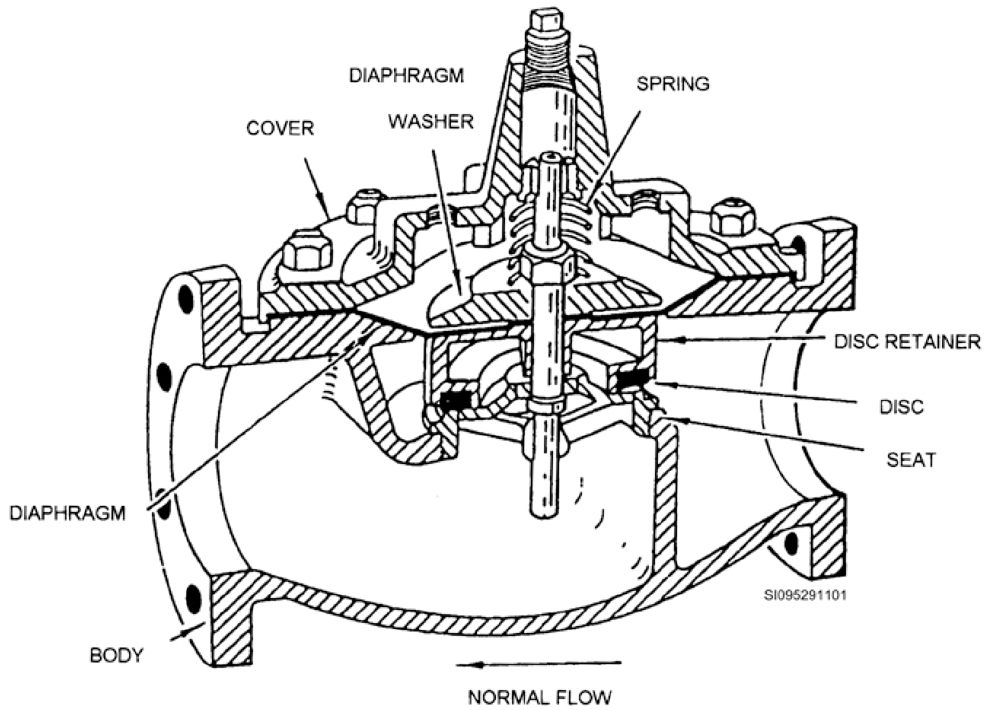


Figure 2–3. Main valve body. (By courtesy of Cla-Val Co.)

While the manual globe valve has a chamber above the disc and another below it, this main valve body has another chamber—the space under the cover and above the diaphragm—*the cover chamber*. The valve’s position is determined by pressure under the diaphragm, pressure over the diaphragm in the cover chamber, and spring tension, which can be OPEN, CLOSED, or MODULATING (in between). The valve opens wide with atmospheric pressure, or less in the cover chamber, and steady line pressure under the diaphragm of more than 3 psi. When cover-chamber pressure is at least as great as the inlet side pressure, the valve closes tightly. The spring tension and the diaphragm assembly weight act together to close it. If the cover-chamber pressure stays between the valve inlet and outlet pressure, the valve modulates.

The main valve body of the 90AF–8 is a diaphragm-type, spring-loaded closed globe valve which opens with incoming fuel under pump pressure. Auxiliary components installed on the valve control the operation of the valve. The 90AF–8 valve is activated, like the 302AF, by an electrical solenoid, but the two solenoids differ in design. The 90AF–8 valve uses a two-port, N.C. solenoid. This electric component used on automatic valves remotely controls the valve. It responds to electric signals from the hydrant outlet’s KISS switch. When it is deenergized, the solenoid closes and traps line pressure, helping keep it closed. The weight of the piston and plunger assembly also helps keep the solenoid closed.

When the solenoid energizes, the plunger rises and lifts the pilot valve. Pressure bleeds from above the piston faster than it builds up through the piston/cylinder wall clearance. The pilot valve continues rising and the piston follows. When the plunger and pilot stem hold the piston fully open, there is full flow through the control loop tubing.

Refueling

For fueling, the 90AF–8 valve has five distinct functions. First, it throttles to maintain constant fuel delivery pressure to the hydrant outlets. Second, it closes quickly to prevent a surge when fuel flowing downstream suddenly stops. Third, the main valve closes quickly when an excess flow condition exists. Fourth, the solenoid provides remote ESO. Fifth, it opens slowly to prevent surges. Figure 2–4 shows the 90AF–8 fueling CV and its auxiliary components; figure 2–5 shows a functional view.

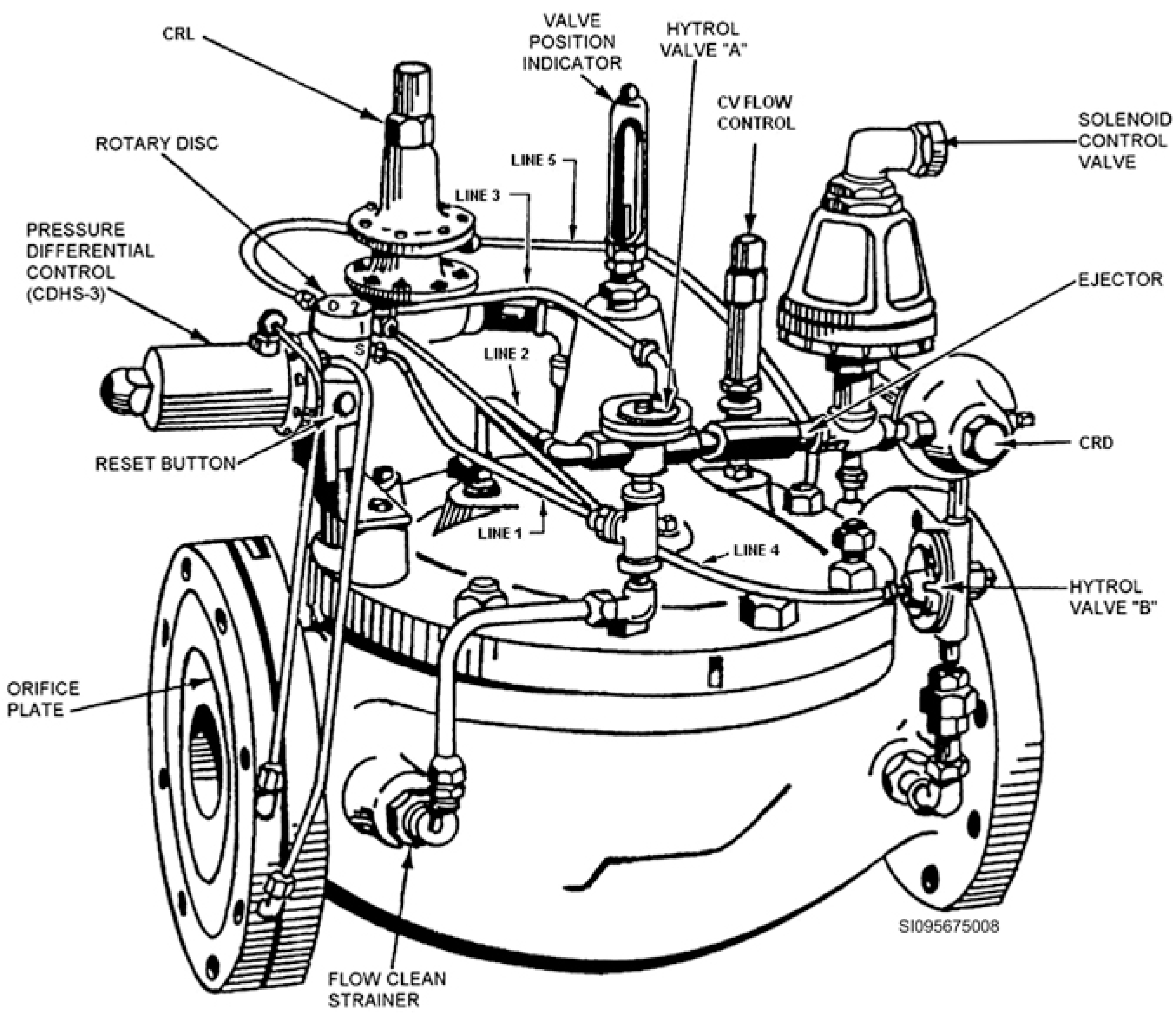


Figure 2–4. Refueling control valve, 90AF–8 (By courtesy of Cla-Val Co.)

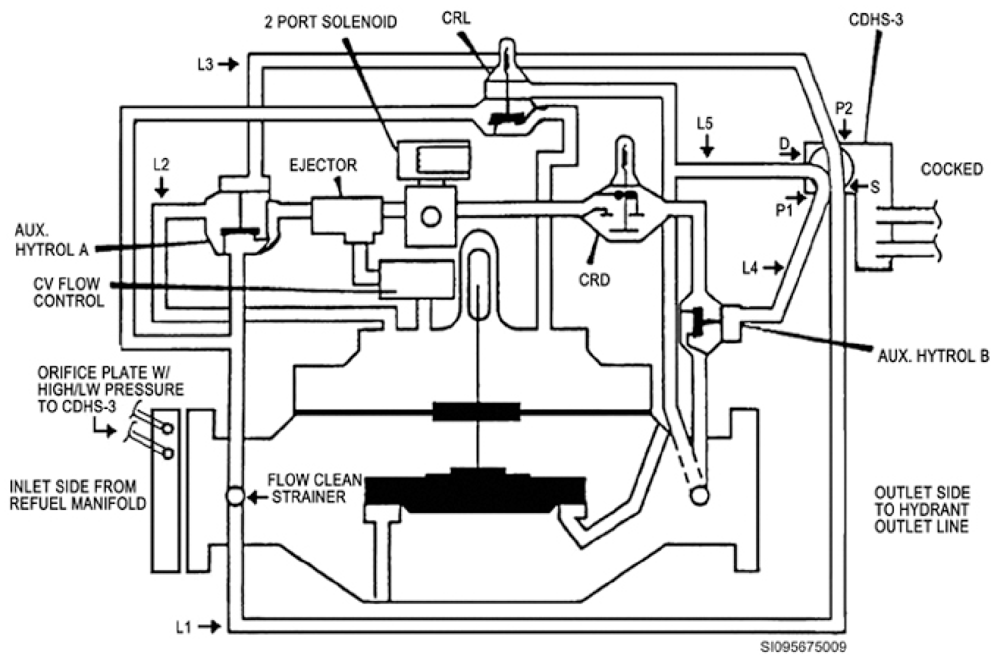


Figure 2–5. Cutaway view, 90AF–8. (By courtesy of Cla-Val Co.)

Since you know the flow sequence of the 302AF valve, you will have little trouble understanding the operation of the 90AF–8 valve. It is important to know each valve's proper flow sequence and operation for testing and troubleshooting. You already know the auxiliary components and the basic principles of how the valve opens. You are now ready to study the valve in detail.

When the KISS switch energizes the solenoid CV on the 90AF–8, the deep-well turbine pump starts. The pressurized fuel enters the control loop tubing through the flow-clean strainer. The control tubing directs the fuel through the auxiliary hytrol A (upstream), ejector, solenoid CV, CRD, auxiliary hytrol B (downstream), and directly into the downstream piping. The pressure downstream builds up, and the CRD takes control by throttling the main valve. Throttling maintains a constant delivery pressure of 100 psi, measured from the farthest hydrant outlet main valve when open and dispensing fuel. Let us look at the two auxiliary hytrols and their purpose. Refer to figure 2–4 as you follow the discussion.

Auxiliary hytrol B (downstream) performs the same function as the one installed on the 302AF, but works together with auxiliary hytrol A in an excess flow condition. The rotary disc assembly of the CDHS–3 is like a railroad track switch that diverts a train from one track to another. However, instead of switching tracks, it switches ports when the CDHS–3 trips. Keep in mind the terms "pump pressure" and "common supply," mean the same thing. While the whole 90AF-8 CV has five lines, the CDHS-3 rotary disk has four ports connecting lines 1, 3, 4, and 5 (fig. 2–4):

- Line 1 attached from the Tee under auxiliary hytrol A to the common supply port (S).
- Line 2 is attached to a discharge port of auxiliary hytrol A to the cover chamber of the main valve (line 2 is not directly attached to the CDHS-3).
- Line 3 attached from the cover chamber of auxiliary hytrol A to port 2.
- Line 4 attached form the cover chamber of auxiliary hytrol B to port 1.
- Line 5 attached from the common drain port (D) and then tees off to the CRL, and to the CRL, then to the downstream side of the main valve.

Under normal refueling conditions, auxiliary hytrol a (line 3) is aligned with the common supply. Since this is a 3-way hytrol and you have pressure in the cover chamber, in this "closed" position, fuel going through auxiliary hytrol A will divert from going into line 2 and directed (to the right in the figure) through the control loop. Line 4 of auxiliary hytrol B is aligned with, or vented to, the common drain and allowed to open under control loop pressure. Therefore, we have:

- Pump pressure → line 1 → common supply port → port 2 → line 3 (auxiliary hytrol A-closed).
- Line 4 (auxiliary hytrol B-open) → port 1 → common drain port → line 5 → main valve discharge.

When there is excess flow at the hydrant outlet, the differential pressure across the orifice plate changes and trips the CDHS–3. Then the ports of the rotary disc realign, directing pump pressure through line 4 and closing auxiliary hytrol B. This prevents pump pressure from escaping out of the main valve cover chamber and backs up the fuel pressure in the control loop through the ejector and onto the cover chamber.

At the same time, line 3 vents through port D (drain) of the rotary disc. This allows auxiliary hytrol A to open and admit pump fuel pressure into line 2, pressurizing the main valve cover chamber. Now we have:

- Pump pressure → line 1 → common supply port → port 1 → line 4 (auxiliary hytrol B-closed).
- Line 3 (auxiliary hytrol A-open) → port 2 → common drain port → line 5 → main valve discharge.

You can see that, when the CDHS–3 trips, fuel pressure is applied from two directions to the valve's cover chamber. This pressure closes the main valve quickly.

Remember that a function of the 90AF–8 valve is to close quickly and prevent a surge when the flow of fuel downstream stops suddenly. The auxiliary component that does this is the CRL. This is the same type of unit used on the 302AF valve. The CRL senses delivery pressure through line 5 and is set to open when the delivery pressure increases to 5 psi above the 90AF–8's NOP. When delivery pressure rises faster than the CRD valve can react, the CRL opens, sending pump pressure into the cover chamber of the main valve and closes it. You can tell when the main valve is closed by the height of the valve stem in the valve position indicator (VPI) (fig. 2–6).

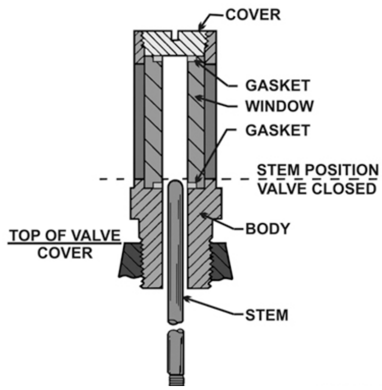


Figure 2–6. Valve position indicator (VPI). (By courtesy of Cla-Val Co.)

409. Inspecting and adjusting the 90AF–8

Every 3 months, inspect the 90AF–8 for leaks, external damage, and for the proper operation of its five functions. There are also four adjustments you make: pressure reducing setting, pressure-relief setting, excess flow shutoff, and the main valve-opening rate. We only discuss the pressure setting of the pressure-reducing control and pressure-relief control. Adjustments for the CDHS–3 and CV flow control are the same as those for the 302AF valve.

Adjusting and repairing

Set the pressure-relief control 5 psi higher than the pressure-reducing control to make sure the main valve closes quickly if downstream flow stops abruptly. With the pressure-relief control bottomed, start the pump and establish a downstream pressure of 5 psi above the NOP. Slowly back off the CRL until the pressure gauge (at the hydrant outlet) starts to drop and the jam-nut locks. Now, slowly back off the CRD until you get the right delivery pressure. Stop the pump; start it again to be sure it holds this pressure. Close the downstream manual valve to test the CRL. The CRL should open and close the main valve.

If fuel is coming out of the cover vent port or if you cannot make the appropriate adjustments, you must take the components apart and replace parts, if necessary. Damaged diaphragms, O-rings, and a misaligned spring can cause problems.

Control switches and solenoid valves

When a solenoid on an automatic valve fails to operate, it is not always the fault of the solenoid. Each solenoid valve has a control switch that must be in the ON position; otherwise, the solenoid is not energized. First, check the position of the switch. If the switch is inoperative due to internal damage, replace it. When the pump house is set up and the switch is activated to energize the solenoid, the solenoid should click. Ice accumulation can prevent the magnet from activating the magnetic switch. If the switch is on and the pump starts but the solenoid does not click, the problem is most likely the solenoid and it must then be replaced.

410. Operating the 50AF–2 pressure-relief valve

This CV (fig. 2–7) operates automatically to relieve excessive pump pressure from the fueling line and to keep a constant inlet pressure to the 90AF–8 valve. The 50AF–2 is set to relieve pressure at 10 psi above the normal inlet pressure (NIP) of the 90AF–8. It has two auxiliary components in its control loop—the strainer orifice and the CRL.

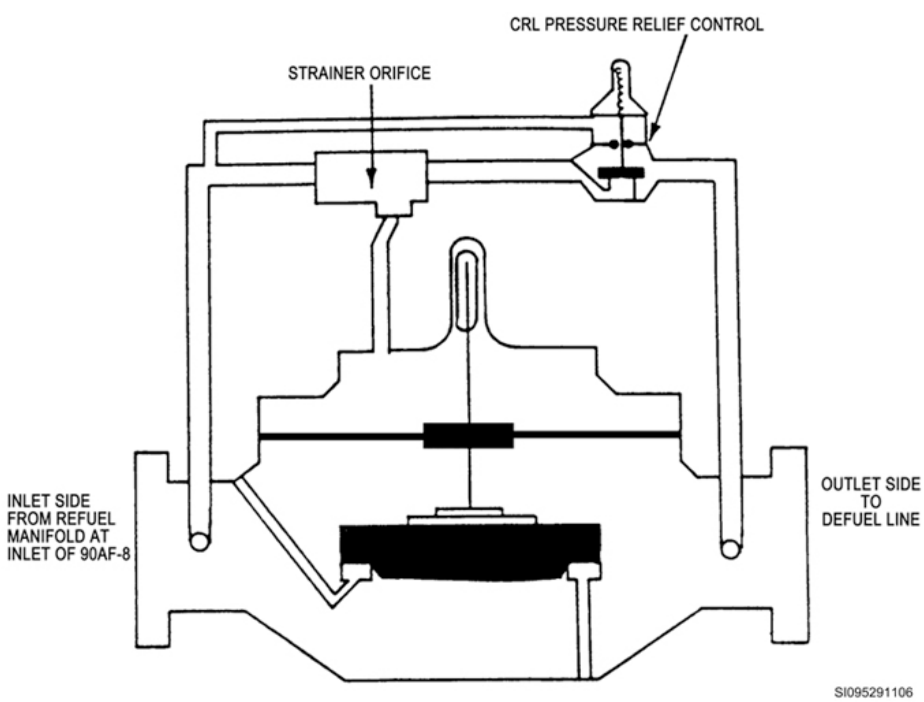


Figure 2–7. Pressure-relief valve, 50AF–2. (By courtesy of Cla-Val Co.)

Strainer orifice

The strainer orifice functions like the ejector-strainer on the 302AF valve but is more efficient. It is important that the cover chamber evacuate quickly and efficiently when the valve must open. The strainer orifice provides this efficiency, whereas the ejector-strainer cannot. Note the similarity between the strainer orifice in figure 2–8 and an ejector-strainer (fig. 1–7 [as previously shown in unit 1]). The operation is the same; but the construction is different. On the strainer orifice, only the primary jet can be removed. The secondary jet is part of the body. Fuel enters port A, goes through a screen, and discharges through port C. Port B is the suction port that connects to the main valve cover chamber. The inspection and maintenance is the same as for the ejector-strainer. The primary jet also uses an O-ring and a gasket you may need to replace periodically.

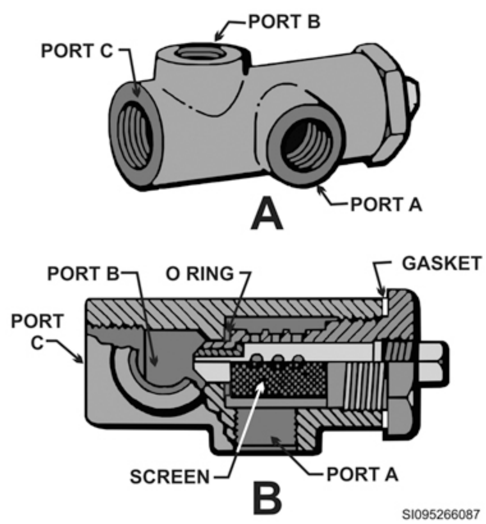


Figure 2–8. Strainer orifice. (By courtesy of Cla-Val Co.)

CRL

The second auxiliary component is the CRL. It is the same type as those used on the 90AF–8 and the 302AF valves. It allows the 50AF–2 to open when the inlet pressure exceeds the CRL setting. The 50AF–2 is N.C. when the fuel system is functioning properly. Spring force holds the pressure control closed until fuel pump pressure in the sensing chamber (on the underside of the diaphragm) exceeds the spring setting. With no fuel flow, fuel pump pressure is directed to the cover chamber of the main valve, holding it closed.

Assume that the fueling line pressure slightly exceeds the CRL setting. Naturally, the CRL opens partway. This permits limited fuel flow through the control system to the discharge side of the 50AF–2. This increase in velocity (speed) through the strainer orifice causes a slight drop in cover chamber pressure. The 50AF–2 valve opens partially to relieve the pressure. When the fueling line pressure fluctuates, the position of the CRL moves to correspond to this change in pressure. In fact, by the slight opening and closing action of the CRL, the fueling line pressure closely holds a constant pressure.

Modulating this way, the 50AF–2 ensures fuel delivery through the 90AF–8 is smoother. This smoothness is important. A sudden surge of pressure across the orifice plate, if great enough, can trip the CDHS–3 on the 90AF–8 and stop the fuel flow. The setting on the CDHS–3 is very sensitive to pressure surges. When the 90AF–8 valve closes because of excess flow, the 50AF–2 opens wide when the pressure reaches 10 psi above NIP and relieves the pump pressure. After the CDHS–3 is reset, the 50AF–2 closes or modulates, depending on how high the pump pressure remains.

The main valve body of the 50AF–2 is installed with the flow under the disc so the valve opens even if the main valve diaphragm ruptures. Thus, we sometimes speak of it as a fail-safe valve.

411. Inspecting and adjusting the 50AF–2

A large part of your job requires inspecting and adjusting components. These tasks are imperative for maximum system performance and longevity.

Inspecting

Twice each year (semiannually) you must inspect the 50AF–2 for leaks and the general condition of its components. Also, check the valve to assure it is opening and relieving pressure.

Test the 50AF–2 valve by closing the manual valve downstream of the 90AF–8 and electrically isolate the 90AF–8 solenoid by turning off the solenoid switch, which is located on the pit wall. Place the magnet on the refuel KISS switch to energize the deep well turbine pump in the pump house (the 90AF–8 will not open because the solenoid is isolated). Observe the 50AF–2 valve position indicator to make sure the valve's CRL is opening at its standard setting of 10 psi above the 90AF–8's normal refueling inlet pressure. You should repeat this test five times to make sure it operates properly. As always, the last thing you must do is to return the system to its original condition.

Adjusting

If you test the valve, as we described in the paragraph above, and discover that the CRL on the 50AF–2 is not set correctly, then you must adjust the settings.

The first thing you must do is observe and record the 90AF–8's inlet pressure during normal refueling. Before adjusting the 50AF–2, you must close the manual valve downstream from the 90AF–8. Electrically isolate the 90AF–8 solenoid at the solenoid control switch, which is located on the pit wall. This ensures the pump pressure is full at the inlets of the 90AF–8 and the 50AF–2. Now remove the seal and cap from the 50AF–2 CRL. Before starting the deep-well turbine pump, turn the adjusting screw clockwise until the CRL has maximum spring tension. Start the deep-well turbine pump by placing the magnet on the refuel KISS switch. Now, both automatic valves are closed. Then, turn the CRL adjusting screw counterclockwise until the inlet pressure gauge reads at the desired pressure setting. The pressure setting on the 50AF–2's CRL may differ from base to base, but the standard is 10 psi above the 90AF–8 NIP. Always check with your supervisor or trainer for specific pressure settings at your base.

Once the 50AF–2 pressure-relief valve is adjusted, you must check its operation by testing the valve as we explained above. After you adjust the 50AF–2, replace the CRL cap and secure it with a seal.

412. Operating and maintaining the 134AF defuel control valve

In this lesson we will discuss the functions of the 134AF defueling CV and the quarterly inspections.

Functions

The 134AF defueling CV (fig. 2–9) is the simplest valve in the LCP. Its components consist of a flow-clean strainer, ejector, solenoid, and valve position indicator (VPI). The 134AF has only one purpose: to open or close the defuel line. During refueling, the solenoid is deenergized, directing pressure to the top of the main valve, holding it closed. When you place a magnet on the defuel KISS switch, the solenoid on the 134AF is energized and fuel passes through the ejector and solenoid. The valve then opens wide. The 134AF functions as a remote-controlled block valve and requires no adjustment.

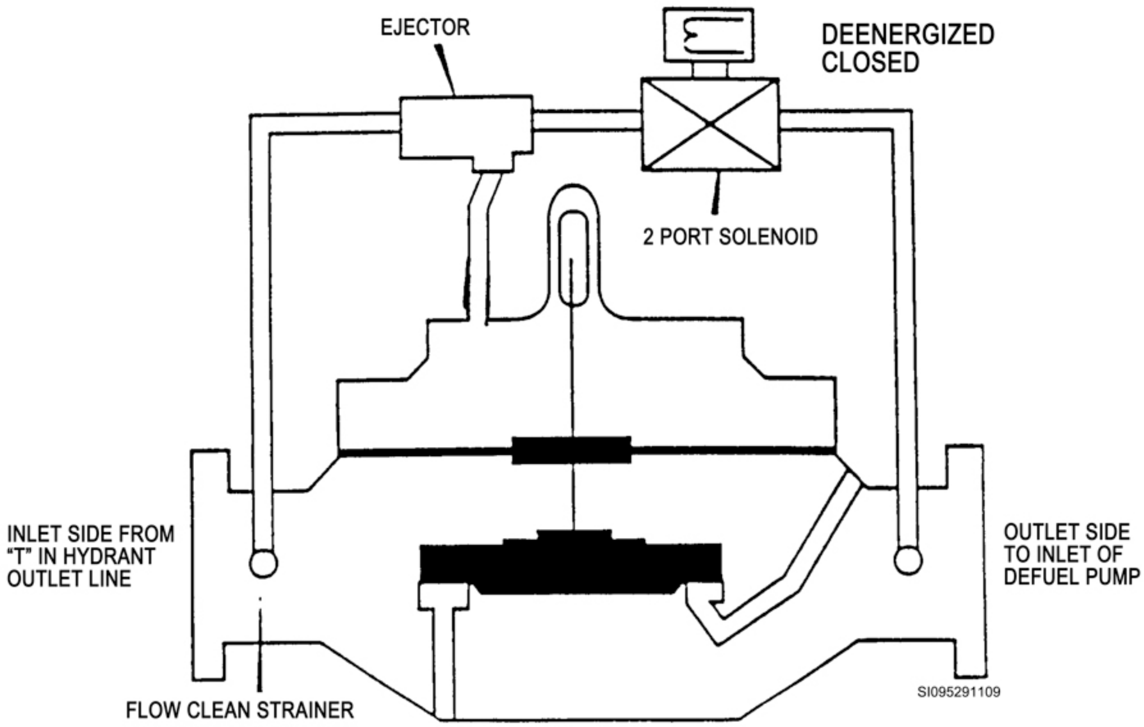


Figure 2–9. Defueling control valve, 134AF. (By courtesy of Cla-Val Co.)

Inspecting 134AF

Inspect the 134AF valve quarterly by checking for leaks and the general condition of the components. Also, ensure the valve opens while defueling and remains closed during refueling.

413. Operating and maintaining the 41AF rate-of-flow control valve

The 41AF rate-of-flow CV is similar to the 40AF–2A F/S discharge valve, but it has some new components and functions.

Functions

The 41AF rate-of-flow CV has two distinct functions in the LCP. The first is to hold the flow rate through the defuel pump, during defueling, at 200 gpm. The second function is to act as a check valve by preventing fuel from flowing in reverse from the downstream defueling piping when the 50AF–2 opens during refueling.

Refer to figure 2–10 for the following discussion. The pressure-differential control (CDHS–2) enables the 41AF to control the rate of flow through the defuel pump during defueling. The CDHS–2 senses the differential pressures across the orifice plate assembly through the L.P. and H.P. lines. Spring tension holds the CDHS–2 valve open similar to a CRD. Low and high pressures from the orifice plate assembly regulate the CDHS–2 unit's opening and closing. The CDHS–2 causes the main valve to throttle like a pressure-reducing valve. When the CDHS–2 closes slightly, the movement puts pressure back on the cover chamber of the main valve. When the CDHS–2 changes position, accordingly, the position of the main valve changes to control the fuel flow rate.

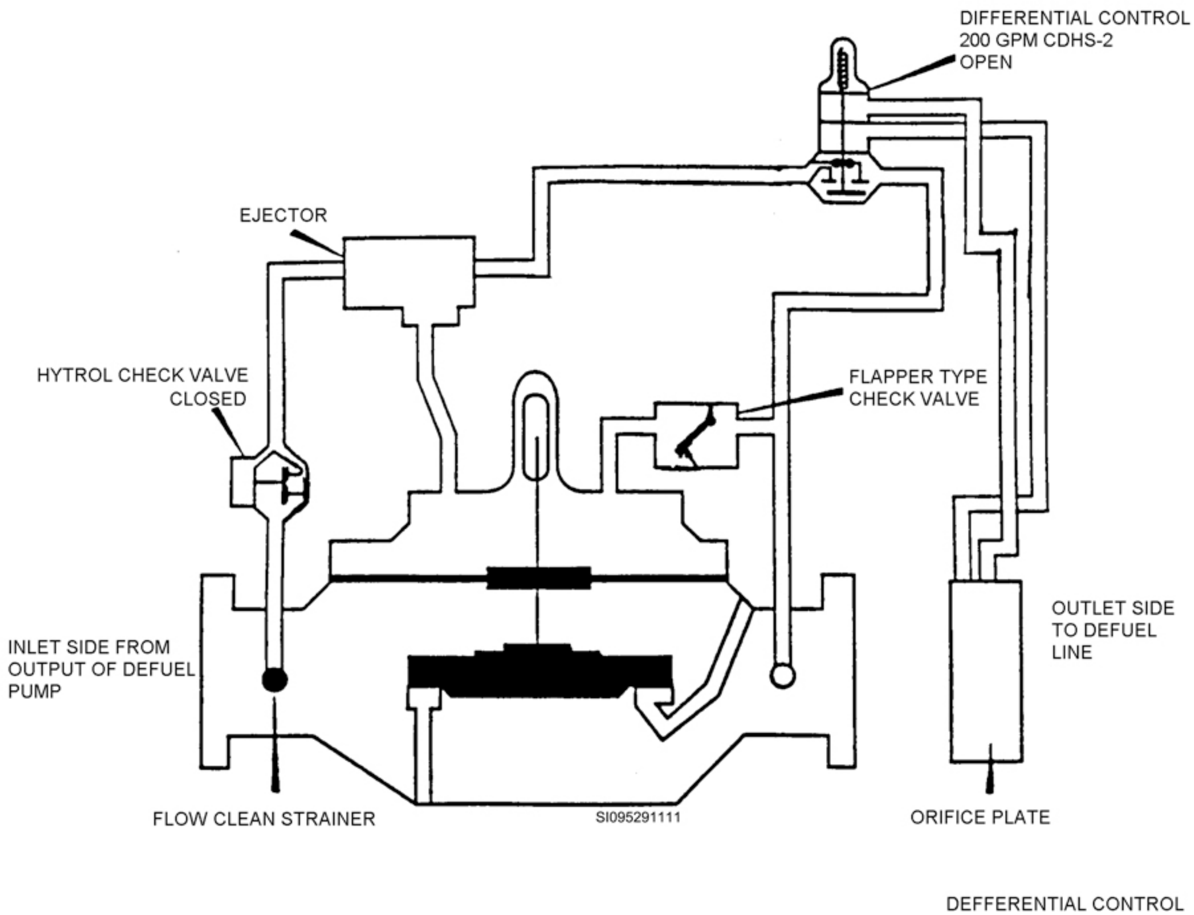


Figure 2–10. Defuel rate-of-flow control, 41AF. (By courtesy of Cla-Val Co.)

You start the defuel pump by placing the magnet on the defuel KISS switch at the hydrant outlet. The solenoid on the 134AF energizes, allowing the defuel valve to open. Pump pressure enters the control loop of the 41AF valve and opens the hytrol check valve (fig. 2–11). Fuel flows through the ejector, then through the CDHS–2. The CDHS–2 takes complete control of throttling the main valve to maintain a 200 gpm flow rate.

If the fuel flow is reversed from the defuel piping (50AF–2 relieving excess pressure), the swing-type check valve opens and directs pressure to the 41AF cover chamber, closing the main valve and protecting the defuel pump by preventing it from running backwards. The hytrol check valve closes to keep pressure from escaping the cover chamber. This valve appears in figure 2–11. When outlet pressure exceeds inlet pressure, the outlet pressure is applied to the top of the diaphragm through the drilled passage in the body, closing the hytrol check. When inlet pressure is greater, it forces the diaphragm and disc assembly up to open the hytrol check valve. Fuel in the cover chamber is forced out through the drilled passage.

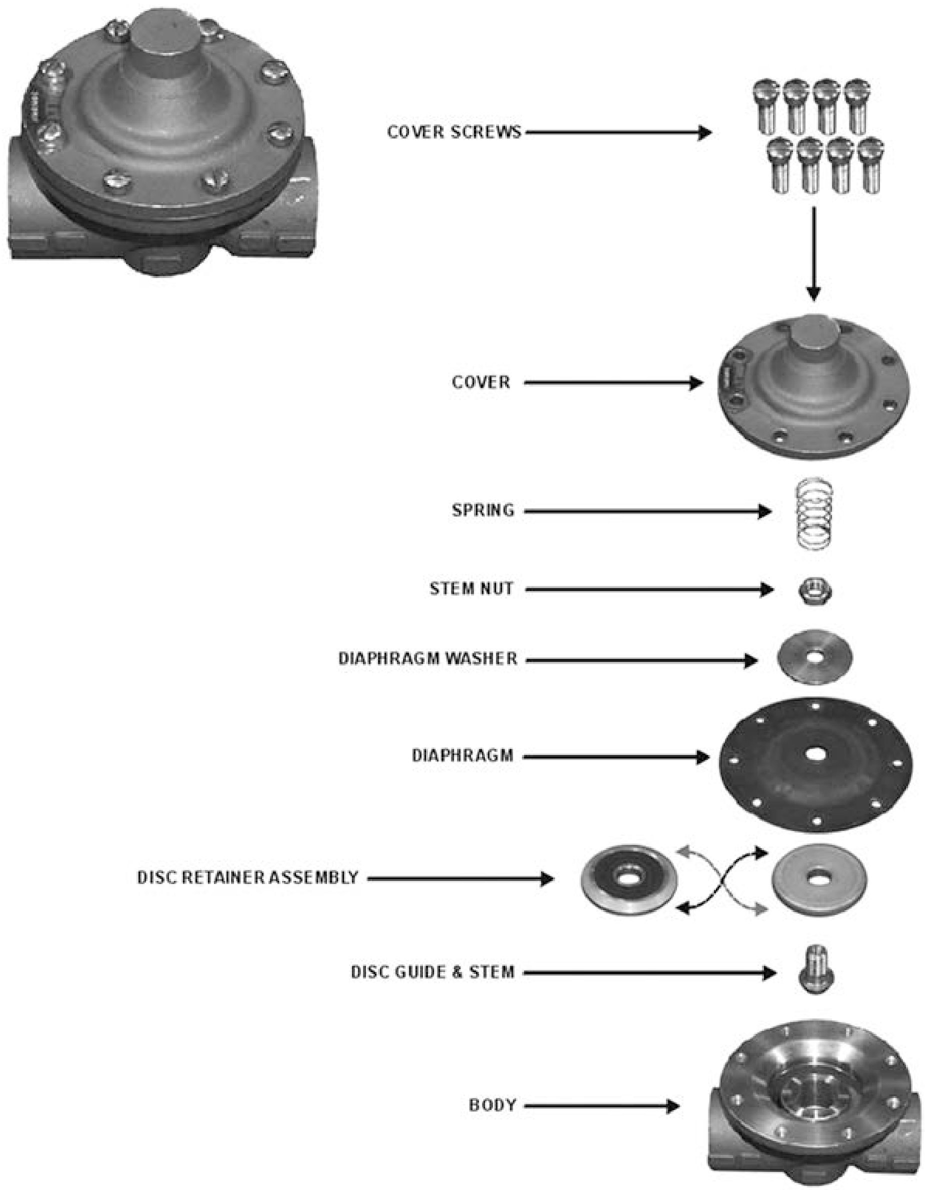


Figure 2–11. Hytrol check valve.

The 41AF valve, which you will learn about later, is used in the modified Type II hydrant system and becomes the 41AF–10. The only difference between the two valves is a solenoid installed in the downstream control tubing after the CDHS–2.

Inspecting and adjusting

You must inspect the 41AF valve for leaks and the components' general condition quarterly. Check the defueling operation of the valve and the operation of the check valve function.

With no pressure on the system, set the CDHS–2 differential pressure control. To do this, you must back off (turn counterclockwise) the adjusting screw on the CDHS–2 until it has minimal spring tension. Then turn the adjusting screw clockwise in two complete turns to obtain the lowest rate-of-flow setting on CDHS–2. *Never apply pressure to CDHS–2 if the adjusting screw has less than this two-turn setting.* Connect a fueling truck and hose cart to the hydrant outlet. Place the magnet on the defuel KISS switch. The defuel pump and the solenoid on the 134AF are now energized. Turn the adjusting screw clockwise on the differential control until you obtain a 200-gpm flow rate. Remove the magnet from the KISS switch and return the system to original condition.

Self-Test Questions

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

407. Type II hydrant system operational features

1. How many automatic valves are located in the LCP of the Pritchard system?

2. At the hydrant outlet, what is used to start the pumps in the pump house and energize the solenoid on the RCV in the LCP?

3. During refueling, which refueling valve does the fuel have to pass through to reach the hydrant outlet?

4. What types of manual valves are used in the LCP?

5. Which of the four automatic valves in the LCP are used during defueling?

6. How can you isolate the defuel pump?

7. What LCP component cuts off the defuel pump when the vacuum in the line between the defuel pump and the hydrant outlet reaches a predetermined setting?

8. What type pump is used in the LCP for defueling?

408. Operating the 90AF–8 refueling control valve

1. What five functions does the 90AF–8 RCV serve?

2. What type manual valve is similar to the automatic main valve's body stem, disc and seat?

3. How are the positions of an automatic valve determined? What are those positions?

4. Match each 90AF–8 RCV function in Column A with the appropriate components in Column B. Each component in Column B may be used more than once.

Column A	Column B
____ (1) Throttles the valve, maintaining constant delivery pressure.	a. Solenoid.
____ (2) Prevents downstream surges when fuel flow is suddenly stopped.	b. CRD.
____ (3) Trips when an excessive flow condition exists.	c. CDHS–3.
____ (4) Provides a remote ESO.	d. CRL.

409. Inspecting and adjusting the 90AF–8

1. What should you inspect on the 90AF–8 every three months?

2. List the adjustments required on the 90AF–8.

410. Operating the 50AF–2 pressure-relief valve

1. What component opens the 50AF–2 valve very quickly and efficiently?

2. Which component on the 50AF–2 valve allows the main valve to open once inlet pressure is exceeded?

3. What happens to the 50AF–2 valve if the CDHS–3 on the 90AF–8 valve trips due to pressure surges?

4. Why is the 50AF–2 valve installed with the flow under the disc?

411. Inspecting and adjusting the 50AF–2

1. How do you test the 50AF–2 pressure-relief valve?

2. What *must* you observe and record before adjusting the 50AF–2?

3. Which manual valve must you close before adjusting the 50AF–2?

4. Before starting the deep-well turbine pump, what must you do to the adjusting screw on the 50AF–2 CRL?

5. What is the standard for adjusting the 50AF–2 CRL? Who do you check with for specific pressure settings at your base?

412. Operating and maintaining the 134AF defuel control valve

1. How does the defueling CV operate?

2. What would you inspect on the defuel CV?

413. Operating and maintaining the 41AF rate-of-flow control valve

1. What are the two distinct functions of the 41AF rate-of-flow CV?

2. Which component on the 41AF maintains the defueling rate of flow through the defuel pump?

3. What is energized when you place a magnet on the magnetic defuel (KISS) switch? What flow rate is then established?

4. Which two components on the 41AF work together to prevent reverse fuel flow?

5. How does the hytrol check allow fuel to pass through in one direction but closes in the other direction?

6. How often is the 41AF inspected?

7. Explain how to adjust/set the CDHS–2.

2–2. Hydrant Outlet

The hydrant outlet pit and the electrical control station in Pritchard fuel systems differ considerably from those in the Panero fuel systems. The Pritchard pit is much larger and has a heavy metal hinged plate as a protective cover. The pit cover is strong enough to withstand the weight of a vehicle or an aircraft passing over it. The original pit cover also has two hydraulic actuators to control the closing speed and to assist in opening. The hydrant adapter installed on the riser pipe is normally a Clayton Valve (Cla-Val) 352AF unit. It is entirely different from the adapters used in the Panero system.

414. Hydrant outlet constructional features and maintenance

In this lesson we will discuss the construction features of the 325AF hydrant adapter. The last topic will be the magnetic control switch for the Pritchard fuel system.

352AF hydrant adapter and level control valve

This type of hydrant adapter (fig. 2–12) has two functions. First, like other hydrant adapters, it provides a quick, leak-free connection between the installed piping and the portable hose equipment. Its second function is to control its own fuel level when defueling stops. This keeps air from entering the installed piping system. The 352AF is designed only for use with the 351AF, which is a quick coupler attached to the portable hose equipment (MH–2 hose cart). A rod in the coupler actuates the poppet valve. The valve only opens when the coupler is securely fastened in place, ready to receive fuel.

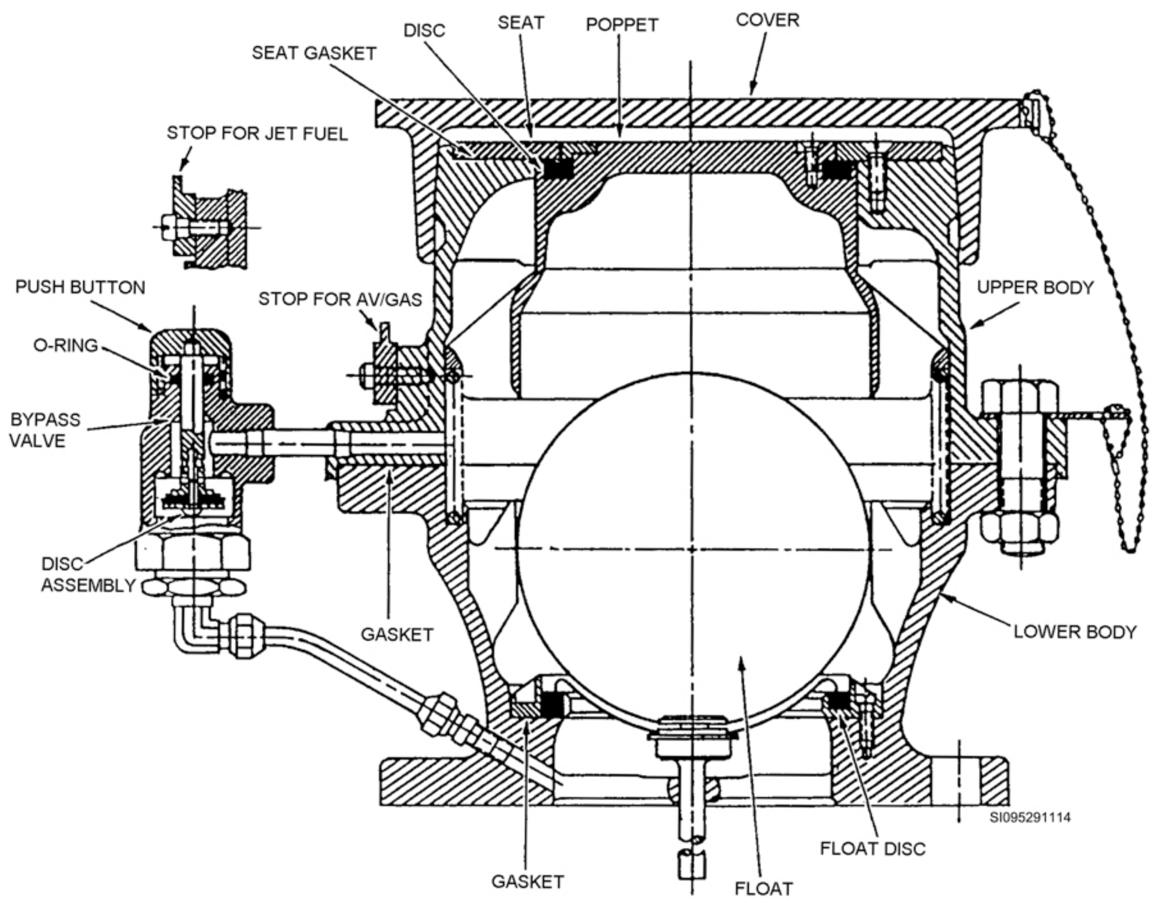


Figure 2–12. Hydrant adapter and level control valve, 352AF. (By courtesy of Cla-Val Co.)

In fueling, turn the valve lever on the coupler to the OPEN position. This opens the poppet valve on the adapter. When fuel pressure is applied to the adapter float assembly, the float lifts off its seat and permits fuel to flow. A combination of buoyancy and velocity forces keep the float up (open) at all flow rates.

To defuel with the 352AF, the valve chamber must be full to lift the float ball. This opens the automatic bypass valve that is part of the float assembly. When fuel pressure on both sides of the float is equal, the entire float assembly rises. If the pressure is not equal (if there is greater pressure above than below the float), fuel flows through the automatic bypass valve until the pressure equalizes. The automatic bypass valve opens at a maximum differential pressure of 35 psi. This allows the float to lift and permits defueling. The defuel pump must not be started until the pressure has equalized or the float will be held tightly against its seat. Usually, the pressure equalizes almost instantly. Some adapters may also have a manual bypass valve installed as a backup in case the automatic bypass valve fails.

Defueling stops before any air can enter the piping system. When the fuel level drops in the 352AF adapter, the float assembly closes. Then the defuel pump starts pulling a slight vacuum in the lateral piping. Do you recall the vacuum control switch (see fig. 2–2) mounted on the pit wall? This switch has a sensing line that taps into the defueling line just downstream of the 90AF–8. The only purpose of the vacuum control switch is to stop the defuel pump motor. It also has two adjustment settings (high and low). The switch is wired into the defuel pump motor control circuit.

When the vacuum created by the defuel pump reaches the high setting of the vacuum control switch, the switch opens. This opens the electrical control circuit to the pump motor. The pump motor cannot restart until the vacuum in the lateral piping drops to the low adjustment setting on the vacuum switch. Now you know how the 352AF controls the fuel level in the lateral piping.

Almost all of the maintenance on the 352AF involves at least a partial valve disassembly. When you work on the 352AF, be sure to close the manual valve downstream of the 90AF–8 in the LCP. All parts on the 352AF are easy to replace. Remove the cover and seat to replace the seat gasket. This disc is a common leaking point, so also remove the poppet to inspect and replace the fuel resistant Buna-N or Viton disc. Remove the upper body to replace the gasket between the upper and lower body and to inspect the float. The adapter must be disconnected from the piping when you replace the float disc and the gasket beneath it the float. Be careful with the internal poppet spring while you are disassembling the upper and lower body halves. When reassembling, be sure that both ends of the spring completely engage the mating grooves.

When repairing the valve, remember a faulty O-ring on the valve stem can cause leakage from the manual bypass valve pushbutton. The O-ring must be replaced. Also, remember that if the float disc does not seat right, air will enter when the fuel level drops below the float. This, in turn, prevents the defuel pump from shutting off automatically.

As you look at figure 2–12, notice that there are two stops, one for jet fuel and the other for aviation gasoline (AVGAS). A 352AF equipped with a jet fuel stop cannot be connected to a hose coupling (351AF) used for AVGAS. When you replace a 352AF, make certain that you have the right type of stop installed. Check it before you install the stop. If necessary, remove and use the stop from the faulty 352AF. If you find one of these stops broken, replace it at once.

Remote magnetic controls

The Pritchard fuel system uses a magnetic control (KISS) switch to operate the system. It is a sealed, weatherproof, magnetic switch. It requires a portable magnet on a lanyard cord to activate the switch. The emergency-stop switch is also a magnetic switch. The cover for the emergency-stop switch has a magnet built into the switch cover.

After the pump house is set up to operate properly, place the magnet on the refuel or defuel KISS switch to energize the pump you wish to use. The horseshoe magnet may have a small hole that a cord or lanyard attaches through (a small nylon parachute cord is recommended) to quickly remove the magnet, which then stops the pump immediately.

The emergency-stop switch is normally a closed circuit. To activate (or operate) it, lift the emergency-stop cover and release. After the emergency-stop circuit is broken, a manual reset is required at the pump house control room. Establish standard operating procedures (SOP) to deactivate the pumps at the pump house when the system is not in use. This keeps unauthorized personnel with a magnet from starting the refuel or defuel pump when the system is not in use.

Maintaining these magnetic controls consists primarily of keeping the switch plates free of debris, water, and ice. If the magnetic switch fails, just pry the switch plate loose with a suitable tool, and pull the wires up through the threaded hole until you can cut off the butt connections and strip the insulation. Test the new switch plate assembly with an ohmmeter and magnet before you install it. Attach the test leads to the magnetic switch wires. Place a magnet on the KISS switch then test it with an ohmmeter. The ohmmeter should read zero. When you remove the magnet, the ohmmeter should read “OL” (open lead). Connect the wires with a crimped-on butt connector and clean the sealing surface on the receptacle with sandpaper or scrapers to remove all the old sealer. Apply new sealer similar to the originally installed switch. Firmly push the switch unit into the receptacle opening and hold it there until the adhesive seal cures (securely fastens).

Grounding

The hydrant outlets are grounded to a galvanized or stainless steel ground rod. Tie-down anchors are used as grounding rods. They are $^{5}/_{8}$ inch in diameter and at least 8 feet long. Drive the top of the rod 2 inches below the surface of the apron pavement. To provide access for attaching the flexible grounding cables, cup out the surface of the pavement around the rod.

Only tie-down anchors actually used and approved as ground rods are identified as approved static ground connections. They are identified by the month and year painted in 3-inch letters on the pavement adjacent to the grounding point. These static ground connections are usually located between the outlet pit and the electrical receptacle box. The lateral piping and electrical conduit are connected to the static ground with $^{3}/_{32}$–inch stainless steel wire rope with a nylon cover. If the piping system has cathodic protection, however, the piping is *not* connected to the static ground. The static ground rods are connected to metal reinforcements buried deep in the concrete of the apron. Everything is interconnected to provide good dissipation of static electrical charges from aircraft and fuel equipment.

Self-Test Questions

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

414. Hydrant outlet constructional features and maintenance

1. What are the two functions of the 352AF adapter?

2. What coupler *must* be connected to the 352AF to open the adapter?

3. What allows the float in the hydrant adapter to rise (lift off its seat) and stay open to allow fuel to flow?

4. What 352AF constructional feature allows pressure to equalize if the pressure above the float is greater than the pressure below the float?

5. What happens if the defuel pump starts before the pressure on either side of the float is equalized?

6. When defueling stops, what feature of the 352AF prevents air from being drawn into the piping system?

7. During defueling, the fuel level drops in the 352AF adapter. Briefly explain what happens to the system when the defuel pump is still running.

8. Which part(s) of the 352AF adapter must be removed to replace the disc?

9. What *must* you replace if you notice leakage around the push button on the bypass valve?

10. What component on the hydrant adapter ensures jet fuel is not dispensed to a reciprocating, AFGAS aircraft?

11. How do you operate the magnetic emergency-stop switch?

12. How do you test the new magnetic switch plate assembly?

13. What are the hydrant outlets grounded to?

14. How are approved static-ground connections identified?

15. What two items, at the hydrant outlet, are connected to the approved static ground, and what type of cable is used to make this connection?

16. What would be different about the grounding of the hydrant outlet if the piping has cathodic protection?

2–3. Modified Pritchard

A modification to the Pritchard system was necessary to increase its defueling capability due to tighter flying and maintenance schedules for the KC–135 tankers and other large aircraft. Many Pritchard systems were modified from their original 200 gpm (maximum) defueling capacity to defuel flow rates above 300 gpm. The new defueling procedure requires the use of an aircraft pump unit (APU). The APU pumps the fuel from the aircraft to the LCP and into an operating storage tank. The pump gets hydraulic power from one aircraft engine operating at an idling speed. The defueling pump in the LCP is only used to evacuate the hose cart.

415. Operating the 51AF–4 rapid defuel valve

In this lesson we will discuss the modification to the Pritchard LCP and the components to the 51AF–4 and 50AF–2 valves.

Type II modification

Compare figure 2–2 with figure 2–13, which shows the modified Pritchard LCP. The change removes the 134AF defueling CV and installs a pipe tee in its place. A bypass line with a 51AF–4 is installed around the defueling pump and is manifolded into the line just downstream of the 50AF–2.

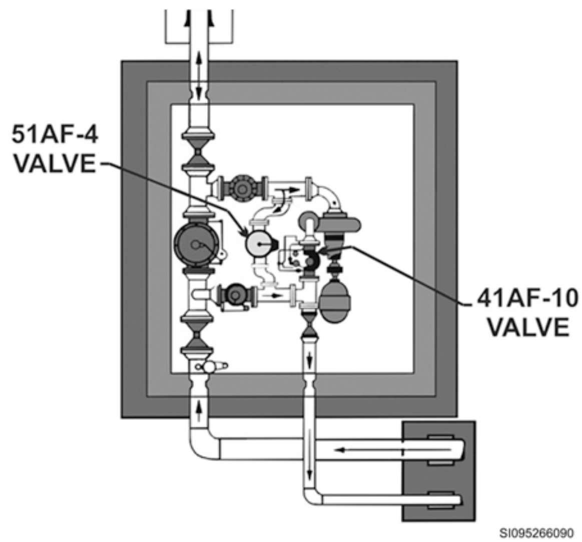


Figure 2–13. Modified Pritchard system LCP.

The 134AF electrical solenoid is installed just downstream of the 41AF's CDHS–2 to convert it to a 41AF–10 valve (fig. 2–14). The solenoid is energized open, along with the defuel pump, when a magnet is placed on the defuel KISS switch. The 41AF–10 keeps the same semiannual inspection frequency as the 41AF. Since we have already covered the 41AF in detail, and the 41AF–10 is nothing more than a 41AF with a solenoid installed in the control loop, we will not discuss it again in this lesson.

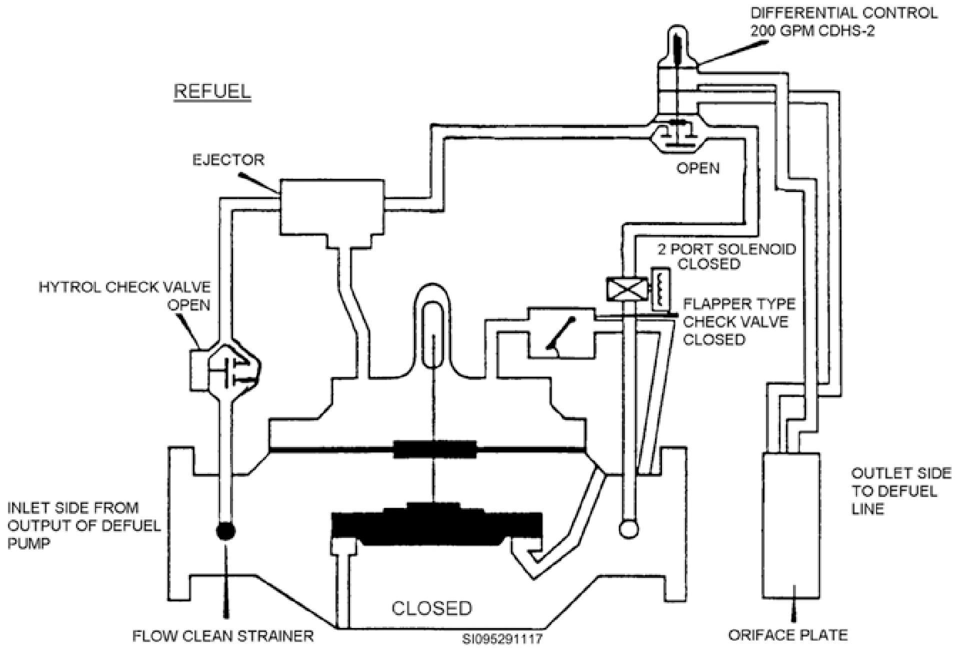


Figure 2–14. Combination rate-of-flow and solenoid shutoff valve, 41AF–10. (By courtesy of Cla-Val Co.)

51AF–4 components and operation

The 51AF–4 valve is actually the 134AF valve body with new auxiliary components mounted on it. When the 134AF valve is removed from the piping, it is stripped of all auxiliary components. New components are added to the body to convert it to a 51AF–4 valve. The 51AF–4 is installed the same way as the 50AF–2, with fuel flow under the disc. Figure 2–15 shows the 51AF–4 valve.

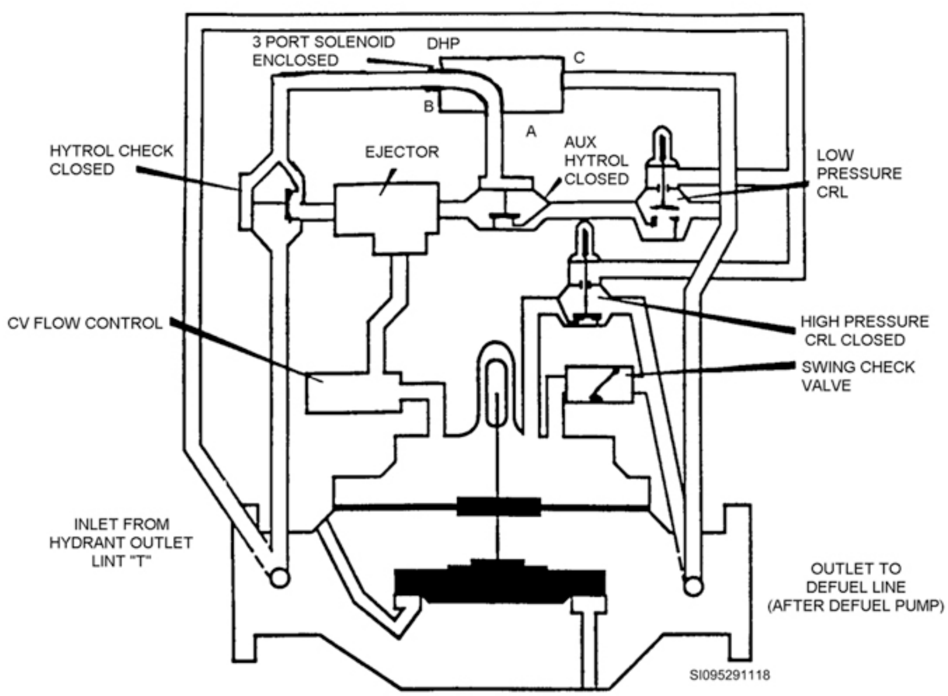


Figure 2–15. Rapid-flow defuel (solenoid deenergized), 51AF–4. (By courtesy of Cla-Val Co.)

Let us look at the 51AF–4's component facts and functions before we proceed to the operation.

Ejector

The ejector works the same as it does on any other valve, to aid in opening the main valve.

3-port solenoid

The solenoid on the 51AF–4 is a three-port, two-way unit.

- It is electrically connected in parallel with the solenoid installed on the 90AF–8 valve. When the 90AF–8 valve is energized open for refueling, the solenoid on the 51AF–4 valve energizes. The solenoid energizes to keep the main valve closed and to keep the fuel from bypassing.
- The solenoid is deenergized, relieving pressure off the auxiliary hytrol's cover chamber to allow the main valve to open for rapid defueling.

Auxiliary hytrol

The auxiliary hytrol works in conjunction with the 3-port solenoid to open and close the control loop.

- It closes the control loop and the main valve when the solenoid is energized during refueling operations.
- It opens (and the main valve, in turn) when the control loop is under pressure and the solenoid is deenergized during rapid defueling operations.

Pressure-relief controls (CRL)

The 51AF–4 valve has two CRLs, one L.P. CRL and one H.P. CRL.

- The H.P. CRL opens allowing the 51AF–4 main valve to relieve hydrant outlet line pressure to the defuel line.
    - The H.P. CRL is set 5 psi above the 90AF–8's pressure-relief setting.
- The L.P. CRL opens any time the hydrant outlet line pressure rises above 5psi. Its 5 psi setting means that it will close to maintain 5 psi on the hydrant outlet line.
    - 5 psi in the hydrant outlet line makes sure the line stays full of fuel.

CV flow control

The CV flow control is installed in reverse to control the main valve's closing speed to prevent surges in the hydrant outlet line.

Swing check valve

The swing check valve remains closed to keep pressure on the main valve cover chamber during refueling. It will open to dump pressure on the main valve cover chamber during reverse flow.

Hytrol check valve

The hytrol check valve remains closed during reverse flow to prevent fuel from escaping the main valve cover chamber.

Look at figures 2–15 and 2–16 as we go through the operation of this valve.

When a magnet is placed on the hydrant outlet refuel KISS switch, the solenoid on the 51AF–4 valve is energized. This aligns port B with port A, and port C of the solenoid is blocked. Delivery line pressure from the fueling line enters the solenoid and is directed to the cover chamber of the auxiliary hytrol, closing it. Line pressure also enters through the hytrol check valve and goes into an ejector. With the auxiliary hytrol closed, fuel pressure is now directed through the CV flow control, pressurizing the cover chamber of the main valve and closing the valve. The swing check valve keeps pressure from escaping the main valve cover chamber. The CV flow control on this valve is the same type used on other valves we have discussed, but it functions differently. On the 51AF–4, it controls the closing speed of the main valve and prevents a sudden surge in the fueling line (it controls the opening speed of the other valves you learned). The H.P. CRL is now in command of the main valve.

When delivery pressure in the fueling line increases to the setting of the H.P. CRL (5 psi above the 90AF–8's CRL setting), it opens and lets the main valve open, relieving excess fuel pressure. Normally, this CRL will not function unless the 90AF–8 fails to close in response to a high-delivery pressure. When reverse pressure comes from the defueling piping, the 51AF–4 valve acts as a check valve, just as the 41AF valve does. When fueling stops, the solenoid on the 51AF–4 is deenergized, aligning port A with port C and venting the hytrol valve cover chamber. Pressure trapped in the fueling line now flows through the ejector and opens the auxiliary hytrol. The L.P. CRL opens and relieves pressure from the lateral piping. When the lateral pressure drops to 5 psi, the L.P. CRL closes, causing the main valve to close.

During rapid defueling, the pump pressure from the aircraft opens the 51AF–4. When the pressure is more than 5 psi, the L.P. CRL opens causing the main valve to open wide. Pressure builds up in the defueling pump, but it cannot flow through the 41AF–10 valve because of the solenoid installed on the 41AF valve to make it a 41AF–10 valve. The electrical leads of this N.C. solenoid are connected in parallel with the control circuit for the defueling pump motor, just as on the 134AF valve. If the defuel pump in the pit is not energized, then the 41AF–10 solenoid is deenergized closed. This prevents any fuel flow through the valve control system during rapid-flow defueling.

Hydrant outlets

To permit rapid defueling, the float assembly from the 352AF adapter is removed. A $^{1}/_{8}$-inch angle valve is installed, in the tapped hole, in the body of the hydrant adapter to bleed off the vapor and air. (Adapters equipped with a manual bypass valve must have the bypass valve removed to allow the angle valve to be attached.) The rubber dust cover normally provided with the adapter is replaced with an X73 aluminum blanking cap (fig. 2–16). The caps are installed over the adapter when the adapter is not in use. They keep the vacuum on the unused adapters in place when the defueling pump operates.

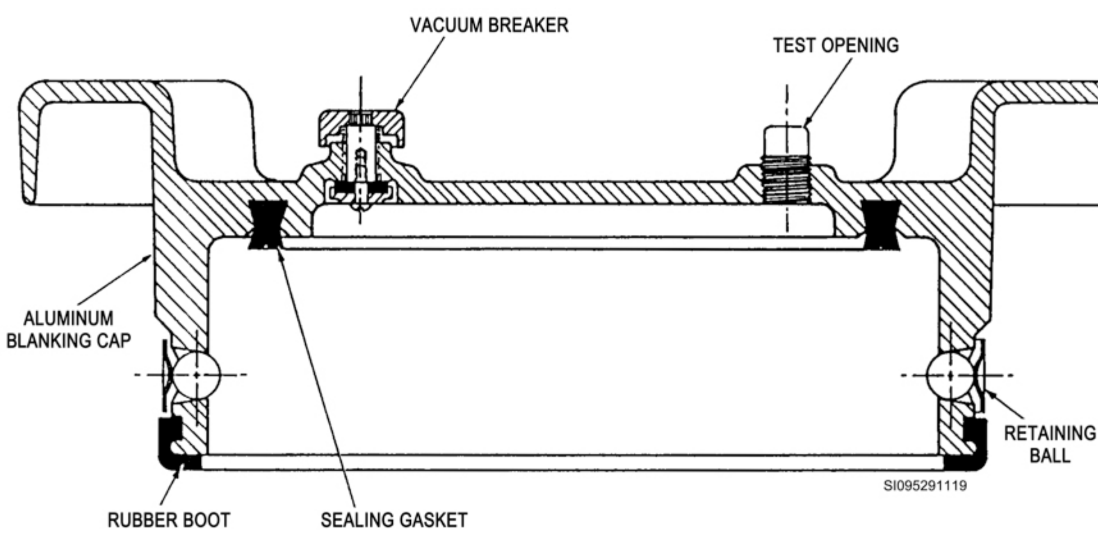


Figure 2–16. X73 Aluminum blanking cap. (By courtesy of Cla-Val Co.)

A manually operated vacuum breaker admits air, dissipates the vacuum, and lets you remove the blanking cap from the adapter. The sealing gasket and cap form an airtight seal above the hydrant adapter. The cap is held in place by four spring-loaded retaining balls. There are also (1) a rubber boot around the bottom of the cap for protection and (2) a test opening to install a vacuum gauge and check the cap-sealing gasket. The 352AF adapter and level CVs that have been modified for rapid defueling are now called 358AF hydrant adapters.

416. Inspecting and adjusting the 51AF–4 valve

This combination dual-pressure relief, solenoid shutoff, and check valve (51AF–4) does all that its name implies. Its inspection and maintenance differs only slightly from the automatic valves you have already studied. The two CRLs on the 51AF–4 are not interchangeable with those on different model valves, but they operate and adjust alike. The solenoid valve also differs from those on other automatic valves. You have already studied the components of the 51AF–4 and should be ready to adjust the valve.

Pressure setting valve controls

The 51AF–4 pressure setting consists of adjusting the two CRLs and the CV flow control. Set the L.P. relief control at 5 psi; it only operates when the solenoid is deenergized. Set the H.P. relief control 5 psi above the 90AF–8's CRL setting. It only operates when the solenoid is energized during refueling.

Inspect the 51AF–4 quarterly for leaks, damage, and wear. Check its operation as you do other automatic valves, making sure it works right. If the pressure settings are not as specified, adjust the CRL.

Adjusting low-pressure relief

To adjust the L.P. relief control, energize the system by placing a magnet on the refueling KISS switch. No hose cart is needed for this procedure. When pressure builds up fully in the lateral piping and the 90AF–8 valve closes, deenergize the system. The 51AF–4 valve should open and the pressure in the lateral pipe should drop. When the 51AF–4 closes, notice the lateral line pressure gauge reading; this is the present setting of the L.P. CRL. If the gauge reads above 5 psi, slowly turn the L.P. CRL adjusting screw counterclockwise to bring the pressure down to 5 psi. Energize and deenergize the system again. The 51AF–4 valve should maintain 5 psi in the lateral piping when the system is idle. Then, lock the jam nut down, install the cap, and seal the control once you have set the L.P. relief. As you check the adjustment, note the closing time of the 51AF–4. The closing time should be 3–5 seconds. Adjust the CV flow control clockwise to increase closing time or counterclockwise to decrease closing time.

Adjusting high-pressure CRL

Adjust the 51AF–4 H.P. CRL to 5 psi above the 90AF–8 CRL set point to adjust the H.P. CRL; you must have enough pressure in the lateral piping to open it. First, bottom the adjusting screw on the 90AF–8 H.P. CRL. Get a hose cart and a fueling truck and energize the system using the refuel KISS switch. Adjust the 90AF–8 pressure reducer (CRD) by slowly turning it clockwise until the pressure gauge in the pit reads 5 psi above the NOP. Slowly turn the adjusting screw on the 51AF–4 H.P. CRL counterclockwise until the valve starts to open. Then turn the adjusting screw clockwise until the valve starts to close. Energize and deenergize the system to recheck the setting.

Once the 51AF–4 is properly set, turn the 90AF–8 CRD adjusting screw counterclockwise until the pressure drops to 5 psi above NOP. Now back off on the 90AF–8 CRL adjusting screw slowly until it starts to close the valve. Then turn the CRD adjusting screw counterclockwise until you reach NOP. Be sure to cap and seal the pressure reducer and the two relief controls before you leave the area.

Self-Test Questions

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

415. Operating the rapid 51AF–4 defuel valve

1. What valve was removed from the modified Pritchard LCP?

2. Match each 51AF–4 function in column A with the appropriate components in column B. Some functions are used with more than one component or not at all.

Column A	Column B
____ (1) Prevents reverse flow through the control loop.	a. Hytrol check.
____ (2) Holds the valve closed during refueling operations.	b. CV-flow control.
____ (3) Closes to keep the hydrant line full of fuel.	c. Ejector.
____ (4) Relieves excess pressure to the defueling line.	d. Auxiliary hytrol.
____ (5) Relieves pressure from the hytrol cover chamber.	e. L.P. CRL.
____ (6) Dumps pressure onto the main valve cover chamber during reverse flow.	f. H.P. CRL.
____ (7) Controls the main valve closing speed.	g. Swing check valve.
____ (8) Opens at 5 psi.	h. Three-port solenoid.

3. What causes the 41AF–10 solenoid to deenergize closed?

4. What component prevents fuel from flowing through the defuel pump during a rapid-flow defueling operation?

5. List the changes that occurred in the 352AF. What is its new number?

416. Inspecting and adjusting the 51AF–4 valve

1. To set the pressure on the 51AF–4 valve, what three components are adjusted?

2. Which of the three components is adjusted based on the 90AF–8 CRL's setting?

3. What is used to set the L.P. CRL?

4. What should the lateral piping pressure be when the system is idle if the L.P. CRL is set correctly?

5. What pressure does the 51AF–4's H.P. CRL open if the 90AF–8 CRD is set to open at 105 psi?

Answers to Self-Test Questions

407

1. Four.
2. Refueling contacts of the magnetic control station (KISS switch).
3. The 90AF–8 RCV.
4. Non-lubricated plug or ball valves.
5. The 134AF and the 41AF.
6. By opening the defuel pump circuit breaker.
7. The vacuum control switch.
8. Self-priming, centrifugal.

408

1. Pressure reducing, nonsurge, pressure relief, excess flow shutoff, and ESO.
2. A manual globe valve.
3. By pressure under the diaphragm, pressure over the diaphragm in the cover chamber, and spring tension. The positions are open, closed, or modulating.
4. (1) b.
   (2) d.
   (3) c.
   (4) a.

409

1. Leaks, external damage, and the proper operation of its five functions.
2. Adjust the pressure reducing setting, pressure-relief setting, excess flow shutoff, and the main valve opening rate.

410

1. Strainer orifice.
2. The CRL.
3. It opens wide when pressure reaches 10 psi above the 90AF–8 valve's NIP.
4. So it opens even if the main valve diaphragm ruptures.

411

1. By closing the manual valve downstream of the 90AF–8 and electrically isolate the 90AF–8 solenoid by turning off the solenoid switch. Then place the magnet on the refuel KISS switch to energize the deep-well pump in the pump house. Make sure the valve opens at its standard setting of 10 psi above the 90AF–8's normal refueling inlet pressure. Repeat the test five times to make sure it operates properly.
2. The normal inlet pressure of the 90AF–8 during refueling.
3. The valve downstream from the 90AF–8.
4. Turn the adjusting screw clockwise for maximum spring tension.
5. The standard setting is 10 psi above the 90AF–8 NIP. Your trainer or supervisor.

412

1. During refueling, the solenoid is deenergized and pressure is directed to the top of the main valve, holding it closed. When you place a magnet on the defuel KISS switch, the solenoid on the 134AF is energized and fuel passes through the ejector and solenoid, opening the valve.

2. Look for leaks and check the general condition of components and ensure the valve opens during defueling and remains closed during refueling.

413

1. It holds the preset flow rate during defueling at 200 gpm and it acts as a check valve, by preventing fuel from flowing in reverse when the 50AF–2 opens during refueling.
2. CDHS–2, differential control.
3. The solenoid on the 134AF is energized and the defuel pump starts. A 200 gpm flow rate is established.
4. The hytrol check and the swing check valves.
5. When outlet pressure is applied to the top of the diaphragm through the drilled passage in the body, the hytrol check closes.
6. Quarterly.
7. By turning the adjusting screw counterclockwise until it has minimal spring tension. Then turn the adjusting screw clockwise in two complete turns. Place a magnet on the defuel KISS switch. Turn the adjusting screw on the CDHS–2 clockwise until you get a flow rate of 200 gpm.

414

1. Provides a quick, leak-free connection between the installed piping and portable hose equipment; and it controls its own fuel level when defueling to keep air out of the piping system.
2. The 351AF.
3. Buoyancy and velocity.
4. The automatic bypass valve.
5. The float will be held tightly against its seat.
6. The float assembly.
7. The float assembly stops, the defuel pump starts pulling a vacuum in the lateral piping, the vacuum control switch senses the high vacuum setting, then opens the electrical control circuit to the defuel pump motor.
8. The cover, seat, and poppet.
9. The O-ring.
10. The stop, one for the jet fuel and the other for the aviation gasoline.
11. Simply lift the emergency-stop cover and release.
12. Use an ohmmeter and magnet to attach the test leads to the magnetic switch wires. Place a magnet on the KISS switch, the test with an ohmmeter. The ohmmeter should read zero; when the magnet is removed, it should read “OL” (open lead).
13. A galvanized or stainless steel ground rod.
14. Only tie-down anchors used and approved as ground rods are identified by the month and year, painted in 3-inch letters on the pavement adjacent to the grounding point.
15. The lateral piping and the electrical conduit are connected to the static ground, using with 3/32–inch stainless steel wire rope with a nylon cover.
16. The piping would *not* be connected to the static ground.

415

1. The 134AF defueling CV.
2. (1) a.
   (2) d, h.
   (3) e.
   (4) f.
   (5) h.
   (6) g.
   (7) b.
   (8) e.

3. When the defuel pump in the pit is not energized.
4. The solenoid, deenergized closed, on the 41AF–10.
5. The float assembly was removed; an angle valve was installed; and the rubber dust cover was replaced with an aluminum-blanking cap. The 352AF is now called a 358AF.

416

1. The two CRLs and the CV flow control.
2. The H.P. CRL.
3. Normal system pressure.
4. 5 psi.
5. At NOP of 105.

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.

17. (407) How many *manual* valves are found in the lateral control pit (LCP) of the Pritchard system?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

18. (407) Which lateral control pit (LCP) component automatically cuts off the defuel pump when a predetermined amount of inches of mercury is reached?
    a. Solenoid control switch.
    b. Pump circuit breaker.
    c. Vacuum control switch.
    d. Panel selector switch.

19. (408) When the cover chamber pressure of the 90AF–8 refueling control valve (RCV) is *at least* as great as the inlet pressure, the valve will
    a. pulsate.
    b. modulate.
    c. open fully.
    d. close tightly.

20. (408) If the cover chamber pressure on a 90AF–8 refueling control valve (RCV) stays between the inlet and outlet pressure, the valve
    a. pulsates.
    b. modulates.
    c. opens fully.
    d. closes fully.

21. (408) What type of solenoid is used on the 90AF–8 refueling control valve (RCV)?
    a. Two port, normally open (N.O.).
    b. Two port, normally closed (N.C.).
    c. Three port, N.O.
    d. Three port, N.C.

22. (408) At what pounds per square inch (psi) does the pressure-reducing control (CRD) deliver constant pressure on the 90AF–8 refueling control valve (RCV)?
    a. 50.
    b. 55.
    c. 100.
    d. 105.

23. (408) On the 90AF–8, the pressure-relief control (CRL) is set to
    a. 5 pounds per square inch (psi) higher than the normal operating pressure (NOP).
    b. 5 psi higher than the normal inlet pressure (NIP) of the 51AF–4.
    c. 5 psi higher than the inlet pressure of the 90AF–8.
    d. 5 psi higher than the 51AF–4.

24. (409) You operationally inspect the 90AF–8 refueling control valve (RCV)
    a. monthly.
    b. quarterly.
    c. semi-annually.
    d. annually.

25. (409) What pressure rate *must* you establish before setting the pressure-relief control (CRL) on the 90AF–8 refueling control valve (RCV)?
    a. 2 to 3 pounds per square inch (psi) above normal downstream pressure.
    b. 2 to 3 psi above normal upstream pressure.
    c. 5 psi above normal downstream pressure.
    d. 5 psi above normal upstream pressure.

26. (410) What can be removed from the strainer orifice used on the 50AF–2 pressure-relief valve?
    a. Only the primary jet.
    b. Only the secondary jet.
    c. The primary and secondary jets.
    d. Neither the primary nor secondary jet.

27. (410) Why is the flow installed under the disc of the main valve body on the 50AF–2 pressure-relief valve?
    a. To increase system pressure to the main diaphragm.
    b. So the main valve diaphragm operates properly.
    c. For a smoother flow through the valve diaphragm.
    d. So the valve opens if the main valve diaphragm ruptures.

28. (411) The *standard* pressure setting, on the 502AF–2 pressure valve's pressure-relief control (CRL), is based on the 90AF–8 refueling valve's pressure of
    a. 2–3 pounds per square inch (psi) above its normal operating pressure (NOP).
    b. 2–3 psi above its normal inlet pressure (NIP).
    c. 10 psi above its NOP.
    d. 10 psi above its NIP.

29. (412) How often is the 134AF defueling control valve (CV) operationally inspected?
    a. Monthly.
    b. Quarterly.
    c. Semiannually.
    d. Annually.

30. (413) To adjust the flow rate of the differential control on the 41AF rate-of-flow control valve (CV), you *must* turn the adjusting screws
    a. clockwise for maximum spring tension.
    b. clockwise for minimum spring tension.
    c. counterclockwise for maximum spring tension.
    d. counterclockwise for minimum spring tension.

31. (414) When defueling stops, the 352AF hydrant adapter controls its own fuel level in order to
    a. keep moisture out of the system.
    b. prevent corrosion in the piping system.
    c. keep the fuel pressure from getting too high.
    d. prevent air from entering the installed piping system.

32. (414) At what *maximum* differential pressure, in pounds per square inch (psi), does the 352AF hydrant adapter's automatic bypass valve (BPV) open?
    a. 15
    b. 25.
    c. 35.
    d. 45.

33. (414) Before air can enter the piping system, the defuel pump stops when the 352AF
    a. bypass opens.
    b. bypass closes.
    c. float assembly opens.
    d. float assembly closes.

34. (414) When the defuel pump shuts off, what opens its electrical control circuit?
    a. Vacuum control switch.
    b. Pump circuit breaker.
    c. Pump control switch.
    d. Air control switch.

35. (414) After activating an emergency-stop switch at the Type II hydrant outlet, you reset the system to refuel by
    a. placing the magnet on the refuel magnetic control station switch.
    b. placing the cover back on the emergency switch.
    c. manually resetting the controls in the lateral control pit (LCP).
    d. manually resetting the controls in the pump house control room.

36. (414) What type of ground rods are hydrant outlets grounded to in the piping system of the Type II Hydrant System?
    a. Tin.
    b. Cast steel.
    c. Black iron.
    d. Galvanized/stainless steel.

37. (415) When a magnet is placed on the defuel keep it simple, system (KISS) switch, the solenoid of the 41AF–10 defuel valve is energized open along with the solenoid on the
    a. defuel pump.
    b. 90AF–8 refuel valve.
    c. 134AF defuel valve.
    d. 51AF–4 rapid defuel valve.

38. (415) How often is the 41AF–10 inspected?
    a. Monthly.
    b. Quarterly.
    c. Semiannually.
    d. Annually.

39. (415) The *primary* purpose of having 5 pounds per square inch (psi) in the lateral piping on the 51AF–4 rapid defuel valve is to
    a. relieve excess pressure during refueling.
    b. make sure the defuel piping stays full of fuel.
    c. make sure the hydrant outlet line stays full of fuel.
    d. prevent reverse flow during rapid flow defueling.

40. (415) Besides removing the float for rapid defueling, some of the other changes to the 352AF adapter were installing
    a. an angle valve and replacing the cover with a rubber dust cover.
    b. an angle valve and replacing the rubber dust cover with an aluminum-blanking cap.
    c. a manual bypass valve (BPV) and replacing the cover with a rubber dust cover.
    d. a manual BPV, an aluminum dust cover, and replacing the poppet.

41. (416) After adjusting the high pressure (H.P.) on the 51AF–4 valve's pressure-relief controls (CRL), what is the *last* thing you should do to the CRL before leaving the area?
    a. Tighten the jam nuts.
    b. Tighten the adjusting screws.
    c. Cap and seal them.
    d. Turn off solenoid switches.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Type III Hydrant System

NEW AND IMPROVED, each hydrant fueling system has become bigger, faster, capable of refueling more aircraft in less time, and are more complex. New aircraft and mission requirements have made this possible. This latest hydrant system uses state-of-the-art equipment. It actually has a computer, or a microprocessor, which senses the need for flow and energizes 1, 2, 3, or 4 pumps to establish fill rates that can vary anywhere between 40 and 2,400 gpm. With this hydrant system, all the aircraft parked on the fueling ramp can be filled at the same time. If an aircraft is being filled and another aircraft needs defueling, there is no problem because this system is capable of doing both at the same time.

Yes, this system is larger and different, but as you go through this unit, you will find many familiar pieces of equipment. Take your time. If you find yourself getting confused, think back to the other lessons you have already learned. Remember, this system must follow the same laws and principles of hydraulics as any other fueling system. This system may look different and have equipment you have not seen; however, if you allow yourself, you will be amazed at how much you have learned thus far and how that information is easily transferred from one fuel system to another.

3–1. Type III System Components and Equipment

The Type III prototype was developed by the Phillips Petroleum Company in the mid-1950s. It was originally designed for fueling military transports and bomber aircraft. The recommended hydrant fueling system was a pressurized system automatically controlled by demand, utilizing groups of high-volume pumps, F/Ss, and a pipeline distribution system arranged for extreme flexibility and operational simplicity.

Over 50 years have passed since those ideas were placed on paper. The original *idea* has not changed; however, the original designs have changed many, many times. As you travel from one base to another, you will encounter these different designs. You will notice that all current type III systems are similarly built to deliver 2,400 gpm. You will also notice great differences, such as piping and equipment configurations, as well as various automatic valve manufacturers. To simplify the study of the automatic valves, we will discuss the valves made by the Cla-Val company.

We begin by looking at the components used to make up this system. We do that by moving through the system methodically. We start with receiving equipment, then from storing to issuing equipment, and finally to the "brain" or pump control room. Follow figure 3–1 as we discuss the lessons that follow.

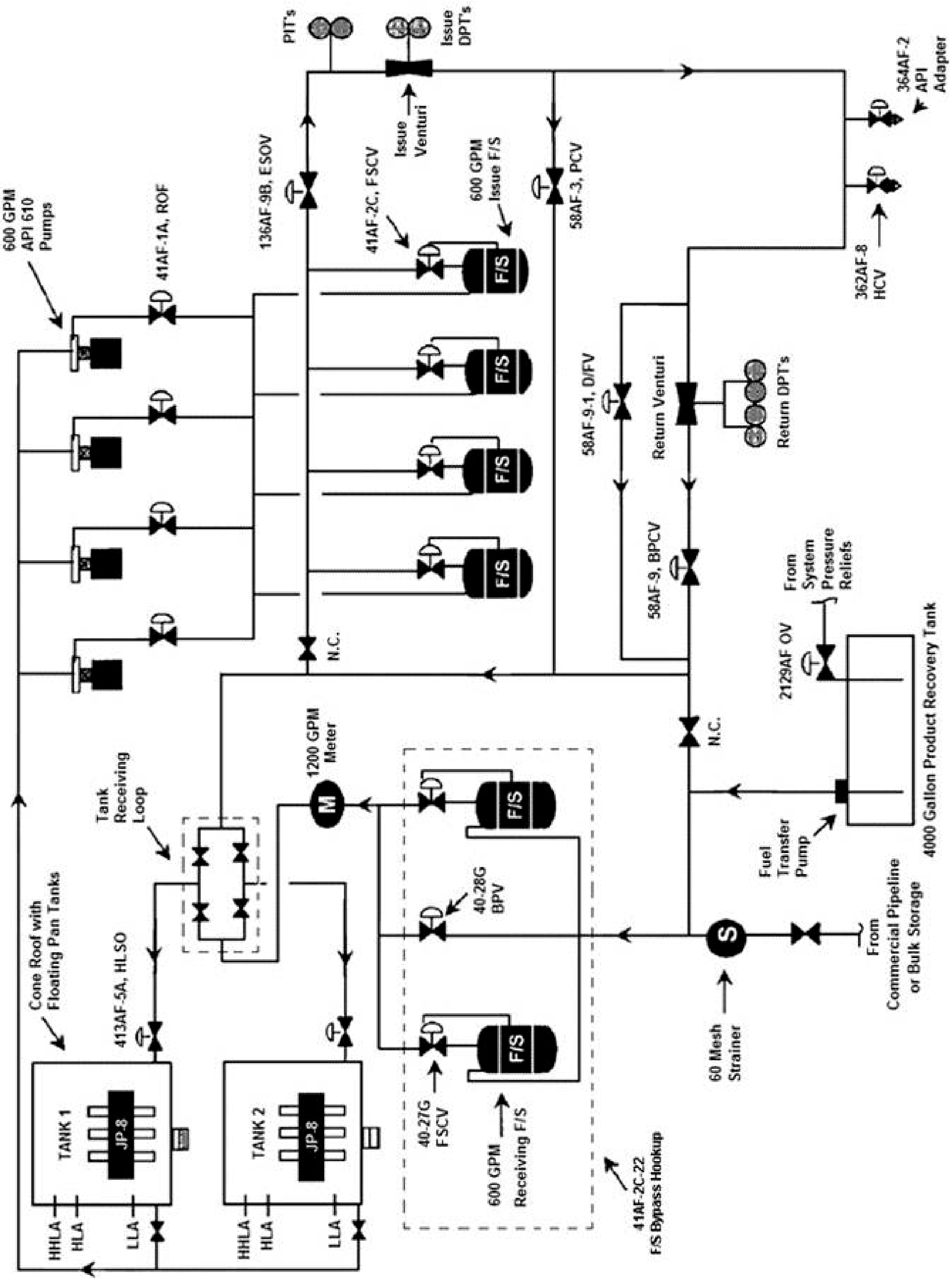


Figure 3–1. Type III system flow diagram.

417. System piping

Before we begin our journey through the system, let's discuss the piping that carries the fuel. The main fuel lines, from bulk storage to the issue F/Ss, that are 12 inches or larger are made of carbon steel, American Standard of Testing Material (ASTM) A53, grade B. Main lines that are 2 ½ inches through 10 inches are carbon steel, either Schedule 40S, American Petroleum Institute (API) 5L, Grade B; or ASTM A53, Grade B. Piping that is 2 inches or smaller is Schedule 80, API 5L, Grade B or ASTM A53, Grade B.

The piping from the issue F/Ss, through the hydrant loop, and back to the receiving loop that is 2 ½ inches and larger is stainless steel, Schedule 20S, ASTM 358, Type 304L. Piping 2 inches or smaller is stainless steel, Schedule 80, ASTM 358, Type 304L. Stainless steel is less susceptible to rust than other piping and ensures the quality of fuel being delivered to the aircraft. The control tubing used in this system is seamless stainless steel, ASTM A269, Grade TP316, with a Rockwell hardness of B80 or less. The pressure-relief and drain-system piping is carbon steel, Schedule 40, API 5L, Grade B or ASTM A53, Grade B.

418. Type III receiving equipment

This fuel system, like others you have studied, can receive fuel via truck, tank car, pipeline, barge, or even aircraft tanker. The receiving method depends on where the system is located on base and which method is the most economical. It is not necessary to discuss the information you have already learned, so we only cover the equipment required for receiving fuel into the system's storage tank. Follow figure 3–1 as we discuss it.

Strainers

Fuel entering this system first goes through an 8-inch strainer. The strainer must conform to Military Specification (MIL-S)–13789. This strainer is constructed of stainless steel and has a removable basket. The basket contains a 60-mesh screen supported by a larger stainless steel wire mesh. It also has a bottom drain. The drain has a ball valve installed so fuel and/or pressure can be removed without using a drip pan. When you drain fuel from the strainer, it goes directly into a product-recovery tank. This strainer can be either single inlet and single outlet or dual inlet and dual outlet.

This strainer has a piston-type direct reading differential-pressure gauge. This gauge indicates the condition of the strainer basket. After each receipt, operators need to open and check the strainer to ensure nothing remains. When fuel is flowing at the designated flow rate, there should be no more than a 3 psi pressure drop in a clean strainer. When the differential-pressure gauge reaches 10 psi, the operator must clean the strainer.

Receiving filter separators

The cleanliness of the fuel is a major concern. Therefore, this system follows the strainer with two horizontal F/Ss. These two separators are in parallel and manifolded together. F/Ss used in the Type III system are API 1581, Group II, Class B, rated at 600 gpm each. They operate very similar to the separators you learned about earlier, but we will cover some important differences.

F/S bypass package 41AF–2C–22

The 41AF–2C–22, F/S bypass hookup (fig. 3–2), is used when the system receives fuel from a cross-country pipeline. The purpose of the F/S bypass is to prevent pressure surges when the F/S CV closes due to water rising inside either one of the receiving F/Ss or when the differential pressure across either receiving F/S reaches 15 psi.

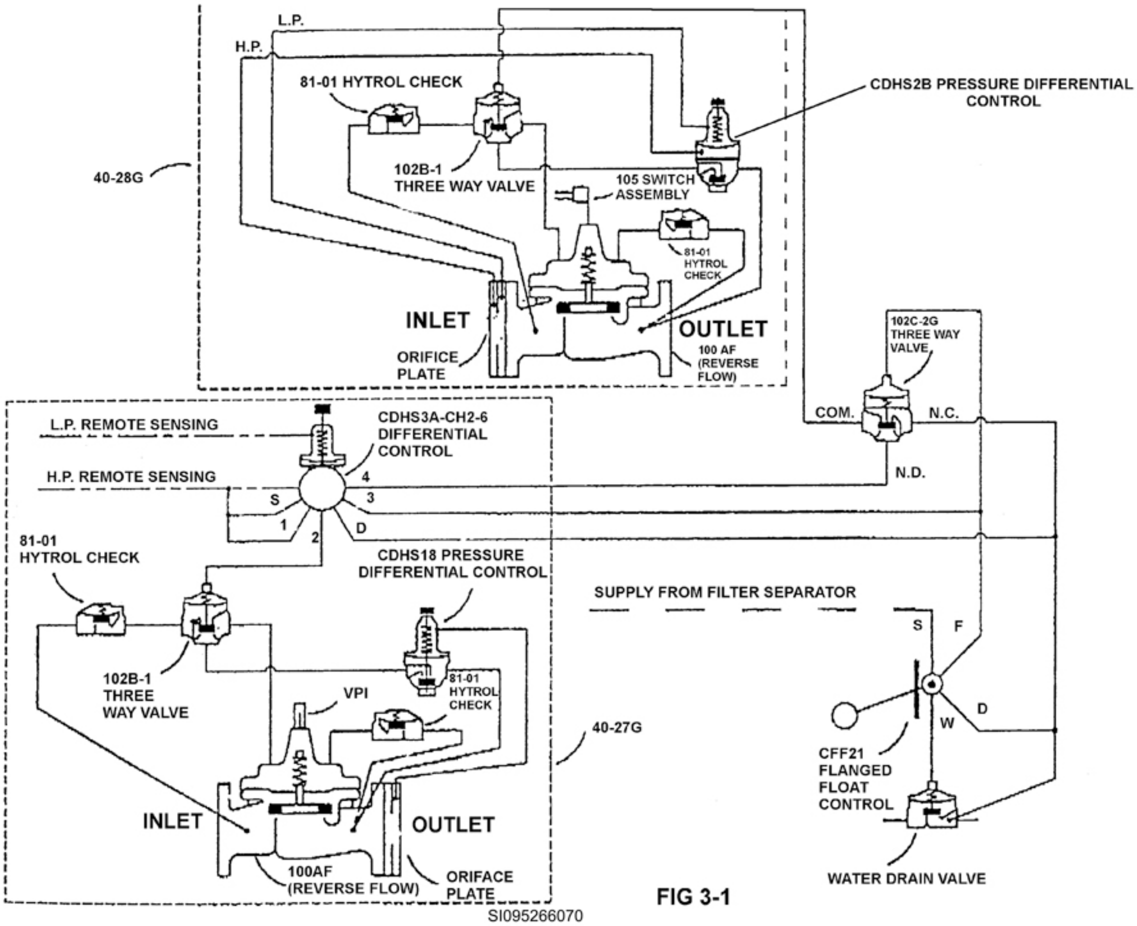


Figure 3–2. Filter/separator bypass hookup, 41AF–2C–22. (By courtesy of Cla-Val Co.)

The 41AF–2C–22 consists of five components:

1. 40–27G filter/separator control valve (FSCV) (the old 41AF–2C–13).
2. 40–28G bypass valve (BPV) (the old 41AF–2E).
3. 102C–2G three-way hytrol.
4. CFF21 flanged float control.
5. 100AF water drain valve (WDV).

40–27G FSCV

The 40–27G FSCV is a 6-inch automatic valve used on the receiving F/S only and works about the same as the 40AF–2C you studied earlier. The flow control function limits the flow through the F/S at 600 gpm. The flow controller operates from differential pressure created by an orifice plate. Water slug shut off is done by the CFF21 flanged float control pilot. The 40–27G performs two new functions: maximum differential-pressure shutoff and check valve.

40–28G *BPV*

The 40–28G BPV is used *only* on systems that receive fuel directly from a cross-country pipeline. If the system receives fuel from base bulk storage, this valve is not necessary and a manual valve is used in its place. This manual valve can be opened to bypass the F/S. The 40–28G is opened and closed by the 102C–2G or the F/S float. The BPV or manual BPV is located on a bypass line between the two receiving F/Ss.

The *purpose* of the BPV is to open fully and bypass fuel around the F/S whenever the float rises, indicating either a high water level or a differential pressure of 15 psi, sensed across a receiving F/S, closing the 40–27G. The BPV remains open until the CDHS–3A-CH2–6 on the 40–27G is manually reset. A limit switch is used in conjunction with the VPI, which closes an electrical switch when the BPV opens. Once the BPV opens, the limit switch illuminates a light on the pump control panel and sounds an audible alarm. This provides a remote indication that the BPV is open and fuel is bypassing the F/Ss. This warns the operator to shut the system down as soon as possible without causing a deadhead pressure situation.

41AF–2C–22 flow conditions

The 41AF–2C–22 operates under three different flow conditions:

- *Normal flow* means everything is working properly.
- *Differential pressure shutoff* means 15 psi differential is sensed across the F/S.
- *Excess water shutoff* indicates the float in the F/S is in the top position.

Normal flow condition

Figure 3–3 shows the 41AF–2C–22 under normal conditions (less than 15 psi differential pressure and the F/S float in the lower position).

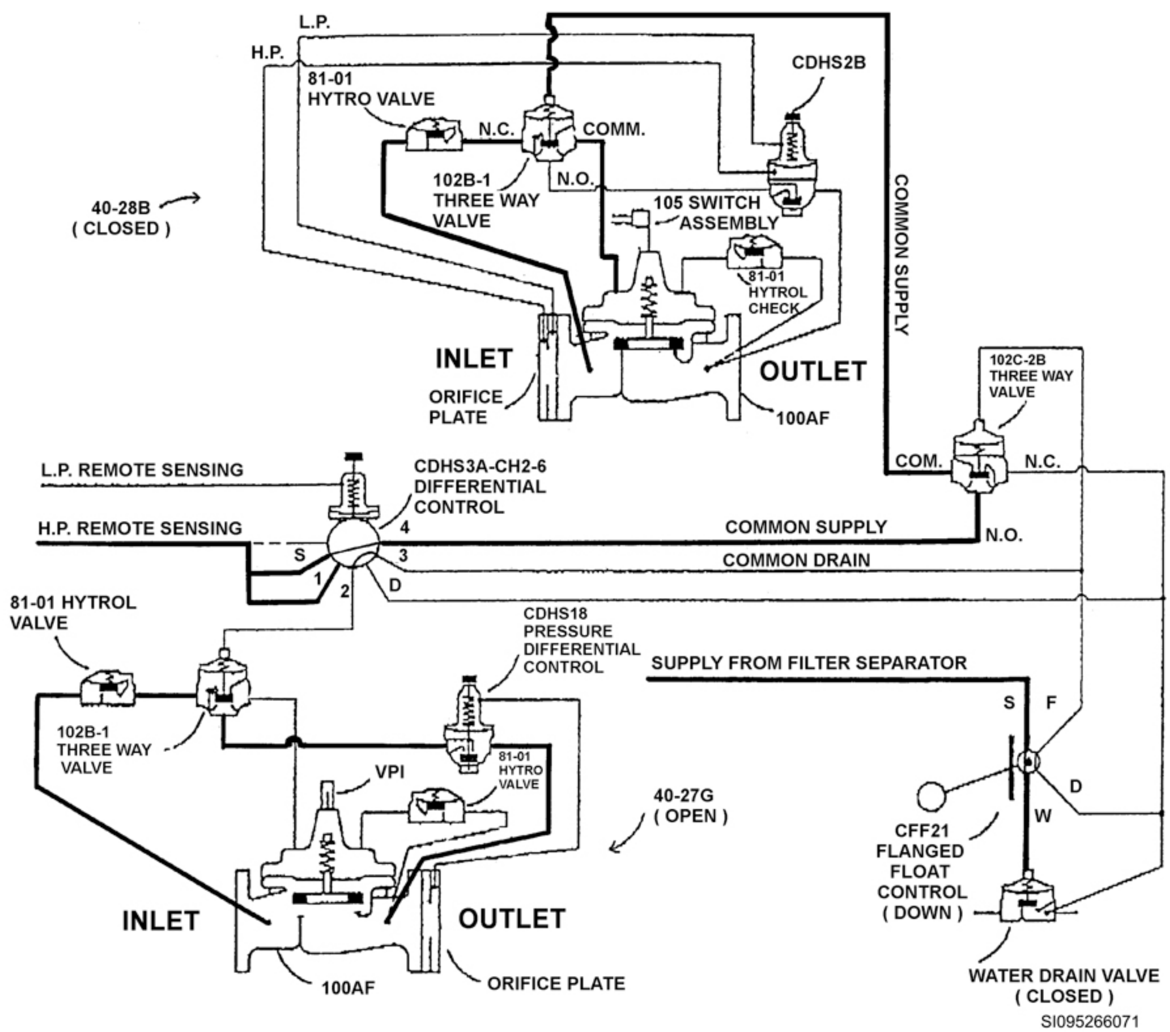


Figure 3–3. Normal flow conditions, 41AF–2C–22. (By courtesy of Cla-Val Co.)

The 40–27G differential pilot is in the cocked position, which aligns port 5 with 4 and aligns port 2 with 3. H.P. is routed through the N.O. and common (COM.) ports of the 102C–2G three-way valve to the cover chamber of the 102B–1 three-way valve on the 40–28G BPV, closing the 40–28G BPV. The 40–27G main valve is then commanded by the CDHS18 and the CFF21 float control.

The CDHS18 acts like a CDHS–2 and maintains a 600 gpm rate of flow through the F/S.

Maximum differential pressure shutoff feature

The 40–27G (fig. 3–4) closes rapidly when differential pressure across the F/S increases to 15 psi. This feature protects the elements from bursting and prevents contaminated fuel downstream. The shutoff control (CDHS3A–CH2–6) is the same type of differential control used for excess flow shutoff in the Type I and II hydrant fueling systems. On the Type I and Type II refueling control valves (RCV), an orifice plate creates the differential pressure. On this valve, the differential pressure is sensed across the F/S elements. H.P. is connected to the inlet of the F/S, and L.P. is connected just downstream of the elements. As the elements become dirty, the L.P. gets lower, creating a bigger difference between H.P. and L.P.

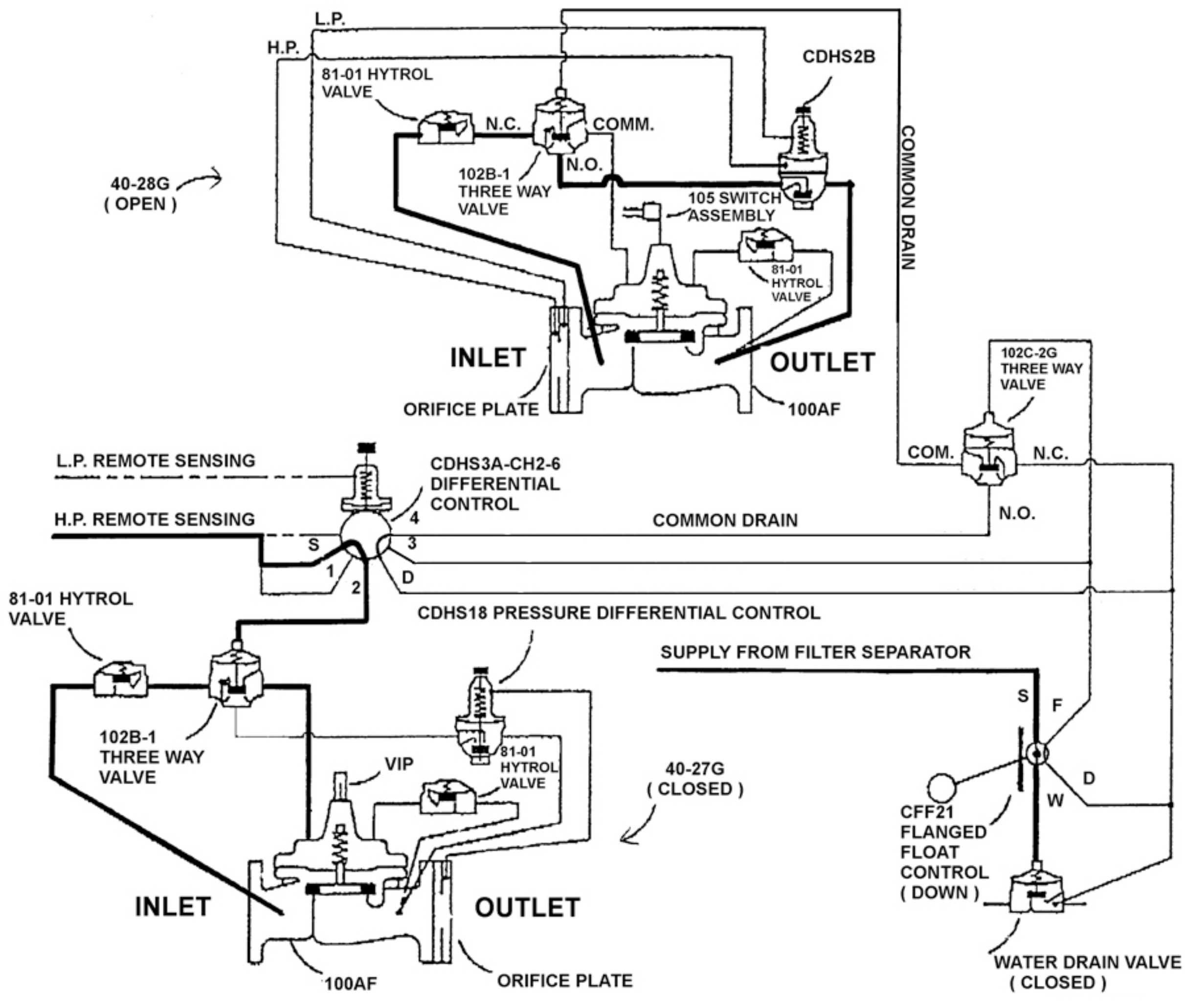


Figure 3–4. High-differential pressure shutoff, 41AF–2C–22. (By courtesy of Cla-Val Co.)

Depending on the differential pressure control set-point, the H.P. will eventually overtake the L.P. and spring tension. Look at figure 3–4. When H.P. overtakes L.P. and spring tension, the CDHS3A-CH2–6 differential control trips and realigns port S (supply) with port 2 and realigns port 4 with port

D (drain). This relieves pressure from the cover chamber of the three-way pilot valve on the 40–28G bypass valve through the N.O. and COM. ports of the 102C–2G three-way valve, opening the bypass valve. The ports' realignment also directs pressure to the 102B–1 three-way valve in the control loop of the 40–27G, closing the main valve very quickly. The 40–27G will not operate again until the differential control is manually reset.

Excess water shutoff

Figure 3–5 shows the 41AF–2C–22 when there is excess water in the F/S. The following table shows what happens when the float changes position. When excess water enters the F/S and the float rises to the top position, the 40–27G closes and the 40–28G opens. This is done when the flanged float control disc is realigned. The "S" port is aligned with the "F" port, and the "W" port is aligned with the "D" port in the flanged float control.

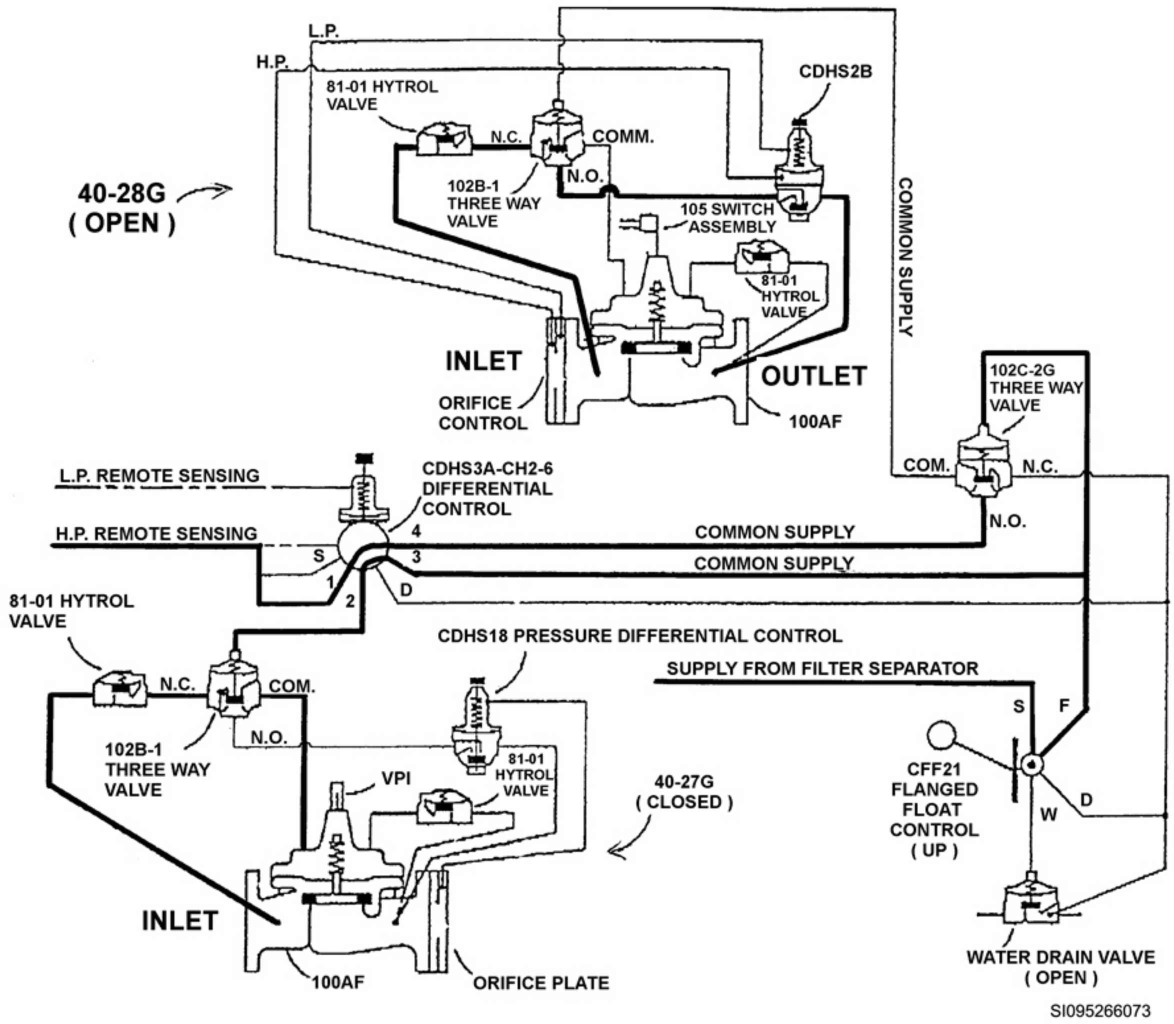


Figure 3–5. Excess water shutoff, 41AF–2C–22. (By courtesy of Cla-Val Co.)

41AF–2C–22 Component Position				
CFF21 Float Control		**102C–2G Three-Way**	**40–28G Bypass**	**100AF Water**
FLOAT POSITION	***PORTS CONNECTED***	***VALVE POSITION***	***VALVE POSITION***	***DRAIN VALVE***
Rises	"S" - "F" "W" - "D"	"COMM - N.C."	Open under command of rate-of-flow control	Open to drain water from F/S
Down	"F" - "D" "S" - "W"	"COMM - N.O."	CLOSED	CLOSED

With "S" and "F" aligned, fuel pressure is directed to the 102C–2G cover chamber, aligning ports COM. and N.C. This aligns the BPV 102B–1 cover chamber with a common drain, which aligns the N.C. port with the N.O. port. This allows the BPV to open under the control of the CDHS–2B.

Also, when the "S" port is aligned with the "F" port in the flanged float control, pressure is directed to port 3 through port 2 of the FSCV differential control. This applies pressure to the cover chamber of the three-way valve, aligning the N.C. port with the COM. port and directing pressure to the FSCV cover chamber, closing the main valve.

When the float returns to the bottom position, the FSCV opens and the BPV closes, and the system returns to its normal flow condition.

Check valve

The 40–27G FSCV and the 40–28G BPV also perform as a check valve. The check feature functions the same as the check feature on the 41AF rate-of-flow CV in the Type II hydrant fueling system.

Water drain valve

There is no difference here. The WDV operates the same as before. When the float is in the middle or top position, the WDV opens and dumps water. This water drains into the same product-recovery tank as the drain for the strainer. If the float is in the top position, the 40–27G FSCV closes and the 40–28G BPV opens.

In some cases, the automatic water drain has been removed from the F/S. This in no way affects the operation of the FSCV. If water enters the separator and causes the float to rise to the top position, the FSCV closes and the BPV opens. The operator must then manually drain the water in the separator.

Meter

Following the F/S in the receiving line, you will find a 1,200 gpm one-way flow and positive-displacement-type meter. The meter register has a non-setback total indicator and a setback-type run indicator. The setback run indicator registers individual runs without affecting the total of all runs registered on the total indicator. The total indicator has a minimum of seven figures, and the setback run indicator has a minimum of six figures. The register reads in gallons; the smallest unit of measurement is one gallon. New to our study of meters is the capability of this meter to transmit a signal to the control room, which activates an electronic digital counter on the PCP. The electronic counter counts 1 gallon each time the meter counts 1 gallon.

Meter-proving connections

Just downstream of the receiving meter are two, 2 ½-inch meter-proving connections. These connections have a manual valve located between them. You can calibrate the receiving meter by closing the manual valve and connecting a master meter to the proving connections.

Tank receiving loop

The receiving line enters a loop with four manual valves. Refer back to figure 3–1 for the location of the tank receiving loop. By opening and closing two of the valves, you choose which tank receives fuel. The receiving loop also receives fuel from the hydrant loop return line. By opening or closing the other two valves, you determine which tank receives the returning fuel from the hydrant. In the Type III and the Type IV system, you can issue fuel out of and receive fuel into the same fuel tank at the same time.

419. Type III tanks and their components

The tanks used for storage in the Type III system are also the operating tanks. You have already learned about the different type of tanks and components used by the AF. Here you will learn about the requirements for the Type III operating tanks and about a product-recovery tank with its associated components.

Operating storage tanks

These tanks must conform to Standard Design AW 78–24–27. They can range in size from 2,500, 5,000, or 10,000 barrel (bbl.). The mission of the base dictates what size tanks are used. These tanks must be internally coated in accordance with Unified Facilities Guide Specifications (UFGS).

If suitable, on-base bulk storage tanks located within one mile of the fueling apron can be used as the operating tanks. These base bulk storage tanks must be modified to meet the criteria of Standard Design AW 78–24–27.

High-level shutoff valve 413AF–5A

All fuel received into the operating tanks must go through a high-level shutoff valve (HLV). The 413AF–5A is activated by a ball float located on the exterior of the tank at the required shutoff height. Fuel enters the control loop of the main valve (fig. 3–6) and becomes the supply pressure, which is eventually used to close the valve. When the float is in the DOWN position, the hytrol cover chamber vents to drain, allowing the main valve to open. When the float rises to the TOP position, the rotary disc changes ports and directs the supply pressure to the cover chamber of the hytrol, closing the main valve. This valve also has a check valve feature to prevent reverse flow.

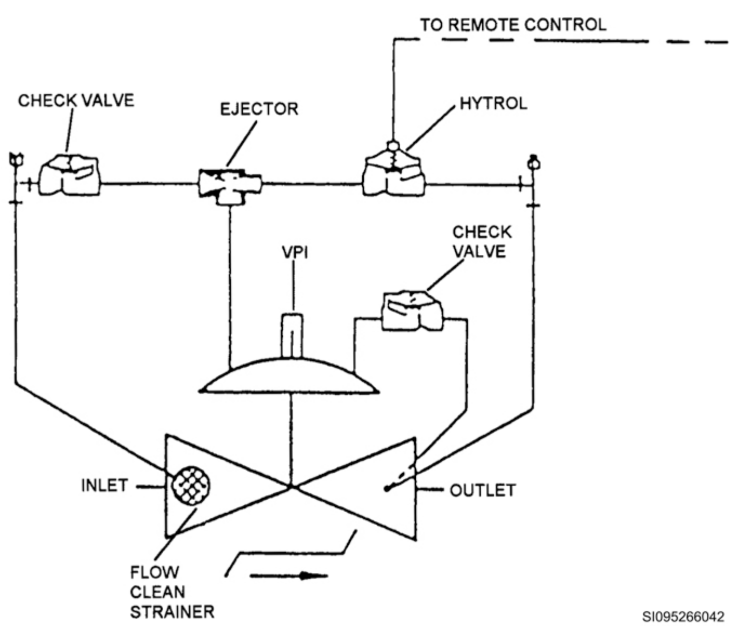


Figure 3–6. High-level shutoff valve, 413AF–5A. (By courtesy of Cla-Val Co.)

The float chamber must be accessible from the tank stairway. This requirement is necessary so the 413AF–5A can be operationally tested. A manual tester is incorporated on the float control so the rotary disc assembly and the 413AF–5A closing feature can be checked without filling the tank up with fuel to the high-level shutoff point.

Tank level indicators

The operating tanks have indicators that provide local and remote fuel level readings. Local reading means right at the tank; remote reading is a digital reading on the PCP graphic display.

Both units read in increments of feet and tenths of a foot. The servo compartment of the level indicator must be approved by Factory Mutual or Underwriters Laboratories (UL) and listed for use in Class 1, Division 1, Group D, for hazardous locations. It must also have a thermostatically controlled heater to protect it from condensation and freezing.

Tank level indicator alarms

Besides having a HLV, there are two high-level alarms on each tank. Like the high-level shutoff float chamber, the high-level alarm float chamber must be positioned on the tank to allow access from the tank stairway. These alarms are an added precaution in case the 413AF–5A fails to close. There is also a low-level alarm, which protects the fueling pumps.

You can hear and see these alarms. The PCP has an alarm annunciation panel and a graphic display that shows what condition exists. The alarm annunciation panel has windows with engraved and painted letters that are illuminated from behind. There are also visual indicators located on a graphic display. This display is a simple line drawing of the system with green, red, and amber lights. The PCP is covered in more detail later.

Low-level indicator alarm

This tank component activates the alarm annunciation, which gives a visual and audible alarm when the fuel level in the tank has reached a predetermined level. When the low-level alarm activates, it will sound a horn and cause the lights behind the annunciation alarm window, marked as low-level alarm, to flash. In addition, it will shut down any or all fueling pumps that might be operating at the time.

High-level alarm

The first high-level alarm is located just below the 413AF–5A float assembly and is a warning that the fuel is about to reach the float assembly. When fuel reaches the high-level alarm setting, the high-level alarm window on the PCP flashes and a *vibrating* horn sounds. After an operator acknowledges the alert condition, the visual indicator is steady and the horn shuts off. The steady light stays on until the fuel level falls below the high-level alarm setting.

High-high-level alarm

This high-high-level alarm is located just above the 413AF–5A float assembly and below the tank overflow vents. When fuel reaches the setting of the high-high-level alarm, the high-high-level alarm window on the PCP flashes and a *resonating* horn sounds. After an operator acknowledges the alert condition, the visual (PCP) indicator is steady and the horn turns off. The steady light remains on until the fuel level falls below the high-high level alarm setting.

Since the high-high-level alarm float is above the 413AF–5A float assembly, you will have to simulate the high-high-level condition to perform a manual test. To test the high-high-level alarm, you must first isolate the float assembly from the operating tank. Then slowly fill the float assembly with fuel until the audible and visual alarms activate. Once you test the alarm, drain the fuel from the float assembly through the drain valve before opening the tank isolating valves.

Outlet valve

This 12-inch manual valve is a non-lubricated double-block-and-bleed (DBB) valve and is located on the suction line of each of the two operating storage tanks. The outlet valve has a limit switch connected to it to indicate whether the valve is open or closed. In the Type III system, one outlet valve must be fully open and the other one must be fully closed. By having one valve open and one closed, the system tells the microprocessor which tank is being used so it only monitors that tank for a low-level condition.

Product-recovery tank

This tank is a separate system used to collect liquid (fuel and water) from the Type III system. Two-inch piping connects the pressure reliefs, strainer drains, F/S automatic water drains, low/high point drains, and the operating storage tanks water draw-off system. When the system components are opened for maintenance, automatically or manually, the fuel or water drains into this tank. This makes it nice for maintenance. For instance, if you had to remove a valve, you would only have to isolate the valve by using a low-point drain between the isolation valves. Once the valve is isolated, you can open the low-point drain and drain the fuel into the product-recovery tank. Once fuel is contained in the product-recovery tank, it can be pumped through the receiving F/S back into the operating storage tanks.

Tank design

The product-recovery tank is a 4,000-gallon, double-wall, steel tank with an interstitial leak monitor. The tank must conform to the requirements of UL–58, *Standard for Safety, Steel Underground Tanks for Flammable and Combustible Liquids*. The pit and access way is a steel vault with a rolling pit cover. The manhole is 36 inches in diameter and has a stainless steel or fiberglass ladder extending to the floor of the tank.

Leak detection monitor

The annular space provided between the primary and secondary tank walls allows all leaked products from the tank to be contained and flow freely. The leak detection system attached to the interstitial monitor is one of the following: vacuum maintenance, positive air pressure maintenance, hydrostatic pressure maintenance, or probe detection. You will have to find out what type of leak detector your particular system uses. The monitoring is continuous and is indicated in the pump control room. The control console generates a visual and audible alarm in the event a leak is detected. The audible alarm has a remote alarm annunciator, which can be heard around the system.

Pumps

The fuel-transfer pump for the product-recovery tank is a deep-well turbine pump with a capacity of 50 gpm when driven at 1,800 rpm. The single- or multi-stage vertical-column suction port is installed 6 inches from the tank floor. It can be automatically or manually operated. When set in the automatic mode, the float switch assembly operates the pump. The float switch assembly is a top-mounted, float-operated type, with a vertical float rod. The switch assembly is flange mounted and the float and trim are stainless steel. The switch is either a magnetically latching reed or a mercury-actuated switch that operates on 120-volts, 60-hertz alternating current (AC) power. When the tank is 70 percent full, the switch assembly automatically energizes the pump. Fuel is then routed through the receiving separators and into the operating storage tanks. When the tank becomes 80 percent full, the switch assembly sounds an alarm. Once the fuel is pumped out and the fuel level drops to 20 percent full, the pump shuts off.

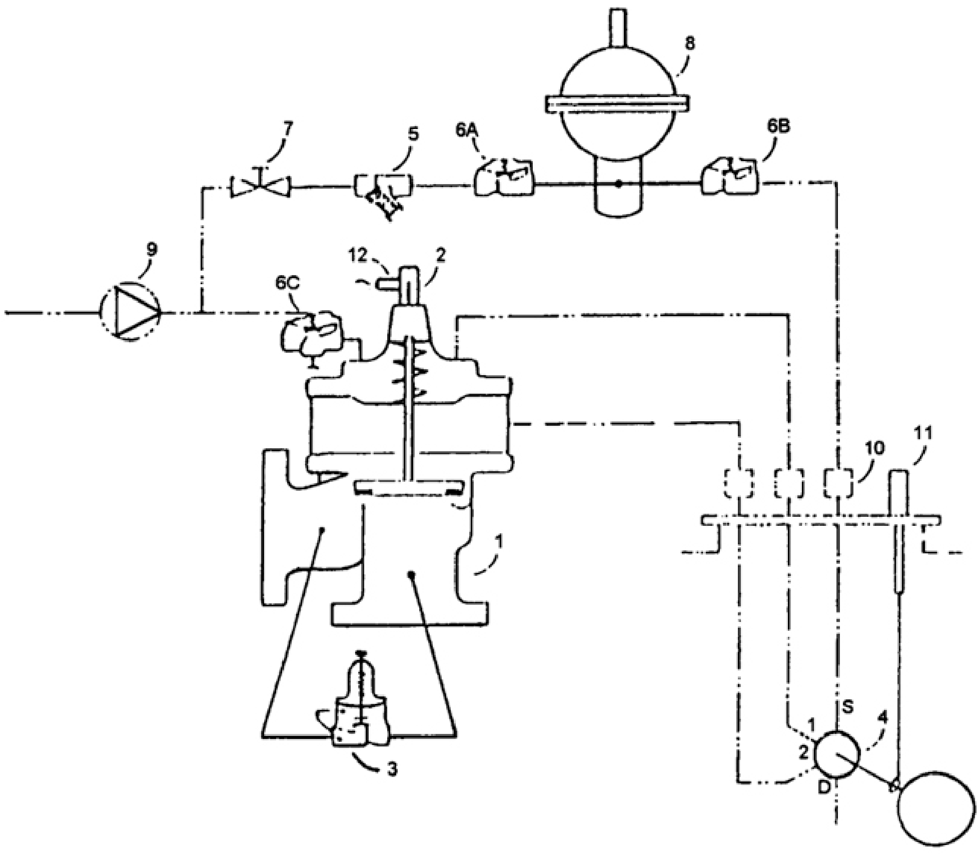
This tank also has a hand-operated pump for removing water. The hand pump is a double-action piston type that delivers liquid on every forward and backward stroke. It has a minimum capacity of one quart per full pump cycle. The pump is made of stainless steel and has a stainless steel suction screen. Connected to the hand pump is an 8-foot-long, $^{3}/_{4}$-inch diameter, API 1529, Grade 2 fuel-resistant hose with a standard aluminum open-end nozzle. This hose hangs on a built-in hose assembly hanger. The hose assembly drains completely when it is not in use. The pump is padlocked to prevent fuel from being pilfered.

Piping system

The entire product-recovery system consists of 2-inch piping and is routed throughout the Type III system. This piping connects the pressure relief, water draw-off, some low/high point drains, and F/S water drains to the product-recovery system. All of this piping merges into a fill line that has a hydraulically operated overfill valve (OV).

The OV 2129AF

This OV is a 2-inch, diaphragm-operated angle valve located on the system drain piping at the product-recovery tank shell. This valve closes anytime the liquid level in the tank reaches 80-percent full. It uses a float assembly similar to the float assembly used on the operating storage tanks, except it is located inside the product-recovery tank (fig. 3–7). This float assembly also has a manual tester; however, the tester is mounted externally (outside the tank) to prove the valves' operation. Whenever this valve is open, a limit switch, similar to the one on the 40AF–28G BPV, illuminates a green light on the PCP graphic display. A red light indicates the 2129AF is closed.



ITEM	BASIC COMPONENTS	QTY.	ITEM	BASIC COMPONENTS	QTY.
1	2100PKH POWERTROL (MAIN VALVE)	1	9	DISCHARGE PUMP SLOP TANK	1
2	X101 VALVE POSITION INDICATOR	1	10	EXPLOSION PROOF VALVE	3
3	55F PRESSURE RELIEF CONTROL	1	11	X76H MANUAL TESTER	1
4	CFM8 FLOAT CONTROL	1	12	X105M LIMIT SWITCH	1
5	X44A STRAINER & ORIFICE ASSY.	1			
6	81-01 CHECK VALVE	3			
7	CK2 BALL VALVE	1			
8	VSM5 PRESSURE RESERVOIR	1			

Figure 3–7. Overfill valve, 2129AF. (By courtesy of Cla-Val Co.)

Pressure reservoir

Previously, you learned that HLVs close when the main valves' inlet pressure is applied to the cover chamber. A tube is routed from the inlet of the 413AF–5A to the float assembly. When the float starts to rise, the inlet pressure is allowed to enter the cover chamber of the 413AF–5A. The 2129AF functions differently. This valve uses a pressure reservoir that is connected to the discharge of the product-recovery tank fuel-transfer pump. The fuel-transfer pump supplies pressure to the pressure reservoir and a check valve system holds the pressure in the reservoir. A supply line from the pressure reservoir is connected to a rotary disc assembly in the float.

When the tank is less than 80 percent full, the float is in the bottom position, aligning common supply with port 2 and common drain with port 1. With common supply and port 2 aligned, the pressure maintained in the pressure reservoir is applied to the 2129AF sensing chamber. Since the cover chamber of the main valve is vented through the common drain of the float assembly, the pressure in the sensing chamber overcomes spring tension on top of the diaphragm, holding the valve in the fully open position.

When the tank is 80 percent full, the float rises and aligns the common drain to port 2 and the common supply with port 1. Since the sensing chamber is now vented, and pressure from the pressure reservoir is applied to the main valve cover chamber, the main valve closes.

Thermal relief

Because the 2129AF would be held shut when the tank is 80 percent full, excess pressure is relieved using the product-recovery piping system. This is done by a CRL piped into the inlet and outlet of the 2129AF main valve body. Whenever the product-recovery piping system pressure reaches 200 psi, the pressure-relief control opens and allows the excess pressure to bleed around the OV.

420. Type III issuing equipment

Most of the issuing equipment is similar to the equipment taught earlier. There are some new items to discuss, but we won't spend much time on system components you already know. Since you know about the outlet valve on the operating storage tanks, we will start with the 16-inch manifold, located just before the fueling pumps, and move through the system the same as the fuel would move.

Manifolds

There are 3 manifolds or headers in the issuing pipeline system. The first one is known as a suction header and is located just upstream of the refueling pumps. This 16-inch suction header is necessary because the Type III system uses pumps that require a flooded suction. Depending on the system demands, 1, 2, 3, or 4 pumps could be running at one time; a smaller line would cause the pumps to starve. All pumps draw fuel from the same manifold. The pipelines connecting the first manifold to the fueling pumps are 8 inches in diameter and are further reduced to 6 inches in diameter before joining the pumps.

The second manifold, or pump discharge header, is directly after the pumps' rate-of-flow CV. This second manifold is 12 inches in diameter. The first manifold prevents the pumps from starving; this second manifold allows fuel to go through any of the 4 issuing F/Ss. The flexibility of this manifold is important. When the system is up and operating, all F/Ss are open and can receive fuel whether one or all pumps are running. Any pump can still be used even if an F/S requires an element change because the fuel can be routed through any of the remaining F/Ss.

A third manifold, or F/S discharge header, is found after the F/S's rate-of-flow CV. This is a 12-inch pipeline that goes directly to the hydrant outlets. All the F/Ss are piped into this line, which adds to the system flexibility.

Manual valves

The manual valves used in the Type III system are either ball valves or DBB non-lubricated plug valves.

All portions of these manual valves that come in contact with fuel are made of a non-corrosive material (e.g., stainless steel or chromium) or is nickel-plated. The stem and trim are also made of stainless steel. Manually operated valves that are 6 inches or larger are required to be worm-gear operated; valves smaller than 6 inches can be wrench operated, and valves smaller than 2 inches have a lever-type handle.

Pumps

The fueling pumps must meet the requirements of API 610, *Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries*. They must be single-stage centrifugal, horizontal mounted, vertical or radial split case, enclosed impeller, with end suction and top vertical discharge. The capacity of the pumps is 600 gpm when driven at 3,600 revolutions per minute (rpm). The pumps are statically and dynamically balanced for all flow rates, ranging from a rate of no flow to 120 percent of the designed rate. The housing is designed so you can remove the impeller, shaft, bearings, and bearing housing as an assembly, without disconnecting the suction or discharge piping.

Pump connections

The pump case end suction is 6 inches, and the centerline discharge is 4 inches. The end suction and centerline discharge are connected to the hard pipe by flexible metal hoses. These hoses have American National Standards Institute (ANSI) Class 300 flanges conforming to American Society of Mechanical Engineers (ASME) B16.5, *Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard*, and must be capable of withstanding 275 psi. They are made of a stainless steel, flexible, metal hose consisting of an inner corrugated stainless steel tube with a stainless steel braided cover.

Mechanical seal

The mechanical seal is a single unbalanced, multiple-spring type. The seal gland is tapped for three connections. They are marked Q for quench, F for flush, and D for drain. To minimize leakage on a complete seal failure, a non-sparking throttle bushing is pressed into the seal end plate against an outside shoulder.

Bearing housing

The bearings are an oil-lubricated, antifriction, radial-thrust type. They should give a minimum of 25,000 hours in continuous operation. The bearing housing has a sight glass so you can check the oil level.

Pump information

A service nameplate is attached to every pump. Use these nameplates, along with the manufacturers' catalogs kept in the Water and Fuel Systems Maintenance (WFSM) office, to gather information when pump parts have to be ordered. Information on the pump service nameplate is stamped with a minimum of the following:

- Manufacturer's name.
- Serial number of pump.
- Capacity in gpm.
- Pumping head (feet of water).
- Maximum specific gravity of fluid to be pumped.
- rpm.
- Horsepower of driver.

Motors

The motor is listed in UL listed for use in Class I, Division I, Group D hazardous areas and has a maximum temperature rating of “T2D–419 degrees F” as defined by National Fire Protection Agency (NFPA) 70.

The motor has a data plate. Some of the information found on the data plate includes:

- Manufacturer’s name.
- Serial number of pump.
- Rated volts and full-load amperes (amp).
- Rated frequency and number of phases.
- Rated temperature.
- Rated full-load speed.
- National Electric Code letters.
- Rated horsepower.
- Frame number.
- Service factor.

The motor and pump shafts are coupled together with a flexible and self-aligning coupling. The coupling is a spacer-type with sufficient length, so the mechanical seal assembly is replaced without removing the motor. Most couplings compensate for .010-inch to .020-inch misalignment but the vibration caused by the alignment condition is not reduced. Since vibration is a major cause of leaks, the pump and motor shafts must be aligned to within 0.002-inch tolerance. The coupling is provided with an Occupational, Safety, and Health Administration (OSHA)-approved coupling guard.

Flow switches

These normally opened switches are located immediately downstream of the fueling pump’s discharge line. They are flanged into the 6-inch pipeline using ANSI B16.5 Class 150 raised face flange. This vane-actuated switch closes a circuit anytime fuel flows through the pipeline. As the fuel moves through the pipeline, it raises the vane, which is connected to a shaft, closing the circuit. The vane is similar to a check valve flapper, but the vane does not prevent reverse flow. These switches are snap action switch mechanisms that are UL listed for Class 1, Division 1, Group D hazardous locations. They are double pole, double throw (DPDT) switches. The power rating for the switches is 120 volts, single-phase, 60 hertz, with a minimum 10 amps.

The flow switches have two purposes: to lock the fueling pumps on after they are called on by the microprocessor and to notify the microprocessor that the pump is pumping fuel. When the flow switch vane does not sense a flow within five seconds of a pump being called on, the microprocessor calls off the unresponsive pump and calls on the next sequenced fueling pump.

Nonsurge check valve 41AF–1A

You learned about the 81AF nonsurge check valve earlier. The 41AF–1A valve serves the same purposes as that valve did in those lessons; however, it has an additional function. This new function controls the flow through the pump. The flow controller is a differential pressure control that uses an orifice plate to create the differential pressure (fig. 3–8). This controller is no different from the flow controller used on the F/S fuel discharge valve. Its purpose is to control the flow rate at 650 gpm. Controlling the flow rate is important because it allows the fueling pump to operate efficiently. Remember, the fueling pumps are manifolded together so one or all pumps can pump through all the F/Ss at the same time. Without the 41AF–1A and with only one pump pumping through all four F/S, the pump would operate outside of its pump curve and eventually destroy itself.

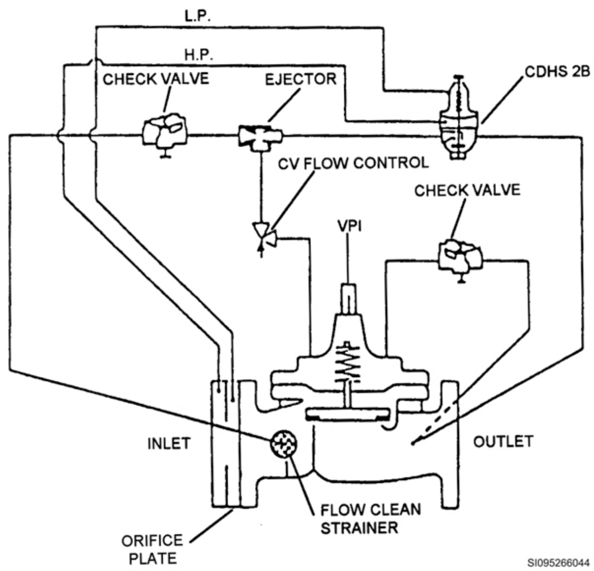


Figure 3–8. Rate-of-flow, nonsurge check valve, 41AF–1A. (By courtesy of Cla-Val Co.)

Issue F/Ss

These separators are connected in parallel and are manifolded at both the inlet and the outlet by 12-inch lines as we mentioned earlier when we covered manifolds. They are 600 gpm F/S and are the same type as the receiving separators you learned about earlier except that they use a different FSCV.

FSCV 41AF–2C

This valve operates the same as the 40AF–2C that we covered earlier except that the 41AF–2C (fig. 3–9) acts as a check valve to prevent reverse flow through the F/S. Two 81–01 hytrol check valves create this function. When outlet pressure is higher than inlet pressure, the check valve on the top left closes and the check valve on the bottom right opens. This directs the higher outlet pressure into the main valve cover chamber, and the main valve closes.

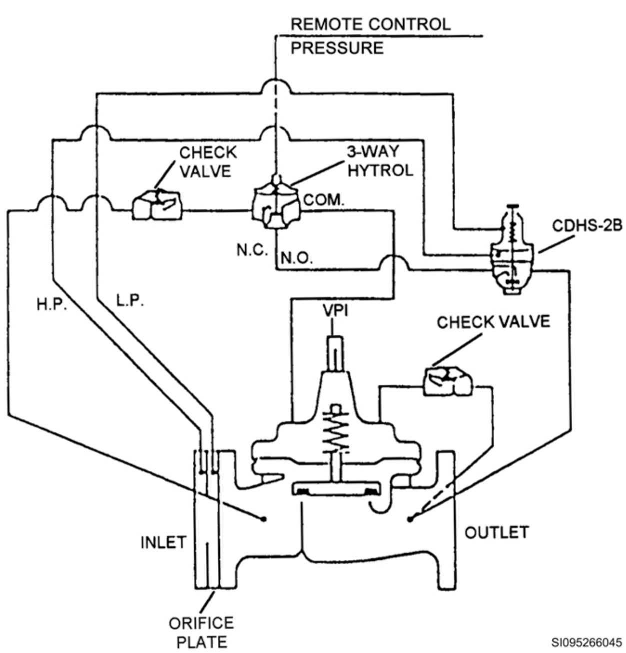


Figure 3–9. Filter/separator control valve, 41AF–2C. (By courtesy of Cla-Val Co.)

ESO valve 136AF–9B

The first component we need to look at in the hydrant loop is the ESO valve. This 12-inch automatic valve (fig. 3–10) is solenoid operated. The two solenoids (solenoid A and B) energize open anytime the system power is on. With the solenoids energized, this valve “free floats.” Free floating means that with any flow, the valve opens and allows fuel to flow through it unrestricted. Any time there is a power failure or an emergency-stop button is pushed, the solenoids deenergize closed, closing the 136AF–9B within 10 seconds. A thermal relief function protects the ESO. When the main valve cover chamber pressure exceeds inlet pressure, the ball check valve opens and relieves the higher cover pressure to the inlet.

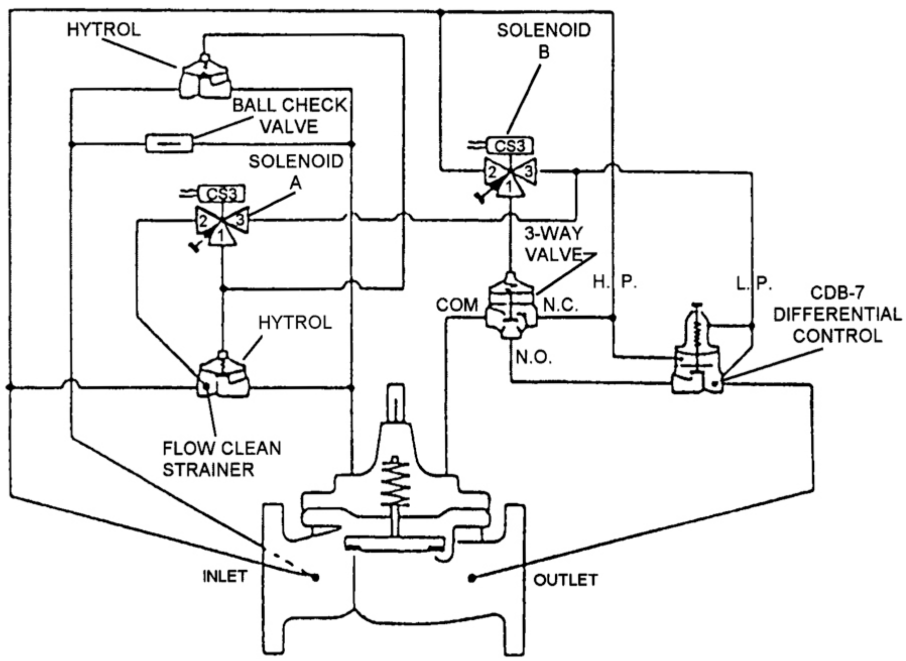


Figure 3–10. Emergency shutoff valve, 136AF–9B. (By courtesy of Cla-Val Co.)

Issue venturi tube

The 10-inch issue venturi tube is located downstream of the 136AF–9B ESO valve and is rated at 2,400 gpm. It is a low-loss differential pressure producer and operates on the same principle as the orifice plate, but it is much more accurate. This venturi consists of a short housing piece and a fully machined, contoured throat section. This contoured throat provides a restriction at the center, with an inlet approach and an exit having geometrically symmetrical curves. This tube has four ½-inch connections for the differential pressure transmitters (DPT).

Return venturi tube

The 4-inch return venturi tube is located upstream of the 58AF–9 valve in the hydrant loop return line. It has the same design characteristics as the issue venturi but is rated at 800 gpm.

Surge suppressors

Surge suppressors (or arrestors) are often installed on the issue and return lines to absorb surges generated by the issue and return CVs (fig. 3–11). Surge suppressors are also useful on fill stands to absorb the surges generated by the fill stand CV. Surge suppressors absorb pressure surges using a bladder contained within a steel vessel. The bladder contains nitrogen at a specific pressure and is typically able to absorb surges 4 times greater than the bladder pressure.

Located below the surge suppressor is a check valve with a hole through the internal valve. When a surge enters the open check valve and is absorbed by the bladder, it is trapped and allowed to return to the system slowly through the hole in the check valve.

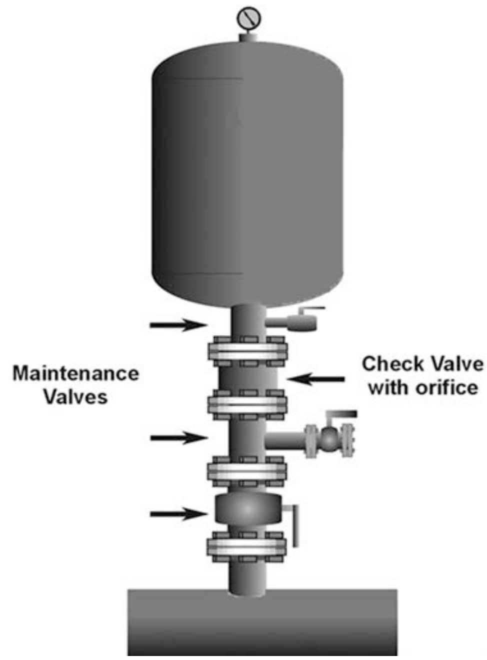


Figure 3–11. Surge suppressor.

In order to check the bladder pressure, you must use the maintenance valves to isolate the unit from the system pressure and vent the area below the bladder to the atmosphere. Once done, you can check the bladder pressure and add nitrogen through the Schrader valve located near the pressure gauge.

Transmitters

This system uses pressure transmitters to start and stop the fueling pumps. There are two different kinds: pressure-indicating transmitters (PIT) and DPTs; each serves a different function. Two PITs are piped into the issue line downstream of the 136AF–9B ESO valve. For systems of 2,400 gpm or less, there are four DPTs piped to the return venturi and two piped to the issue venturi. The microprocessor reads each transmitter so it can get a clearer picture of how the system is operating and determines when it should call a pump on or off.

Older style DPTs consist of a dual-opposed, liquid-filled, rupture-proof bellows-type pressure sensing element operating on differential pressure. The bellows drives a mechanical indicator. This mechanical indicator converts the bellows' movement to a rotation movement transmitted by a torque tube. Newer style electronic DPTs use a tantalum membrane with sensors to detect membrane deflection. Both types of transmitters have an analog two-wire electrical output signal of 4–20 milliamps (mA). This signal is directly proportional to the pressure it senses. A remote power supply located in the PCP provides power to the signal loop.

The bellows housing has a rated working pressure of no less than 500 psi with a minimum differential pressure range of 0–250 psi. The indicator or pointer has an accuracy of .5 percent of its full range, and the transmitter has an accuracy of .25 percent of the pointer indication's range. They have a built-in pulsation damper and a suitable over-range protection. Each transmitter has a vent valve connected to the upper ports to bleed off air. The PIT has a factory assembled two-valve stainless steel manifold, and the DPT has a five-valve stainless steel manifold. They are approved by UL for Class 1, Division 1, Group D, hazardous locations.

PITs

There are two, ½-inch connections for the bellows. On the PIT, the high-pressure side is piped to the issue line, and the low-pressure side opens and senses atmospheric pressure. The PITs have a 6-inch dial face and are read in psi. They sense direct fuel pressure from the issue line and convert that pressure into a signal that can be interpreted by the microprocessor. As we stated before, this signal is a 4–20 mA signal and is directly proportional to the psi sensed. For example, when the system is at zero psi, a 4 mA signal is sent to the microprocessor; when a 250-psi transmitter senses 125 psi in the issue line, a 12 mA signal is sent to the microprocessor. The PIT's primary purpose is to call on the lead pump when system pressure drops below 60 psi and to call off the lead pump when system pressure reaches 175 psi. Remember the PIT only starts the lead pump; the flow switch locks the lead pump on.

You calibrate the PIT by verifying the mA signal sent to the microprocessor. Using an ammeter, you must ensure there is a 4 mA signal being sent to the microprocessor when there is zero psi on the system. Next you must ensure there is a 20 mA signal being sent to the microprocessor when the transmitter is at its maximum psi (250 psi on a 0–250 psi transmitter). If there is a difference in the psi being sensed and the mA signal sent to the microprocessor, then you must adjust the mA output by turning the adjustment screw in the back of the PIT.

DPTs

The DPTs are similar to the PITs; however, there are some differences because the functions are not the same. Their purpose is to sense flow and tell the microprocessor when an additional pump is needed or when to shut off a pump. As we stated before, the signal sent by the DPT is a 4–20 mA signal and is directly proportional to the differential pressure being sensed from the venturi. For example, when the system is at zero flow, a 4 mA signal is sent to the microprocessor. When there is 2,400 gpm flowing through the issue venturi, the issue DPT sends a 20 mA signal to the microprocessor. As we mentioned before, in systems where the flow is 2,400 gpm or less, there are six DPTs and they work in concert to establish the required flow rate.

Two DPTs are piped to the issue venturi tube, and four are piped to the return venturi. The issue venturi tube creates the differential pressure. The H.P. side of the bellows is connected to the upstream side of the venturi tube, and the L.P. side is connected to the center of the contoured throat of the venturi tube.

The DPT indicating dial is also 6 inches in diameter, but the scale is different from the PIT. This scale is graduated over the selected pressure ranges, so the flow rate can be read in gpm. The two issue venturi DPTs sense and indicate 0–2,400 gpm flow rates. The four return venturi DPTs are classified as low- and high-range. The two low-range DPTs sense and indicate 0–100 gpm and the two high-range DPTs sense and indicate 0–800 gpm.

DPT calibration

You calibrate the issue and return DPTs with the use of two *manometers,* a conversion chart, and an ammeter. The manometer looks like a giant thermometer but it measures inches of water pressure. The conversion chart is unique to a specific venturi and converts inches of water differential to gpm. You must observe the inches of water differential between the two manometers and use your conversion chart to figure the gpm. For example, one manometer reads 100 inches of water pressure, and the other manometer reads 80 inches of water pressure, so you have 20 inches of water pressure differential. The conversion chart shows 20 inches of water pressure differential might equal 200 gpm. Use the ammeter to measure the mill amperes sent from the DPT to the microprocessor.

Issue DPT calibration

On the issue venturi, there are five points you must calibrate: 0 gpm; 600 gpm; 1,200 gpm; 1,800 gpm; and 2,400 gpm. To calibrate the DPT on the issue venturi you must:

1. Set up your system manual valves to refuel.

2. Pipe one manometer into the H.P. port of the issue venturi and the other manometer into the L.P. port of the issue venturi.
3. Bleed all the air from the lines and ensure there are no leaks between the venturi and the manometer.
4. Turn the manual override on the backpressure control valve (BPCV) solenoid clockwise to enable the valve to maintain NOP.
5. Using the ammeter, ensure a 4 mA signal is being sent to the microprocessor when there is zero flow through the issue venturi.
6. Manually turn on one pump at a time.

With one pump running and 600 gpm flowing through the issue venturi, observe the DPT and the manometer to ensure they are both reading 600 gpm. If they are not the same, you must adjust the pointer or the digital readout to correct the error. Once the manometer and the DPT are reading the same, use your ammeter to measure the mA output. At 600 gpm, the DPT output should read 8 mA. If the mA output is anything other than 8 mA, you must adjust the output by turning the adjustment screw in the back of the DPT.

With two pumps running and 1,200 gpm flowing through the issue venturi, observe the DPT and the manometer to ensure they are both reading 1,200 gpm. If they are not the same, you must adjust the pointer or the digital readout to correct the error. Once the manometer and the DPT are reading the same, use your ammeter to measure the mA output. At 1,200 gpm, the DPT output should read 12 mAs. If the mA output is anything other than 12 mAs, you must adjust the output by turning the adjustment screw in the back of the DPT.

With three pumps running and 1,800 gpm flowing through the issue venturi, observe the DPT and the manometer to ensure they are both reading 1,800 gpm. If they are not the same, you must adjust the pointer or the digital readout to correct the error. Once the manometer and the DPT are reading the same, use your ammeter to measure the mA output. At 1,800 gpm, the DPT output should read 16 mAs. If the mA output is anything different from 16 mAs, you must adjust the output by turning the adjustment screw in the back of the DPT.

With four pumps running and 2,400 gpm flowing through the issue venturi, observe the DPT and the manometer to ensure they are both reading 2,400 gpm. If they are not the same, you must adjust the pointer or the digital readout to correct the error. Once the manometer and the DPT are reading the same, use your ammeter to measure the mA output. At 2,400 gpm, the DPT output should read 20 mAs.

If the mA output is anything different from 20 mAs, you must adjust the output by turning the adjustment screw in the back of the DPT.

Once you are done, return the system to its normal operating condition.

Return DPT calibration

There are two separate sets of DPT on the return venturi: the low-range DPT has a range from 0–100 gpm and the high-range DPT has a range from 0–800 gpm. The high-range DPT has three points you must calibrate: 0 gpm, 560 gpm, and 700 gpm. The low-range DPT has two points you must calibrate: 0 gpm and 40 gpm.

To calibrate the high- and low-range DPT on the return venturi, you must:

1. Set-up your manual valves to refuel.
2. Pipe one manometer into the H.P. port of the return venturi and the other manometer into the L.P. port of the return venturi.
3. Bleed all the air from the lines and ensure there are no leaks between the return venturi and the manometer.

4. Turn the manual override on the BPCV solenoid clockwise so the valve maintains NOP.
5. Using the ammeter, ensure a 4 mA signal is being sent from the DPT being tested to the microprocessor when there is zero flow through the return venturi.
6. Manually turn on one pump at a time.

With one pump running, adjust a manual valve on the return line to establish a 560 gpm flow rate through the return venturi. With 560 gpm flowing through the return venturi, observe the high-range DPT and the manometer to ensure they are both reading 560 gpm. If they are not the same, you must adjust the pointer or the digital readout to correct the error. Once the manometer and the high-range DPT are reading the same, use your ammeter to measure the mA output. At 560 gpm, the high-range DPT output should read 15.2 mAs. If the mA output is anything other than 15.2 mAs, you must adjust the output by turning the adjustment screw in the back of the high-range DPT.

With two pumps running, adjust a manual valve on the return line to establish a 700 gpm flow rate through the return venturi. With 700 gpm flowing through the return venturi, observe the high-range DPT and the manometer to ensure they are both reading 700 gpm. If they are not the same, you must adjust the pointer or the digital readout to correct the error. Once the manometer and the high-range DPT are reading the same, use your ammeter to measure the mA output. At 700 gpm, the high-range DPT output should read 18 mAs. If the mA output is different from 18 mAs, you must adjust the output by turning the adjustment screw in the back of the high-range DPT.

With one pump running, adjust a manual valve on the return line to establish a 40 gpm flow rate through the return venturi. With 40 gpm flowing through the return venturi, observe the low-range DPT and the manometer to ensure they are both reading 40 gpm. If they are not the same, you must adjust the pointer or the digital readout to correct the error. Once the manometer and the low-range DPT are reading the same, use your ammeter to measure the mA output. At 40 gpm, the low-range DPT output should read 10.4 mAs. If the mA output is different from 10.4 mAs, you must adjust the output by turning the adjustment screw in the back of the DPT.

Once you are done, return the system to its normal operation condition.

There are many types of DPTs and PITs throughout the AF, so be sure to refer to your base's operation and maintenance (O&M) manuals for the specifics on the DPTs and PITs installed at your base.

421. Type III hydrant loop and return line equipment

The hydrant loop is exactly what the name implies—a loop. Fuel enters the loop, which is downstream from the 136AF–9B, and is routed under the flight line, connecting all the hydrant outlets and then returning to the pumphouse.

Hydrant loop

This loop is pressurized at 75 psi when idle. That is why some people refer to this system as a constant pressure system. When the system idles and the system pressure reaches 75 psi or greater, through thermal expansion, a valve opens and relieves pressure to the operating storage tank. When the system is in the automatic mode, if system pressure drops below 60 psi, a PIT senses the drop and calls on the designated lead pump.

Hydrant outlets

The number and location of hydrant outlets are based on the type of aircraft and mission fueling requirements. No matter how many outlets there are, they are all the same type. The first thing we will cover is the pit itself. The hydrant outlet pit is a molded fiberglass pit with an aluminum-counterweighted cover. The cover opens 90 degrees and should only take 30 lb. of pull to open and 50 lb. of push to close it. A Buna-N boot seals the fuel issue pipe at the floor. This boot is secured by stainless steel clamps that are connected to a metal collar, which is welded to the pipe riser and to a flange where the pipe penetrates the pit floor. The first component after the boot is a ball valve. This ball valve is either 4 or 6 inches, depending on the size of the system. A system designed to issue 600 gpm through the hydrant outlet uses a 4-inch riser. A system that issues 1,200 gpm has a 6-inch riser.

Hydrant control valve 362AF–8

The hydrant control valve (HCV) (fig. 3–12), like the hydrant pit ball valve, is sized according to the system's output. Again, if the system is designed for 600 gpm, it uses a 4-inch valve. If it is designed for 1,200 gpm, it uses a 6-inch valve. The main purpose of this valve is to maintain constant nozzle pressure and to relieve excess nozzle pressure.

A fuel-sensing line is connected from a venturi on the R–12 hydrant-servicing vehicle to the remote-sensing pressure-reducing control (CRA) and the CRL on the 362AF–8. The R–12 venturi has been calibrated so these controls have the same pressure as the actual nozzle pressure at the skin of the aircraft. The CRA uses the pressure from the R–12 venturi to maintain a constant nozzle pressure of 45 psi for any flow rate ranging from 50 to 600 gpm or 50 to 1,200 gpm, depending on the system design.

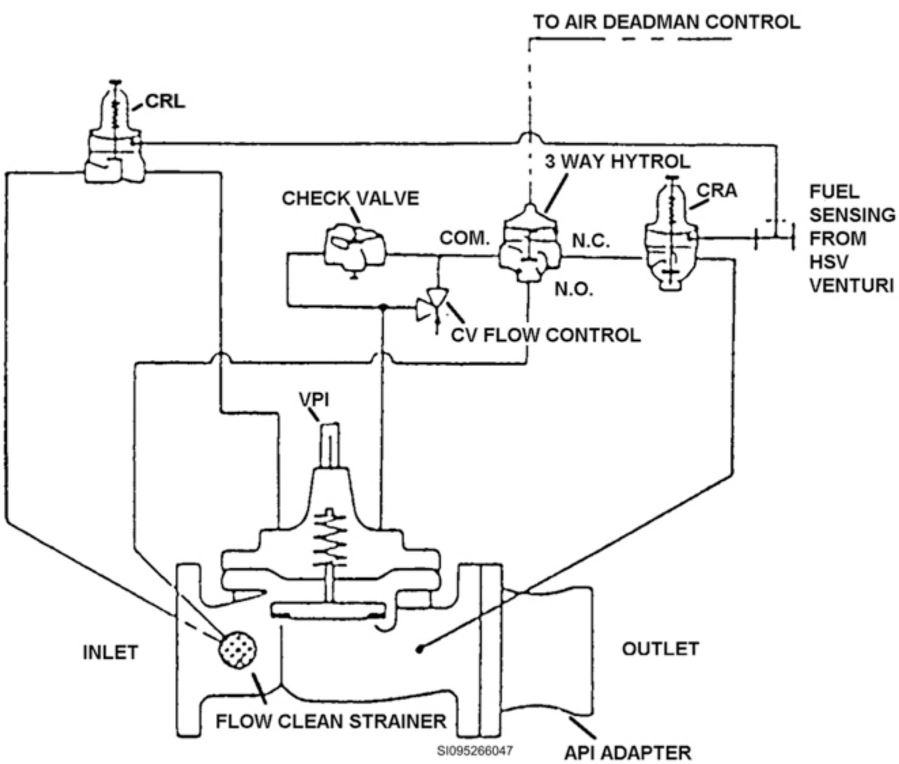


Figure 3–12. Hydrant control valve, 362AF–8.

The 362AF–8 closes rapidly anytime the nozzle pressure exceeds the CRL's set-point of 50 psi and reopens when the pressure drops below that set-point, but only if the deadman control is still activated. The R–12 has a secondary pressure-relief control, the *Brooks valve*, which is designed to relieve excess nozzle pressure at 55 psi. The set point of the Brooks valve is dictated by the air sense pressure setting on the R–12. The air sense pressure must be set 10 psi above the pressure-relief setting required from the Brooks valve. Setting the air sense pressure at 65 psi closes the Brooks valve and relieves excess nozzle pressure at 55 psi.

The *deadman control* is a pneumatically operated control. An air tank on the R–12 provides the air pressure. The deadman is connected to a three-way hytrol in the 362AF–8 pilot system. When the deadman lever is pressed, air is applied to the cover chamber of the three-way hytrol, and the

362AF–8 opens. When the deadman is released, the main valve closes. Should the deadman hose rupture and bleed air from the R–12, the main valve closes in a maximum of five seconds.

Return line

The hydrant loop remains pressurized because the return line has an automatic valve that keeps the loop closed. When this automatic valve opens, fuel returns to one of the operating storage tanks. Do you remember learning back in the tank receiving line lesson that there was a loop that had four valves in it? Just to refresh your memory, this loop not only determines which tank receives fuel from the receiving line, it also determines which tank receives fuel from the return line. When fuel flows through this loop, the fuel passes through the HLV, which protects the tank from overfilling.

BPCV 58AF–9

You have already read that pressure is kept on the hydrant loop by an automatic valve. That automatic valve is a 58AF–9 BPCV (fig. 3–13). This 6-inch automatic valve is capable of flowing up to 2,400 gpm. It is set to open when the loop pressure at the farthest hydrant outlet reaches 100 psi. It adapts to control the hydrant outlet inlet pressure at 100 psi. The set point on this valve is adjustable and has a range of 20 to 200 psi. The 58AF–9 also acts as a check valve to prevent reverse flow.

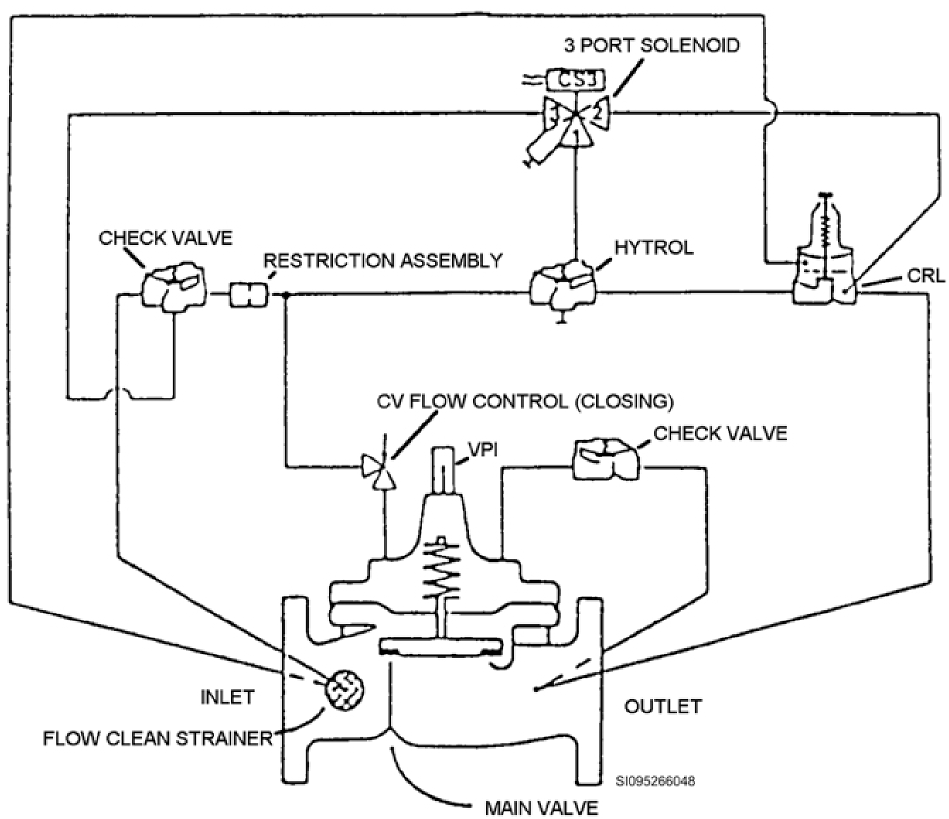


Figure 3–13. Back pressure control valve, 58AF–9. (By courtesy of Cla-Val Co.)

This valve has an electrical solenoid that automatically energizes when the lead pump is called on and deenergizes when the issue venturi DPT senses 600 gpm *and* the return venturi DPT senses a 560 gpm flow rate for 60 seconds with only the lead pump running. When the solenoid is energized, the valve can open when the pressure exceeds the set point of the CRL (100 psi, measured at the furthest hydrant outlet). When the solenoid is deenergized, the valve inlet pressure is applied to the main valve cover chamber to close the valve.

Because of the amount of fuel moving in the hydrant loop and the possibility of a hydraulic shock, the 58AF–9 has to close slowly and therefore has a speed control on it. The speed control (CV flow control) controls only the closing rate and has no effect on the opening rate. The control has an adjustable range of 2 to 30 seconds and is adjusted to close the valve in 3 seconds.

Pressure control valve 58AF–3

As you now know, the hydrant loop is pressurized constantly, and the 58AF–9 BPCV valve opens only when the lead pump is energized and loop pressure increases to 100 psi. What takes care of any thermal expansion or pressures in the loop that exceed 75 psi when the system is idle? The BPCV won't because if the lead pump is not energized, its solenoid holds the valve closed. That's right, there has to be another valve. That valve is the pressure control valve (PCV) (fig. 3–14).

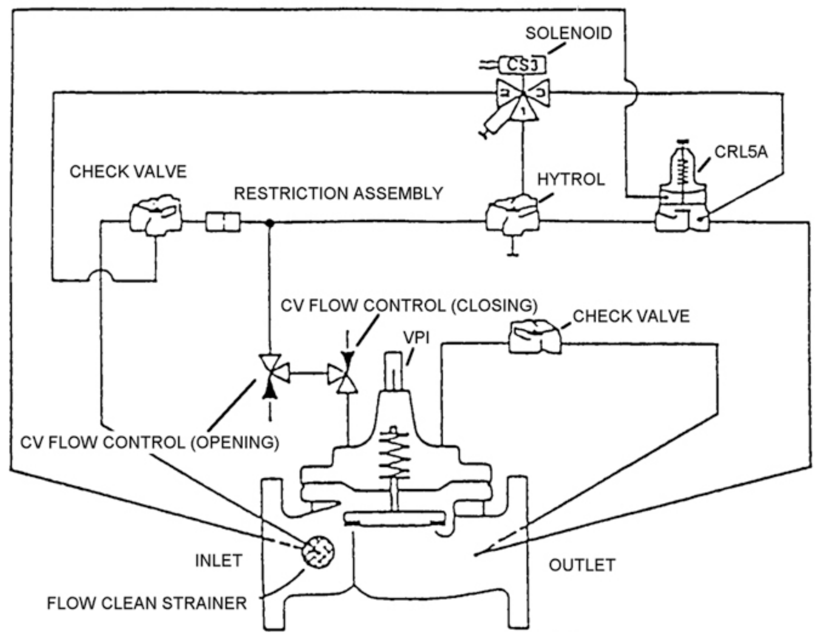


Figure 3–14. Pressure control valve, 58AF–3. (By courtesy of Cla-Val Co.)

The 58AF–3 PCV is a 2-inch automatic valve, capable of 50 gpm flow rates under normal operating conditions. It has a pressure relief and solenoid on it. The solenoid is energized to close the valve *anytime* a pump is running and deenergizes when the pump stops. When the solenoid is deenergized, the pressure relief is allowed to function. The pressure relief has an adjustable range of 20 to 200 psi and is set to close the valve at 75 psi. The inlet piping of the 58AF–3 valve is tapped into the issue piping downstream of the issue venturi, and the outlet piping is tapped into the return piping downstream of the 58AF–9. Thus, excess pressure that bleeds through this valve bypasses the hydrant loop and the 58AF–9.

The opening and closing rates of the 58AF–3 are controlled. The speed controls (CV flow controls) have an adjustable range of 2 to 30 seconds. Both are set at 3 seconds.

Defuel/flush valve 58AF–9–1

The defuel/flush valve (D/FV) is an 8-inch, solenoid CV. In fact, it has two solenoids (fig. 3–15). Solenoid A controls the defuel portion of the main valve and its purpose is to hold the valve closed anytime a fueling pump is running. Solenoid B controls the flush portion of the main valve and functions only when the system is placed in the flush mode. What, then, is this valve's purpose?

As we said, the valve will not open anytime a fueling pump is energized (just like the 58AF–3 PCV). However, when all the pumps are deenergized, it opens and assists the 58AF–3 PCV in reducing the hydrant loop pressure. As soon as the lead refueling pump deenergizes, solenoid "A" energizes, allowing the valve to open and remain open until the loop pressure drops to 80 psi. At 80 psi the valve closes, leaving the remaining 5 psi to be relieved by the 58AF–3 PCV.

Its second function is to allow defueling when the system is idle. You already know that, when the fueling pumps are not energized, this valve is capable of opening. With solenoid “A” energized we know that this valve closes when hydrant loop pressure drops to 80 psi. Well, that also means anytime the hydrant loop pressure rises above 80 psi and none of the fueling pumps are energized, the D/FV opens. So, if the system is idle and an aircraft needs to be defueled, just increase the hydrant loop pressure above 80 psi. The pressure required to open the 58AF–9–1 D/FV is developed by a defuel pump on the R–12 hydrant servicing vehicle. The R–12 defuel pump is rated for 300 gpm at 165 psi. Fuel defueled off of the aircraft flows through the R–12, 362AF–8 HCV, and 58AF–9–1 D/FV, then back to the operating storage tank.

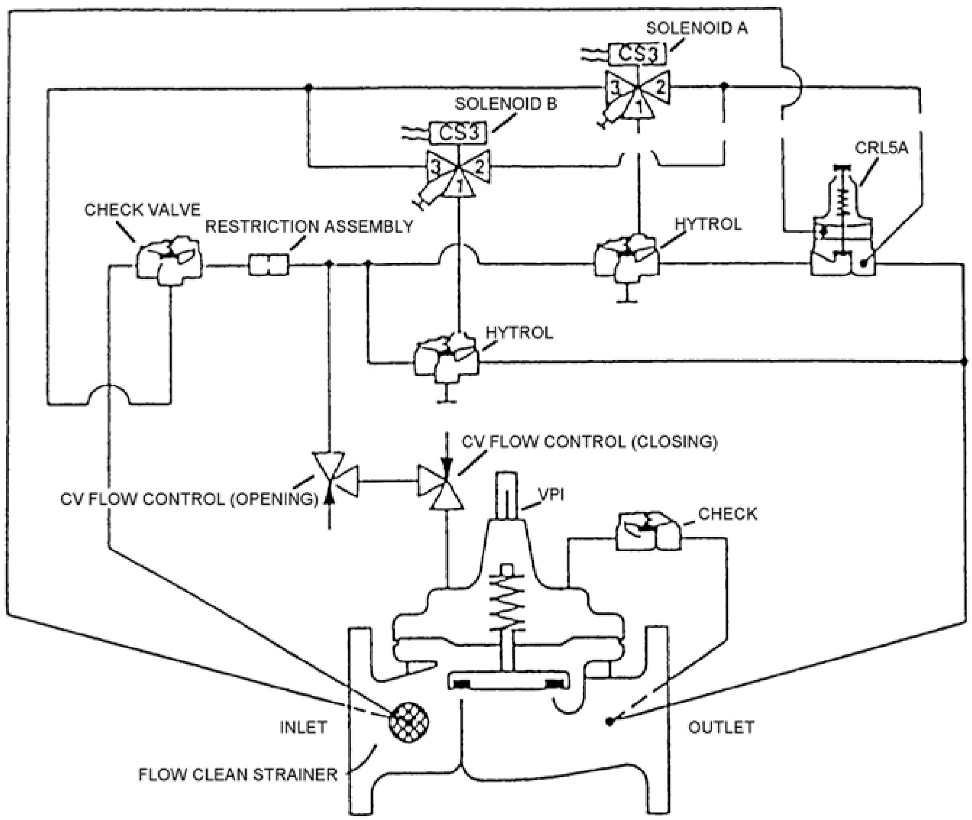


Figure 3–15. Defuel/flush valve, 58AF–9–1. (By courtesy of Cla-Val Co.)

The 58AF–9–1’s final function is, as its name implies, flushing the system. Solenoid “B” energizes *only* when the system is placed in the flush mode. The reason for system flushing is to move fuel through the pipeline as fast as possible and to clean the loop. With the system in the flush mode, energize all available fueling pumps by placing the pumps’ Hand-Off-Auto switch in the “Hand” position to obtain maximum feet per second (fps) flow in the hydrant loop. The 58AF–9–1 D/FV valve opens, allowing the fuel to circulate through the system at a rate of 600 to 2,400 gpm, depending on the number of fueling pumps used.

Return venturi tube and differential pressure transmitters

Just upstream of the BPCV is a 4-inch (diameter) return venturi tube. This venturi tube is identical to the issue venturi tube, only smaller. Connected to it are four DPTs, which are the same as the DPTs mentioned earlier. Two of the DPTs are low-range and two are high-range. The low-range DPTs sense and indicate flow ranges from 0 to 100 gpm, and the high-range DPTs sense and indicate 0 to 800 gpm flow rates.

R-12 hydrant servicing vehicle check-out stand

The checkout stand is made up of the same components that are found in the hydrant outlet pit plus a little more. There is a 362AF–8 HCV, a 364AF–2 API adapter, four 2 ½-inch single point receptacles (SPR), manual valves, and an ESO switch. The 362AF–8 is piped into the hydrant loop just downstream of the issue venturi.

The R–12 has two straight-throat and two 90-degree-angle single-point nozzles. The two straight-throat nozzles are connected to SPRs mounted on a 14-foot riser, which extends over the place wherever the R–12 parks. These two overhead receptacles are not only for testing the straight-throat nozzles but also afford an opportunity to check the hydraulic lift the R–12 provides when using those nozzles. The two 90-degree-angle single-point nozzles are connected to the SPRs located close to ground level, usually not more than 3 feet off the grade. Both of these pipes, which contain the SPRs, are piped into the return line, downstream of the 58AF–9.

R–12 hydrant servicing vehicle

The R–12 hydrant servicing vehicle contains equipment and accessories for making fuel transfers between a hydrant fueling system and an aircraft (fig. 3–16). The R–12 is equipped with two ground fuel servicing hoses (2.5 inches in diameter x 60 feet in length) and two lift platform hoses (2.5 inches in diameter x 10 feet in length). Both types of hoses are equipped with single-point nozzles that are connected to the aircraft to be fueled. In addition, there is an inlet hose (4 inches x 30 feet in length) that is equipped with a hydrant coupling (moosehead) that connects to the 364AF–2 API adapter in the pit.

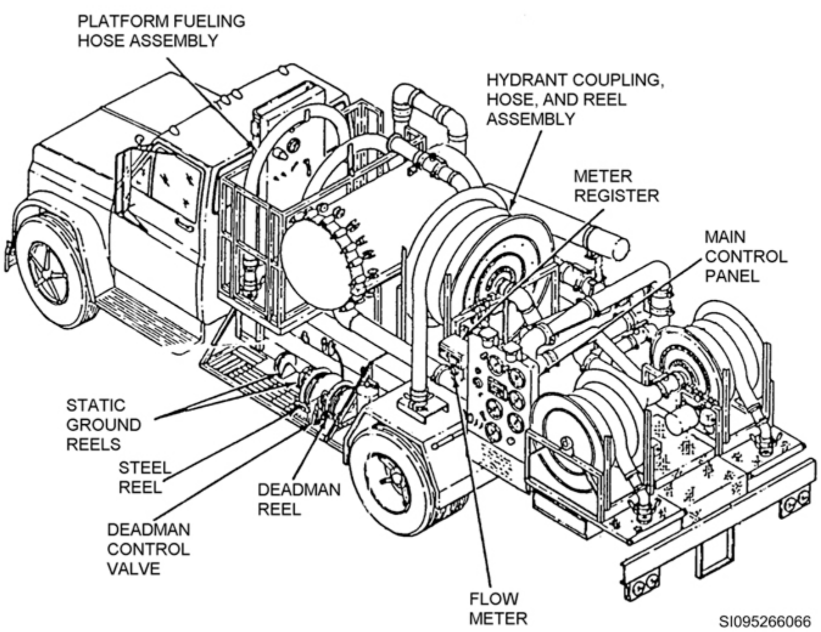


Figure 3–16. R–12 hydrant servicing vehicle.

The R–12 has two small hoses that connect to the 362AF–8. One hose connects the pressure compensating venturi on the R–12 to the 362AF–8 CRA and CRL. It provides fuel pressure to operate these components. The other small hose connects to the cover chamber on the three-way hytrol. When the deadman is depressed, this hose provides air pressure to the three-way hytrol allowing the main valve to open.

When you troubleshoot a Type III system, you should observe certain components located on the control panel (fig. 3–17): surge suppressors, hydrant pressure gauge, nozzle pressure gauge, and air sense pressure gauge.

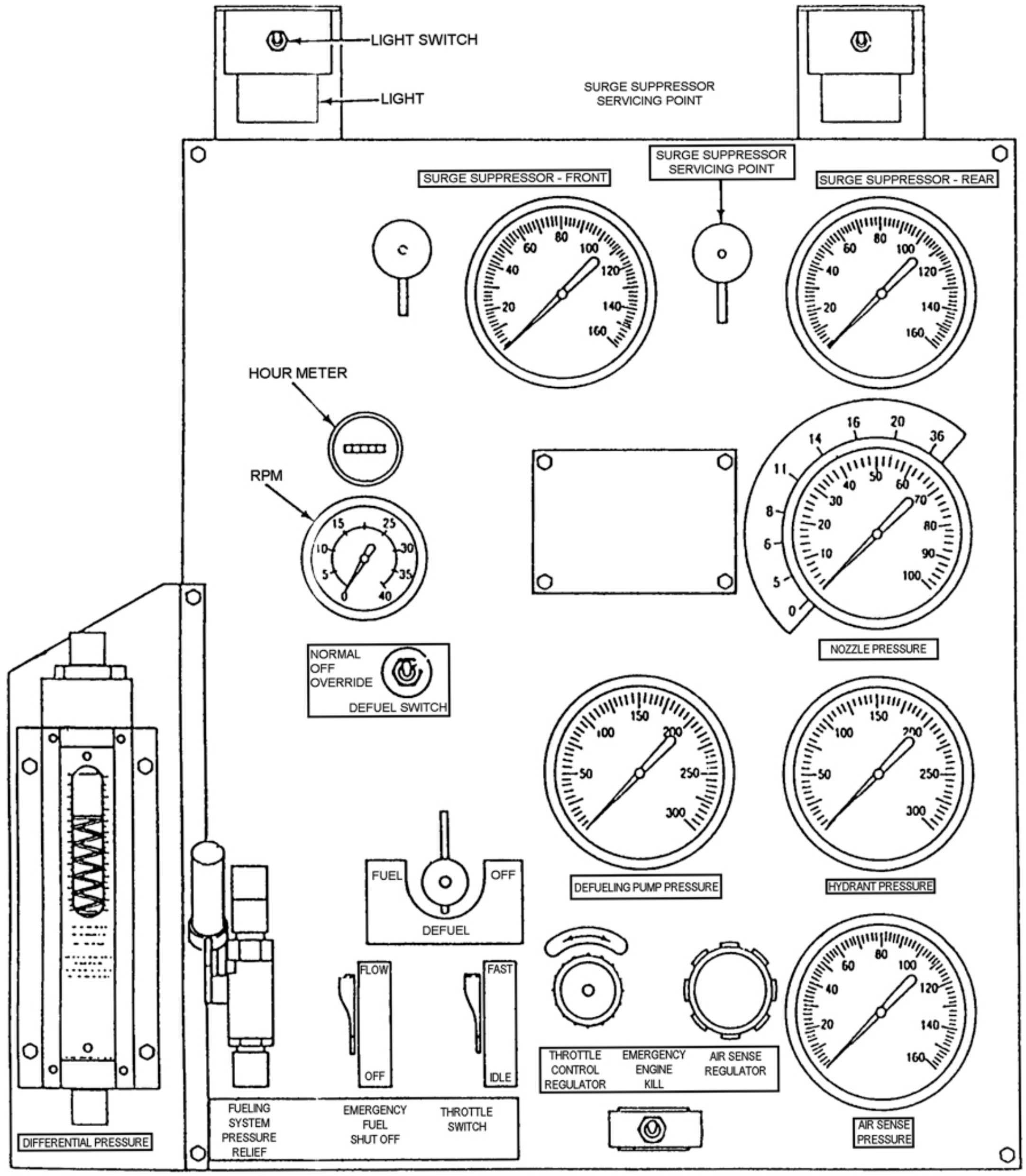


Figure 3–17. R–12 control panel.

The two *surge suppressors* should be charged with a minimum of 65 psi nitrogen. If the pressure falls below 65 psi, you could notice a pulsation in the system pressure when refueling. This is due to having pressure in the surge suppressor too close to the refueling fuel pressure.

The *hydrant pressure gauge* indicates the pressure at the 362AF–8 outlet. Observing this gauge will tell you whether the 362AF–8 valve is open or closed.

The *nozzle pressure gauge* indicates the pressure at the single-point nozzle, which connects to the aircraft for refueling. There are two pressure scales on the nozzle pressure gauge. The inner scale is the one used most, so just disregard the outer scale.

The *air sense pressure gauge* indicates the air pressure within the R–12 and controls the Brooks valve closure. As we said earlier, the air sense pressure needs to be set at 65 psi to ensure the Brooks valve closes at the desired 55 psi. If the air sense pressure is below 65 psi, turn the air sense regulator clockwise to increase the air pressure; if the air sense pressure is above 65 psi, turn the air sense regulator counterclockwise to decrease the air pressure.

422. Type III pump control room equipment

You should now have a basic understanding of how the equipment in the system is used to store, route, clean, and deliver the fuel. Now it is time to look at the brain of the fuel system—the control center.

Pump control room

In past units, you learned a little about the pump control rooms. This is the place where you could select which pit the fuel is pumped to, what pumps to use, and where you turn the power on to operate the system.

The Type III system pump control room can be called the control center because it does all the things mentioned above and more. From the control room, you can determine what the hydrant loop pressure is, how much fuel is in the storage tanks, and the last flow capacity used during a refueling operation. It is probably the first place to go when a job order comes down telling you the system is not working properly. This brain center offers a lot of answers to assist you in determining what and where the problem(s) are and how to correct them.

Pump control panel

As soon as you walk into the pump control room, you will notice that it is probably larger than the ones in the Type I or II hydrant systems. One of the things you may see first, or at least be most interested in, is the PCP shown in figure 3–18. On the front of the PCP is a graphic display (fig. 3–19). The graphic display is a diagram showing the system as a line drawing. Although not shown here, the green lines on this graphic display indicate the receiving and hydrant loop return line. The yellow lines indicate the pump suction, from the storage tank discharge lines to the inlet of the pumps. Yellow lines also show the water draw-off lines from the F/Ss and pressure-relief valves that go to the product-recovery tank. Blue lines are the pump discharge and hydrant loop up to and including the 58AF–9 BPCV, 58AF–3 PCV, and 58AF–9–1 D/FV.

The display is not just a diagram. You can see how much fuel, to the tenth of a foot, is in each tank, including the product-recovery tank; what valves are open (indicated by a green light); and which valves are closed (indicated by a red light). Just by looking at the panel, you know which pumps are running—red for stop and green for running. If the system is receiving fuel, you can watch a counter and see exactly how much fuel is going through the meter. Should an emergency occur, such as an overfilled tank, red lights indicate which high-level alarm is activated.

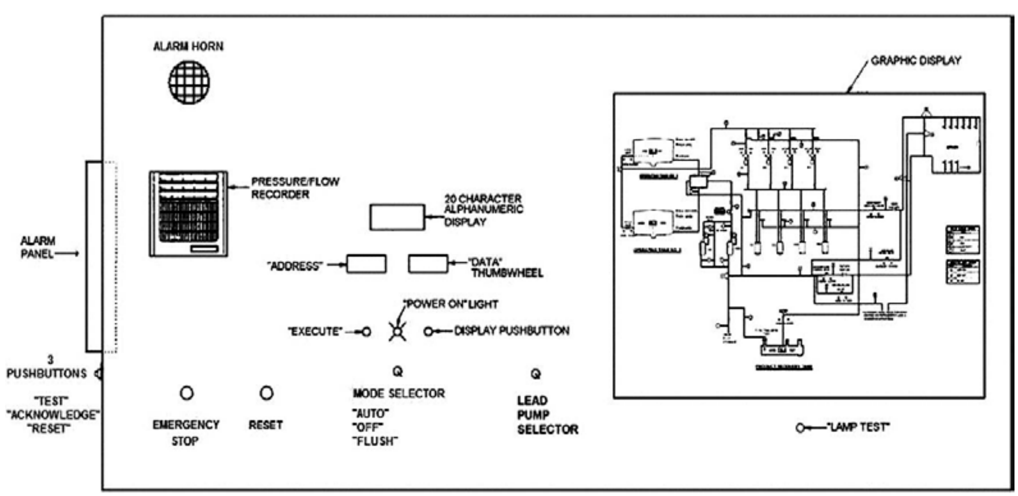


Figure 3–18. PCP.

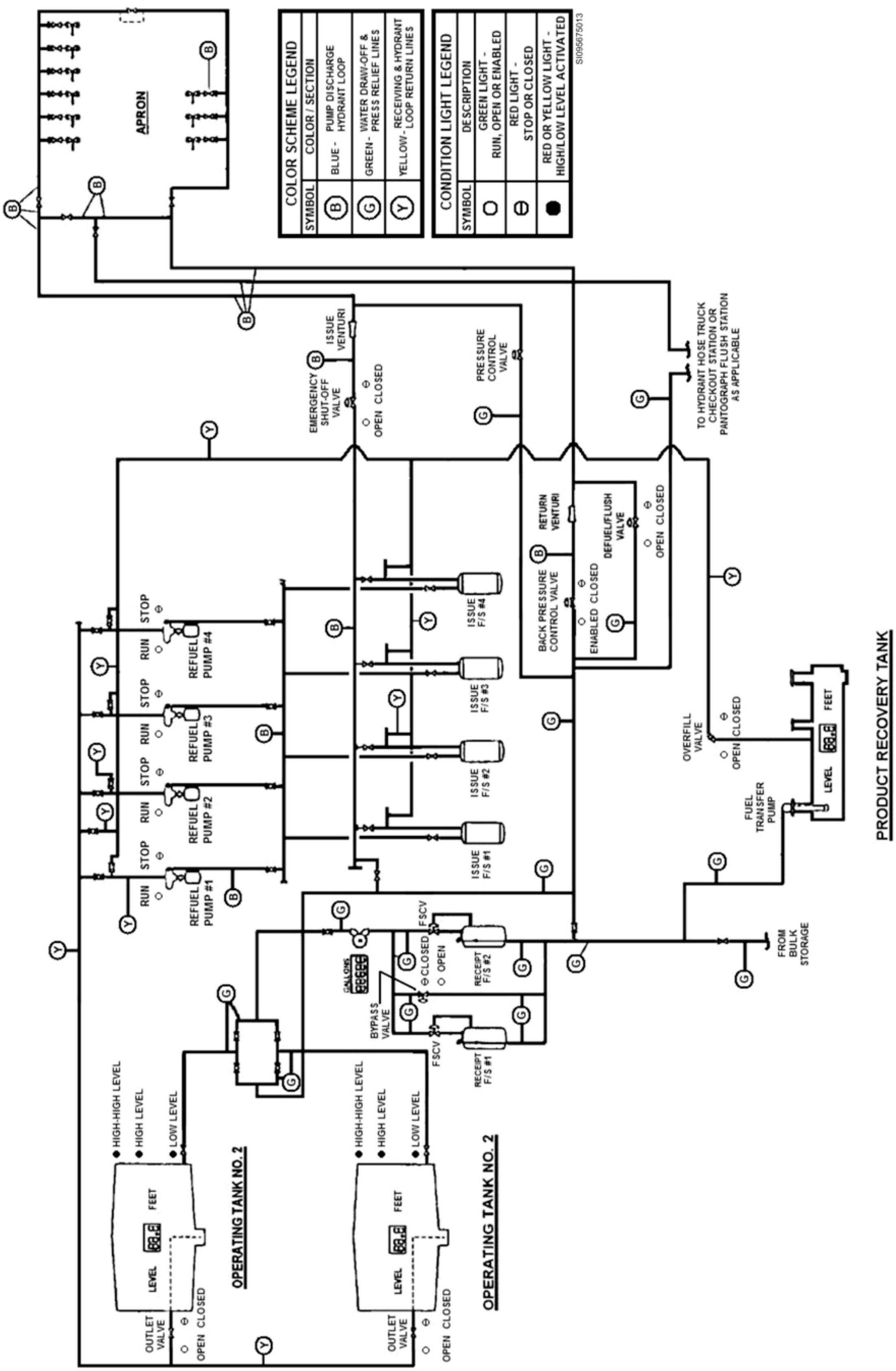


Figure 3–19. PCP graphic display.

Annunciator alarm

Another item that attracts your attention in the control room when an emergency is occurring is the alarm annunciator. The alarm annunciator is flush mounted on the end wall of the PCP and is completely solid state with no moving parts. It operates on 120 volts, 60 hertz. There are windows on the annunciator arranged in rows and columns. Examples of required alarm points are: low-level alarms, high-level alarms, high-high level alarms, leak detectors, vapor detectors, receiving BPV open, pump failure, microprocessor system faults, and any other conditions that may be deemed important to that particular system. These windows are approximately $^{15}/_{16}$-inch high and at least 1 $^{5}/_{8}$ inches long. Each window is engraved and has painted lettering that states its purpose. The windows are illuminated from the rear by 24 to 28 direct current (DC) volt lamps.

There is a push-to-test button on the PCP so that all lamps can be checked. Besides the windows lighting up and flashing, there are two different audible alarm horns to alert personnel to the emergency. One sound is created by a vibrating horn; the second by a resonating horn.

The following conditions cause the vibrating horn to sound:

- Pump # 1 failure.
- Pump # 2 failure.
- Pump # 3 failure.
- Pump # 4 failure.
- High-level oil/water separator.
- System 1 fault.*
- System 2 fault.*
- High-pressure drop receiving FS.
- High-level operating tank #1.
- High-level operating tank #2.
- High-level product-recovery tank.
- Product-recovery tank OV closed.
- Product-recovery tank leak.
- Engine-generator fault.

* System fault alarm is initiated when a system fault is detected.

The resonating horn sounds for any of the following conditions:

- Emergency stop.
- Low-level operating tank #1 (If the outlet valve is not fully closed).
- Low-level operating tank #2 (If the outlet valve is not fully closed).
- High-high-level operating tank #1.
- High-high-level operating tank #2.

Under normal conditions the windows, visual indicators, and horns are off. When an alert condition occurs, the visual indicator flashes and the horn sounds. An alert condition is locked in and must be acknowledged by pushing the acknowledge button before the horn can be silenced. After the alert condition is acknowledged, the visual indicator remains on; however, now the light will be steady instead of flashing. Should another different alert start right after an alert is acknowledged, the horn sounds again and the new condition causes the appropriate window to flash. When the second alert is acknowledged, the horn is silenced and the newly flashing window is steady. Conditions must return to normal before the annunciator windows' lamps turn off.

Operator controls

All the controls are mounted on the PCP door panel and are arranged for easy viewing and operation. There is a three-position selector switch that allows the selection of either AUTOMATIC, OFF, or FLUSH. A second selector switch is used for selecting the lead pump. This switch has as many selections as there are pumps. In other words, if the system uses four fueling pumps, you could select either pump 1, 2, 3, or 4 as the lead pump. Selecting the lead pump fixes the starting sequence for the rest of the pumps. If pump #1 is selected, then the sequence for starting the other pumps is 2, 3, and 4. Selecting pump #2 as the lead pump changes the sequence to 3, 4, and 1. The starting sequence simply follows in-turn: 3, 4, 1, 2; 4, 1, 2, 3; and so forth.

Of course, no control panel would be complete without pushbuttons, and this one has a few. The first button to cover is easily identifiable—the emergency-stop switch. This switch looks like a red mushroom pushbutton. When the emergency-stop button is pressed, all pumps stop, solenoid outputs are deenergized, and a 10 amp, 120 DC volt contact closes, sounding the alarm. Before you can return the system to operation, you must press the reset button.

There are three pushbuttons for the annunciator panel: Test, Reset, and Acknowledge. The test button ensures the annunciator lights and horn operate. The reset button must be pushed any time the system is shut down due to an actuating fire alarm or pressing an emergency-stop switch.

The system cannot be started again until the reset button is pushed. The only way to stop the annunciator horn from sounding and change the flashing lights to steady lights is by acknowledging the problem. You acknowledge the problem by pushing the Acknowledge pushbutton.

Microprocessors

This hydrant system has a brain, the microprocessor, which is the real technological difference between this system and the Type I and II hydrant system. The microprocessor receives messages from transmitters installed in the system and then translates these messages into actions. The pressure transmitter in the issue line does not turn the lead pump on—it sends a signal to the microprocessor, and the microprocessor uses the signal to decide to energize the lead pump. The DPTs, located at the issue and return venturi tubes, sense the flow rate and transmit their information to the microprocessor which, in turn, turns pumps either on or off due to the demand of the system. Tank liquid level sensors let the computer know how much fuel is in the tanks and whether their valves are open or closed. With this information, the microprocessor knows whether fueling pumps can run without damage.

There are two microprocessor-based controllers in the pump control panel. Power is supplied to each microprocessor through separate but identical power conditioners and battery systems. These two microprocessors operate in a redundant fashion, meaning they cycle off and on without interruption. At any given moment, however, only one microprocessor is actively controlling the system’s operation. Because of this cycling or redundancy operation, critical operating data constantly transfers from the active to the back-up processor automatically. If the active microprocessor fails, the backup microprocessor automatically assumes control without interrupting the process. Control can be transferred from one microprocessor to the other manually with a lockout key system. This manual transfer of control also occurs without interrupting the process. Access to modify the program is protected by a key switch or a software code.

Ventilation and climate control

Redundant ventilating units powered from separate panel board branch circuits provide forced air ventilation. These units ensure the interior temperature of the PCP does not exceed 10° F above the ambient (surrounding) temperature. The ventilating units have replaceable filters that are replaced in accordance with the manufacturer’s instructions. There are also space heaters that provide a thermostatically controlled temperature.

Battery system

The microprocessors must have a constant, uninterrupted source of power to maintain their random access memory (RAM). To provide this power source, there is a battery backup system for each microprocessor. These systems are fully automatic and come on line anytime the primary power source drops out. To ensure a constant power source, the battery systems have a fully automatic battery charger. This solid-state battery charger is capable of recharging the battery within 18 hours. The battery itself is able to maintain the microprocessor's memory for a minimum of 30 days. On the front of each microprocessor is a *Battery OK* status light-emitting diode (LED). When the LED is lit, the battery is fully charged. The LED will go out at least three days before the battery becomes weak enough to jeopardize the integrity of the memory.

Each battery is a sealed, maintenance-free battery with a 10-year minimum operating life. A bad battery, which is one that will not accept a charge, can be replaced without any service interruption or jeopardy to the memory's integrity, even when the incoming 60-hertz power is not available.

Original-style operating program

Because the Type III originated in the early 1980s and was continually updated, there were various computer controls. The main difference between them is the way that the data is changed. The older style uses thumbwheels to indicate system parameters then input the information by turning the execute key. The newer styles use a laptop or desktop computer to view the program and make changes. The older style microprocessors' operating program is stored in a battery-backed memory and is fully capable of cold starts without operator (POL personnel) intervention. Program cold start values are permanently installed in the memory, but they are adjustable. Certain parameters can be changed using two thumbwheel switches, two pushbuttons, and a 20-character alphanumeric display.

A display push-button allows you to see the settings on the 20-character alphanumeric display. Rotating the address thumbwheel switch displays each program address and allows you to select an address you want to change. After you select the address, rotate the data thumbwheel to enter the numeric data. When the changes are complete, press the execute pushbutton to enter the new setting into memory.

Look at figure 3–20 for the address parameters and programmable ranges of the microprocessor's memory. If a value is entered into an address that is not within the range of that parameter, the 20-character alphanumeric display indicates "INVALID ENTRY."

ADDRESSABLE PARAMETER	PROGRAMMABLE RANGE	COLD START/DEFAULT VALUE
LEAD PUMP STARTING PRESSURE	30 TO 150 PSI	60 PSI
ISSUE FLOW TO START SECOND PUMP IN SEQUENCE	450 TO 650 GPM	600 GPM
ISSUE FLOW TO START THIRD PUMP IN SEQUENCE	1000 TO 1300 GPM	1200 GPM
ISSUE FLOW TO START FOURTH PUMP IN SEQUENCE	1600 TO 1900 GPM	1800 GPM
RETURN FLOW TO ENABLE NEXT PUMP IN SEQUENCE TO START	10 TO 100 GPM	40 GPM
RETURN FLOW TO STOP FOURTH, THIRD, AND SECOND PUMP IN SEQUENCE (LAG PUMP)	500 TO 800 GPM	700 GPM
RETURN FLOW TO INITIATE LEAD PUMP SHUTDOWN SEQUENCE	500 TO 800 GPM	560 GPM
TIMER TO ENABLE START-UP OF LEAD PUMP	0 TO 120 SECONDS	0 SECONDS
TIMER TO ENABLE SECOND, THIRD, AND FOURTH PUMPS TO START	0 TO 120 SECONDS	10 SECONDS
TIMER TO STOP FOURTH, THIRD, AND SECOND PUMPS	0 TO 120 SECONDS	15 SECONDS
TIMER TO DISABLE BACK PRESSURE CONTROL VALVE	0 TO 120 SECONDS	60 SECONDS
TIMER TO ESTABLISH FUELING PUMP FAILURE	5 TO 20 SECONDS	5 SECONDS
SYSTEM PRESSURE TO STOP LEAD PUMP	75 TO 200 PSIG	175 PSIG

Figure 3–20. Microprocessor program.

New-style operating program

The newer style control panel and its screens are shown in figures 3–21 through 3–25, has the added feature of a graphical operator interface offering five different information screens: opening screen, system values (continuously updated), adjustable system set points, schematic graphic, and alarm annunciator graphic.

Figure 3–21. Opening screen.

Figure 3–22. System values.

Figure 3–23. Adjustable set points.

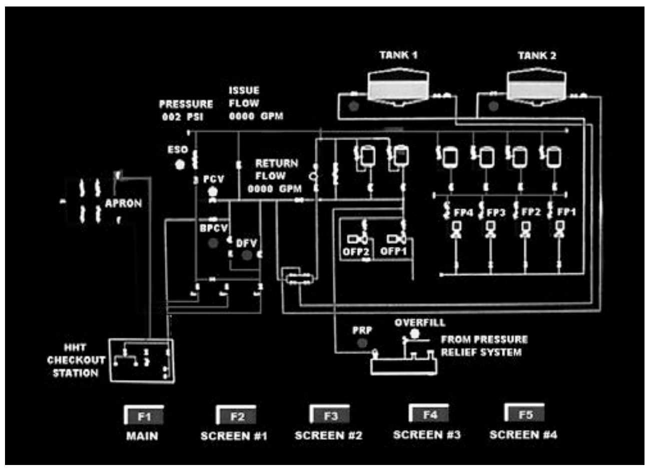


Figure 3–24. Schematic graphic.

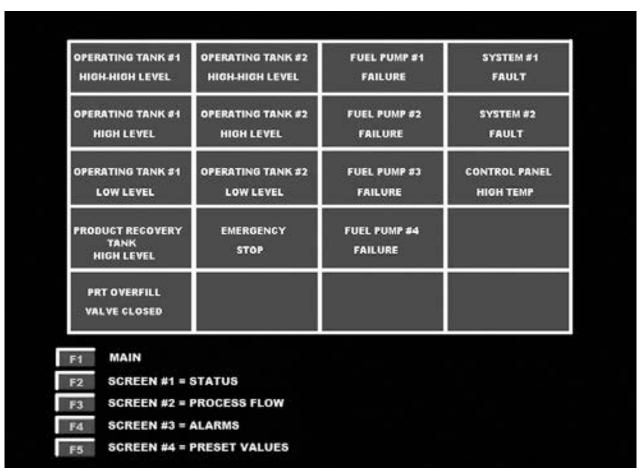


Figure 3–25. Alarm annunciator graphic.

Figure 3–26 shows the inside of a Type III control panel constructed to the requirements of the Type III standard design AW 78–24–28 AF. The inside of the cabinet is designed around the standard layout in figure 3–27. Follow the flow of the power from the top of the panel in figures 3–27 and 3–28.

Figure 3–26. PCP interior.

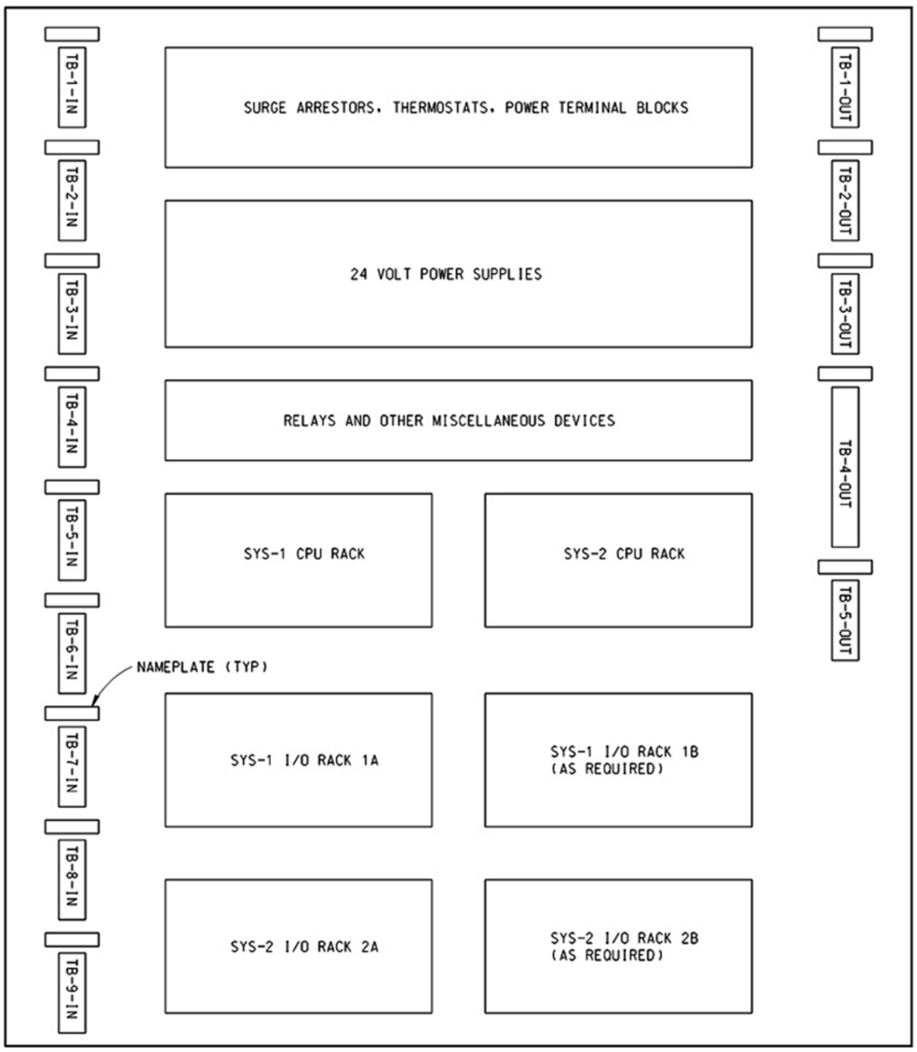


Figure 3–27. Control system block diagram.

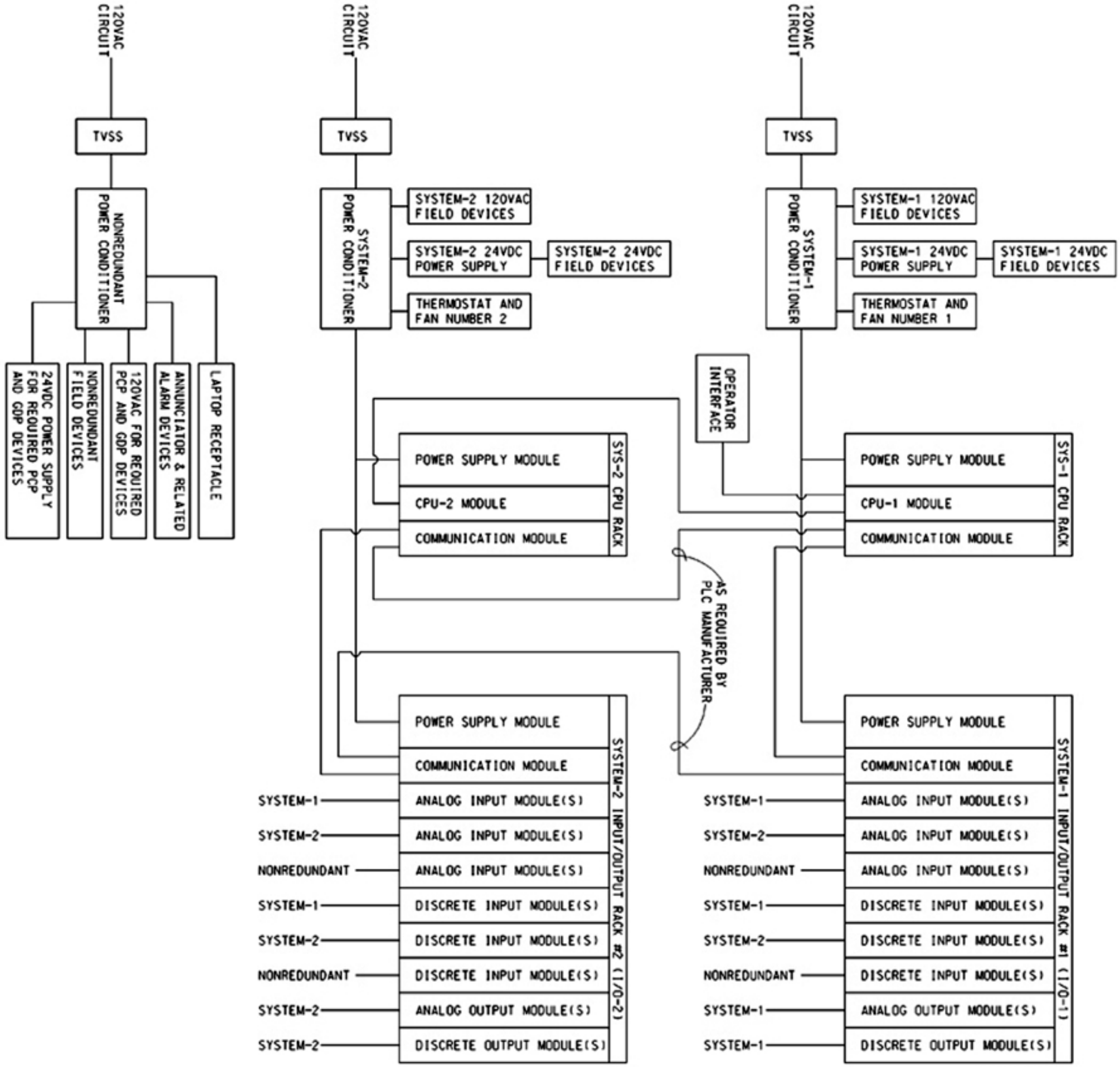


Figure 3–28. Control system connection diagram.

What is a programmable logic controller?

As we mentioned before, a microprocessor controls the fuel system. In the following sections, we will explain how this microprocessor receives and sends information to operate the system. The microprocessor is more commonly known as a programmable logic controller (PLC). It is not quite as advanced as your desktop computer, but then again it is much easier to input specific instructions into the program. Before PLCs, everything you wanted to control electrically had to be wired together so they could interact. If you wanted a pump to shut off on at a high level, then the two components had a wire connecting them. In other words, they were “hard wired” in a PLC system. All the components are hard wired to the PLC and the program, or “soft wiring,” makes the connections between the two. If there were changes you had to make to a hard-wired system, you would have to physically change the wiring. In a PLC system, the only change you make is to the PLC program, which saves greatly on labor.

PLCs use electronic devices such as diodes, transistors, integrated circuits (IC) and other solid-state devices.

Diodes are devices designed to permit electrons to flow in one direction and to block flow from the other direction. A diode consists of two electrodes: a cathode and an anode. The cathode is an electrode that emits (gives off) electrons. The anode collects the electrons and puts them to use.

Transistors are devices that amplify by controlling the flow of current carriers through its semiconductor materials. Transistors also function as switching devices in electronic circuits. The transistor provided instant circuit operation and eliminated the warm-up time needed with the old vacuum tube circuit. The transistor was, and still is, known for its small size, long life, and light weight.

ICs are packaged electronic circuits containing resistors, transistors, diodes, and capacitors, with their interconnected leads. An IC is also called a chip. Advantages, as compared to the transistor, are lower cost, higher switching speed, low-power consumption, and a smaller size. Some of the disadvantages, as compared to the transistor, are that some components cannot be fabricated and large amounts of current and voltage cannot be handled.

Keep in mind that it is not as important to know precisely how an electronic device works at the electron level as it is to know that specific inputs are based on a predetermined output.

Computer and memory

The PLC is the brains of the programmable system. It consists of the power supply, memory, and program. On smaller systems, the power supply is built into the unit. On larger units, it is a separate component.

Inputs

Inputs are the signals that the PLC uses to make decisions on how to operate the fuel system. Input comes from devices outside the PLC cabinet through wires connected to the input/output (I/O) device. The I/O device converts the signals to a form the PLC can understand.

Digital/discrete

Discrete or digital inputs have two states. The first state is an “ON” condition represented by a closed contact, a voltage present, or a 1 in the PLC program; and the second state is an “OFF” condition represented by an open contact, no voltage or a 0 in the PLC program. These types of signals come from open or closed switches on field devices such as high levels, low levels, pump flow switches, and emergency-stop switches. The I/O device converts the signals to 1s or 0s that the program understands. Digital circuits are preferred over analog because they are less expensive, information is much easier to store, digital systems are usually faster than analog systems, are compatible with computer systems and the temperature has less effect on digital systems, which results in a much more stable operation than analog.

Analog

Analog circuits are electronic circuits that have either variable outputs or are controlled by variable inputs. Analog inputs have continuously varying input signals. These types of signals come from field devices such as DPTs, pressure transmitters, and tank level indicators.

Outputs

Outputs are how the PLC makes things happen. Outputs are represented in the PLC program as a coil and are physically on the I/O device as wire connection terminals.

Timers

There are two types of timers: on-delay and off-delay. These timers come between the input contacts and the output coil in the PLC program. When the input contact changes, the timer starts counting as it is programmed. It can count in a time interval from milliseconds to whole seconds before allowing the output coil to change. The on-delay timer does not immediately activate the output coil, but as the name suggests, delays turning on the output. The off-delay is similar but delays turning off the output.

Counters

Counters actually count the number of times the input contacts change. The counter can be programmed to reset when another contact is activated. An example of this might be for one counter to accumulate the total throughput of the receiving meter and activate a light when 1 million gallons have passed. Another counter monitoring the same meter could be reset by pushing a button which allows the operator to see what was just received.

Program

The specific software used to develop and transfer the program to the PLC varies by manufacturer, but the basic principles are the same. First, the program is developed on a laptop computer using the manufacturer's software. Then the laptop is connected to the PLC and the program is transferred to the PLC memory. For our discussion, we will focus on reading an already developed program.

Ladder logic diagram

Associate the symbols and diagram in figures 3–29 and 3–30 with what you already know about inputs, outputs, and coils. If you visualize each vertical side of figure 3–29 as the sides of a ladder and the horizontal lines as rungs of a ladder, you can see why they call them ladder diagrams. The first thing on a rung will be a set of contacts and the last thing will be a coil. The left vertical line in figure 3–29 is the power side of the diagram, and the right side is the neutral side. Following from left to right, you can see that, if input 001 changed to "closed," it would allow coil "M" to close its internal output contacts labeled "M." This is called latching, since input 001 can change to open without affecting this internal circuit. Now that coil "M" is latched on, input 002 must change to "open" in order for the coil to deactivate.

You may ask, "What good is latching and unlatching coil "M," which is internal to the PLC?" PLC coils can have many contacts. Coil "M" would have another set of contacts on another "rung" that could activate coil "N" (fig. 3–31). Coil "N" could activate output contacts to start a motor and light a green "ON" light.

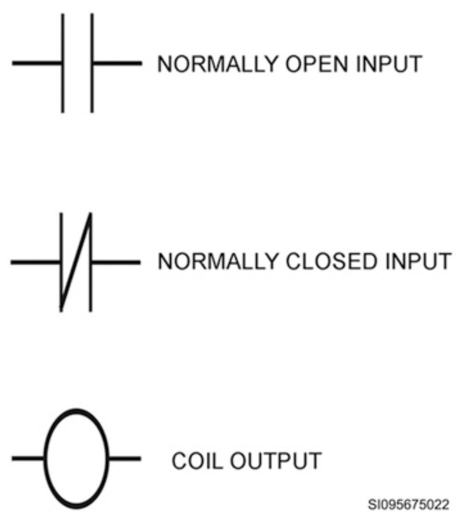


Figure 3–29. Program symbols.

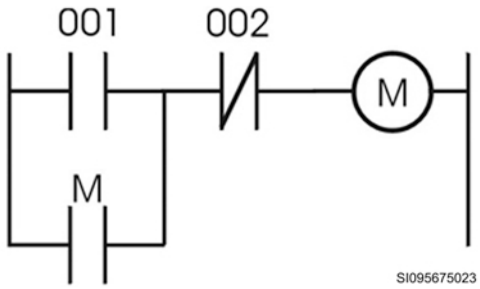


Figure 3–30. 1-rung ladder logic diagram.

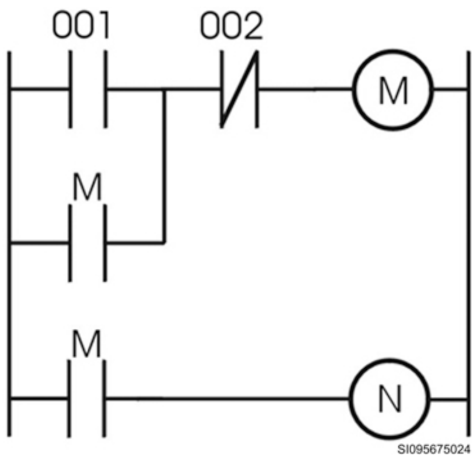


Figure 3–31. 2-rung ladder logic diagram.

Scan

So, how does the PLC use the inputs and outputs to control the system? It does this by checking the inputs, executing the program, and updating the outputs. This 3-step process is called a scan and it is done many times per second (fig. 3–32). If a high-level switch were to close and return power to the PLC input, the PLC would notice this change and change the input status in the program, execute the program based on the new information, then activate the associated output coil. In the Type III system, this activates a horn and flashing light to alert the operator.

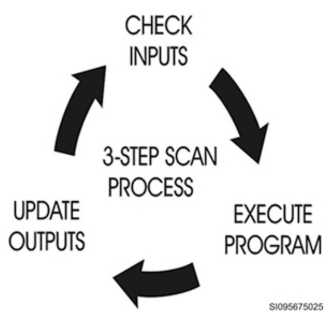


Figure 3–32. Program scan.

Blueprint wiring codes

Blueprint ladder diagrams are very similar to the ladder logic used in the construction of the PLC program, but they are used to find the location of components and wires inside the cabinet on the blueprints. The blueprints' wire numbering system allows you to go easily from a wire number in the cabinet to the wire's location amongst many pages of blueprints. Suppose you find a loose wire labeled "411" and you wonder what it is. The first number tells you that this wire is located on page 4 of the blueprints. Go to that page and notice that the second number is 11. This tells you what the rung number is. Start at the top and count down 11, and there you will notice the same wire number. From here, you can tell what the loose wire is supposed to operate.

Troubleshooting

Troubleshooting starts with observing the small lights on the front of the PLC. The lights also vary with the manufacturer but can show processor information such as power, status, communications, and mode. If the PLC lights indicate a fault, consult the manufacturer's literature for troubleshooting procedures. Once you have determined that there are no problems in the processor, move on to the I/O racks.

Lights on the I/O racks are very important and should be the next stop after verifying that the PLC is functioning correctly. Lights on the front of the I/O also indicate whether or not it is functioning correctly. What you may use more frequently are the lights above the I/O racks indicating input and output status. For example, this is where you go to see whether the I/O is really receiving a high-level tank signal or has a short in the wiring or field device. Some I/O racks do not have lights indicating input status. In this case, you simply use your multimeter to determine whether power is reaching the appropriate terminals.

Self-Test Questions

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

417. System piping

1. What type of pipe is used to carry fuel from bulk storage to the issue F/S in a Type III system if the pipe is 12 inches in diameter?

2. Why does the hydrant loop of a Type III system use stainless steel piping?

3. The pressure relief and drain system of a Type III system uses what type of piping?

418. Type III receiving equipment

1. How can you determine if the receiving strainer requires cleaning?

2. Name the four functions of the 40–27G FSCV.

3. Where is the 40–28G BPV located?

4. Where is a 40–28G BPV installed in a Type III system?

5. What happens to the 40–27G FSCV when the differential pressure across the F/S increases to 15 psi?

6. What component on the 40–28G BPV sends an audible alarm to the pump control panel to indicate the BPV is open?

7. What receiving meter component on the PCP is activated when a gallon of fuel is received?

8. How do you install the master meter to calibrate the receiving meter?

419. Type III tanks and their components

1. When can on-base bulk storage tanks be used as the operating tanks for a Type III hydrant system?

2. What type reading do you get from the tank level indicators and where are these readings displayed?

3. What does the low-level indicator alarm do when it is activated?

4. What happens when an operator acknowledges the alert condition of the high-high level alarm on the 413AF–5A high-level valve?

5. What type of manual valve is the operating storage tank outlet valve?

6. What produce recovery tank components collect fuel and water from the system?

7. What size and type of tank does the product-recovery system use?

8. What types of leak detection monitors can be used on the product-recovery system?

9. What type of pump is used to remove water from the product-recovery tank?

10. Where does pressure that closes the product-recovery tank 2129AF OV come from?

420. Type III issuing equipment

1. How many manifolds are in the issue pipeline and where are they located?

2. What types of pumps are used as fueling pumps and what is their rated capacity?

3. How are the fueling pumps connected to the hard pipe?

4. What type of mechanical seal is used on the fueling pumps?

5. What is the sight glass on the fueling pumps bearing housing used for?

6. What information must be stamped on the fueling pumps’ service nameplates?

7. How are fueling pump and motor shafts coupled together?

8. Where are flow switches located and what are they used for?

9. What flow rate must be set on the 41AF–1A nonsurge check valve’s flow controller and why is it important?

10. How are the issuing F/Ss connected?

11. What feature was added to the 40AF–2C to make it the 41AF–2C?

12. What causes the 136AF–9B ESO valve to close when an emergency-stop button is engaged? How do they work?

13. The venturi tube operates on the same principle as an orifice plate with one exception. What is the exception?

14. Where is the return venturi located?

15. The transmitters used in the Type III hydrant system consist of what type of internal working mechanisms for pressure sensing?

16. At what two system pressures does the PIT send a signal to the microprocessor? What results from each signal?

17. How do you calibrate the PIT?

18. How many DPTs are there on the issue venturi of a 2,400 gpm Type III system?

19. What flow range can you read on the low-range DPT?

20. What flow range can you read on the high-range DPT?

21. What five points must you calibrate on an issue DPT?

22. What three points must you calibrate on the return venturi's high-range DPT?

421. Type III hydrant loop and return line equipment

1. What should the loop pressure be if the Type III hydrant system is idling?

2. How much pull does it take to open the hydrant pit cover? How much push does it take to close it?

3. What is used to seal the fuel issue pipe at the floor of the hydrant pit? How is this device secured?

4. How much pressure at the skin of the aircraft is the CRA on the 362AF–8 set to maintain?

5. At what pressure set point does the CRL on the 362AF–8 closes rapidly?

6. What valve has an air sense pressure of 65 psi, on the R–12, which causes excess nozzle pressure to be relieved at 55 psi?

7. What happens if a deadman hose ruptures?

8. The BPCV opens when the loop reaches what pressure at the farthest hydrant outlet?

9. How many seconds should the 58AF–9 BPCV take to close?

10. The PCV is capable of what flow rate under normal operating conditions?

11. What is the pressure-relief setting on the 58AF–3 PCV? How long does the valve take to close?

12. What position should the 58AF–9–1 D/FV be in during refueling?

13. What happens to the 58AF–9–1 D/FV when all the refueling pumps stop?

14. How is the pressure developed to open the 58AF–9–1 D/FV for defueling?

15. What rate does the 58AF–9–1 D/FV allow fuel to circulate during system flushing? What determines the flow rate?

16. What is the size of the return venturi tube?

17. How many SPRs are there on the R–12 checkout stand?

18. What are the two overhead single point receptacles used for?

422. Type III pump control room and equipment

1. Where is probably the first place you would go when you are told the system is not working properly in the Type III hydrant system?

2. What color lines are on the graphic display and what do they indicate?

3. How can you tell which fueling pumps are operating if you are in the pump control room?

4. What problems are indicated by the resonating horn sound?

5. What must you do to silence the horn?

6. What is the pump starting sequence if fueling pump 3 is the lead pump?

7. How many microprocessors are there in the Type III hydrant system?

8. What happens if one of the microprocessors fails?

9. What does it mean if the microprocessor’s battery status LED is lit?

10. Discrete or digital inputs have states. What are they?

11. What are the steps in a PLC scan?

12. Based on the blueprint writing codes, what page and rung would a wire labeled 622 be located?

3–2. System Modes of Operation

Knowing the equipment and where it is located is important. What you learned in the last section is information contained in the present design criteria and is not necessarily the same for every base that has a Type III hydrant system. You must study and learn the manufacturers' manuals to fully understand the system at your base. The same is true about the way a system operates. You cannot troubleshoot or perform maintenance unless you have a clear understanding of the system. This section covers how the Type III system should operate during automatic idle mode, fueling, defueling, and flush mode according to the present design criteria.

NOTE: To perform maintenance at any base you must read, understand, and consult the manufacturers' training literature and operating manuals for that system.

423. Automatic idle mode

POL personnel normally set up the system in the automatic mode, but as a maintenance person you need to know at least as much as the people who operate it.

Set-up procedures

Whenever a problem exists and a job order is created, your first task should be to ensure the system is set up correctly. This means you must become familiar with the operating instructions and the as-built drawings.

The first place to check is the control room's PCP. Push the pump control panel test buttons to make sure all the lights and alarms work. Select which fueling pump is going to be the lead pump by turning the selector switch. Remember the lead pump should be changed and cycled through periodically so all pumps have approximately the same amount of running time. After selecting the lead pump, you must turn the rotary selector switch marked Automatic-Off-Flush to Automatic, and push the button marked System Start. This causes the system to pressurize automatically.

The next place to go is to the system itself. Here is where you must understand the layout of the system. Make sure you only open those manual valves required by the operating manual in automatic mode, and close those that must be closed. This is when you select which operating storage tank is used to feed the pumps and which tank receives the returning fuel.

Pressurizing the system

As we mentioned before, this system is known as a constant pressure system and automatically pressurizes itself when the system is placed in the automatic mode. There are two PITs (PIT–1 and PIT–2) on the issue pipeline, just downstream of the 136AF–9B ESO. PIT–1 or PIT–2 senses the system pressure and sends control signals to the microprocessor when system pressure drops below 60 psi. This control signal calls on the selected lead pump. At the same time, a signal is sent to the 58AF–9 BPCV, energizing its solenoid to the enable position, allowing the valve to modulate open at its set point of 100 psi. The solenoid on the 58AF–3 PCV is also energized, but it is energized closed to hold the valve in the closed position to keep it from opening while any of the fueling pumps are running. Both solenoids on the 58AF–9–1 D/FV are deenergized. Solenoid “A” is deenergized, holding the defueling side of the D/FV closed and solenoid “B” is deenergized anytime the system is not in the flush mode. Figures 3–33, 3–34, and 3–35 show the solenoid operations of the three main solenoid operated valves.

CONDITION	VALVE ACTION	SOLENOID
'AUTOMATIC' MODE - PUMP START-UP	ENABLE	ENERGIZED
'AUTOMATIC' MODE - PRIOR TO LEAD PUMP SHUT-OFF	CLOSE	DE-ENERGIZED
'FLUSH' MODE	CLOSE	DE-ENERGIZED

SI095266052

Figure 3–33. Solenoid operation, 58AF–9.

CONDITION	VALVE ACTION	SOLENOID
'AUTOMATIC' MODE - LEAD PUMP OFF	ENABLE	DE-ENERGIZED
'AUTOMATIC' MODE - PUMP(S) ON	CLOSE	ENERGIZED
'FLUSH' MODE - PUMP(S) ON	CLOSE	ENERGIZED
'FLUSH' MODE - PUMP(S) OFF	ENABLE	DE-ENERGIZED

SI095266053

Figure 3–34. Solenoid operation, 58AF–3.

CONDITION	VALVE ACTION	SOLENOID 'A'	SOLENOID 'B'
'FLUSH' MODE	OPEN	ENERGIZED	ENERGIZED
'AUTOMATIC' MODE - PUMP(S) ON	CLOSE	DE-ENERGIZED	DE-ENERGIZED
'AUTOMATIC' MODE - LEAD PUMP OFF	ENABLE	ENERGIZED	DE-ENERGIZED

SI095266054

Figure 3–35. Solenoid operation, 58AF–9–1.

The lead fueling pump immediately establishes a 600 gpm flow through the issue venturi tube. With all three automatic valves closed initially, pressure builds in the hydrant loop. When the pressure at the furthest hydrant outlet reaches 100 psi, the 58AF–9 BPCV starts to modulate open to maintain a pressure of 100 psi. If there is no fuel demand external to the system (no aircraft receiving fuel), the return venturi tube senses a total flow of 600 gpm. If the DPTs (DPT–3H or DPT–4H) on the return venturi sense a flow rate of 560 gpm or greater for 60 continuous seconds, the control system initiates a shutdown. First, the solenoid on the 58AF–9 BPCV deenergizes, causing the main valve to close.

When the BPCV closes, the hydrant loop pressure increases. Once the hydrant loop pressure reaches 175 psi, PIT–1 or PIT–2 signals the microprocessor to call off the lead pump. Solenoid “A” on the 58AF–9–1 D/FV energizes, which bleeds the system down to 80 psi, and the solenoid on the 58AF–3 PCV deenergizes, allowing the valve to open; thus, bleeding the system pressure down to 75 psi.

Now the system is pressurized, which is known as an idle condition. Should pressure drop below 60 psi, the startup process starts again. If pressure rises above 75 psi, due to thermal expansion, the 58AF–3 PCV opens allowing the excess pressure to bleed back into the operating storage tank.

424. Automatic refueling mode

When the system is in the idle condition, it is ready to refuel an aircraft. The hydrant servicing vehicle (R–12) coupler is connected to the 364AF–2, API adapter, and one of the R–12’s single point nozzles is connected to the aircraft to be refueled.

Once the deadman on the R–12 is depressed, opening the 362AF–8, the pressure drop is sensed by the microprocessor, which calls on the preselected lead pump. The 58AF–9 BPCV solenoid energizes to the enable position, allowing the valve to modulate and keep the loop pressure at 100 psi. The 58AF–3 PCV solenoid is energized, holding the valve in the closed position while any of the fueling pumps are running. The 58AF–9–1’s solenoid “A” is deenergized to hold the valve closed.

600 gpm flow rate

The lead pump establishes a flow rate of approximately 600 gpm through the issue venturi, and the pressure upstream of the 58AF–9 BPCV increases to 100 psi. At this pressure the 58AF–9 starts to modulate, allowing fuel to flow through the return venturi. The DPT–1 or DPT–2 on the issue venturi senses differential pressure corresponding to the 600 gpm flow rate through the issue venturi. If DPT–3L or DPT–4L senses a flow through the return venturi of more than 40 gpm and DPT–3H or DPT–4H senses a flow through the return venturi of less than 560 gpm, then the lead pump continues to run, delivering fuel to the aircraft on the ramp.

When the aircraft receives its required amount of fuel, the DPT–3H or DPT–4H senses a flow rate greater than 560 gpm through the return venturi for more than 60 continuous seconds. Now the 58AF–9 BPCV solenoid deenergizes, closing the valve, which causes the pressure to rise above 175 psi. This pressure is sensed by PIT–1 or PIT–2, and a signal is sent to the microprocessor, calling the lead pump off. The 58AF–9–1 D/FV solenoid “A” energizes simultaneously with the signal to call off the lead pump, bleeding the system pressure down to 80 psi. The 58AF–3 PCV solenoid deenergizes, allowing the valve to open, relieving the system pressure down to 75 psi.

1,200 gpm flow rate

When the lead pump is running with approximately 600 gpm of fuel passing through the issue venturi, and the return venturi senses a rate flow of less than 40 gpm for a continuous 10 second interval, the second pump is called on. This condition is created when the aircraft being serviced can receive fuel at a rate that exceeds 560 gpm or when more than one aircraft is being refueled at a time. When two pumps are running and the flow rate through the return venturi is greater than 700 gpm for a continuous interval of 15 seconds, the second pump is called off. The system then operates the same as it does at the 600 gpm flow rate. If the flow rate through the return venturi does not remain greater than 700 gpm for 15 continuous seconds, the second pump continues to run until the system operating condition changes.

1,800 gpm flow rate

The third pump is called on when the lead and the second pump are running and approximately 1,200 gpm of fuel passes through the issue venturi at a flow rate of 40 gpm or less for a continuous period of 10 seconds. If the flow rate through the return venturi does not remain below 40 gpm for a 10-second interval, the timer resets and the third pump will not start; only the lead pump and the second pump will run.

With the lead, second, and third pump running and approximately 1,800 gpm passing through the issue venturi, and a flow rate greater than 700 gpm through the return venturi for a continuous interval of 15 seconds, the third pump is called off. If the flow rate through the return venturi does not remain greater than 700 gpm for a 15-second interval, the timer resets and all three pumps continue to run.

2,400 gpm flow rate

With the lead, second, and third pump running and approximately 1,800 gpm passing through the issue venturi, and a flow rate through the return venturi of less than 40 gpm for a continuous interval of 10 seconds, the fourth pump is called on. If the flow rate through the return venturi does not remain less than 40 gpm for a 10 second interval, the timer resets and the fourth pump is not called on.

With the lead, second, third, and fourth pumps running and passing approximately 2,400 gpm through the issue venturi, and if the flow rate through the return venturi is less than 700 gpm, all four pumps continue to operate. If the flow rate through the return venturi is greater than 700 gpm for a continuous interval of 15 seconds, the fourth fueling pump is called off.

As the demand for fuel flow through the 362AF–8 HCV decreases, the flow through the return venturi increases, turning off the pumps in sequence, ending with the lead pump.

If a pump is automatically called on and fails to start, or fails after successfully starting, it is called off and the next idle fueling pump in the predetermined sequence of the four pumps is called on.

425. Automatic defueling mode

An aircraft can be defueled when the system is in the idle or refueling mode. To defuel an aircraft, an operator connects the nozzles on the R–12 hydrant servicing vehicle to the aircraft and to the 364AF–2 API adapter. The R–12 has a defuel pump capable of delivering 300 gpm at 165 psi. To start the defueling process, the operator starts the defuel pump which activates the deadman.

Idle condition

If the refueling pumps are not running, the 58AF–3 PCV and the 58AF–9–1 D/FV are enabled. The fuel being pumped by the hydrant servicing vehicle from the aircraft overcomes the 75 psi setting of the 58AF–3 PCV and the 80 psi setting of the 58AF–9–1 D/FV. This allows fuel to pass through these valves and into the operating storage tanks.

Refueling condition

If the fueling pumps are running and refueling an aircraft, the 58AF–3 PCV and the 58AF–9–1 D/FV are closed. The R–12 pumps the fuel from the aircraft being defueled into the hydrant loop. Once in the loop, the fuel either goes to other aircraft connected to the system, which are being refueled, or flows through the 58AF–9 BPCV and into the operating tanks.

426. Flush mode

This mode cleans the loop system. Cleaning is required if the system is not used for 30 or more consecutive days or if fuel samples indicate contaminants are present.

Purpose

Fuel is flushed through the apron loop and routed back into the operating storage tanks. Flushing the system consists of pumping twice the system line capacity through the loop.

Set-up procedures

Turn the selector switch on the PCP to the “*FLUSH*” mode. This deenergizes the 58AF–9 BPCV solenoid, locking the valve closed, and energizes Solenoid “B” on the 58AF–9–1 D/FV, enabling the valve to free float. Solenoid “A” remains energized as long as the system is not in the “Automatic” mode. Position the manually operated valves to direct fuel through the desired flow path. Place the pump's (AUTO-OFF-HAND) selector switch in the hand position. This starts the pump and closes the 58AF–3 PCV. Start all available pumps to obtain the maximum fps rate. Once you completely flush the system, return it back to the automatic mode idle condition.

Self-Test Questions

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

423. Automatic idle mode

1. Why should the lead pump designation be changed periodically?

2. What components sense the pressure just downstream of the 136AF–9B ESO valve?

3. At what pressure does the 58AF–9 BPCV modulate open to maintain the system pressure?

4. What 58AF–3 PCV component keeps the valve closed when the fuel pumps are running?

5. How many solenoids are on the 58AF–9–1 D/FV?

6. At what hydrant loop pressure does the PIT signal the microprocessor to call off the lead pump?

7. What happens to excess pressure from thermal expansion?

424. Automatic refueling mode

1. What connects the system to the aircraft to be refueled?

2. When the lead pump is running, what flow rate is sensed through the return venturi to call on the second pump?

3. What two conditions require more than one pump to run at the same time?

4. How many pumps are running if the issue venturi senses 1,800 gpm and the return venturi senses 50 gpm?

5. If a pump fails to start when called on by the microprocessor, or fails after successfully starting, what happens?

6. Describe the pump shutdown sequence when 4 pumps are running.

425. Automatic defueling mode

1. In what modes can the system be used to defuel?

2. Where is the defuel pump on the Type III system?

3. Defueling in the idling mode causes fuel pumped by the R–12 to pass through which valve(s)?

4. If you are defueling one aircraft while another aircraft is being refueled, where does the (defueled) fuel go?

426. Flush mode

1. What is the purpose of the flush mode?

2. What happens to the fuel when it is flushed through the system?

3. You have turned the selector switch on the PCP to the “FLUSH” mode and need to start the flush mode. What selector switch is used?

Answers to Self-Test Questions

417

1. Carbon steel, ASTM A53, grade B.
2. It is less susceptible to rust and ensures the quality of the fuel delivered to the aircraft.
3. Carbon steel, Schedule 40, API 5L, Grade B or ASTM A53, Grade B.

418

1. When the differential pressure gauge reaches 10 psi.
2. Flow control, water slug shutoff, maximum differential pressure shutoff, and check valve.
3. *Only* on systems that receive fuel directly from a cross-country pipeline.
4. On a bypass line between the two receiving F/Ss.
5. The 40–27G closes.
6. The limit switch.
7. An electronic digital counter.
8. By closing the manual valve and connecting the meter to the proving connections.

419

1. If they are suitable, located within one mile of the fueling apron and modified to meet the criteria in Standard Design AW 78–24–27.
2. Local and remote fuel level readings. A local reading is displayed at the tank and the remote reading is displayed on the PCP graphic display.
3. It sounds a horn and causes the lights behind the annunciation alarm window, marked as low-level alarm, to flash, and it shuts down any fueling pumps operating at the time.
4. The PCP is steady and the horn turns off.
5. A 12-inch, non-lubricated DBB valve.
6. The pressure reliefs, strainer drains, F/S automatic water drains, low/high point drains, and the operating storage tanks water draw-off system.
7. A 4,000-gallon, double wall, steel tank.
8. Vacuum maintenance, positive air pressure maintenance, hydrostatic pressure maintenance, or probe detection.
9. A hand operated pump with a double-action piston that delivers liquid on every forward and backward stroke.
10. From the pressure reservoir by way of pressure supplied form the fuel-transfer pump connected to the discharge of the product-recovery tank fuel.

420

1. There are three manifolds (or headers). The suction header is located upstream of the refueling pumps; the pump discharge header is directly after the pumps' rate-of-flow CV; and the F/S discharge header is found after the F/Ss; rate-of-flow CV.
2. They must meet API 610 requirements and must be single-stage centrifugal, horizontal mounted, vertical or radial split case, enclosed impeller, with end suction and top vertical discharge. Their capacity is 600 gpm when driven at 3,600 rpm.
3. By flexible metal hoses.
4. Single unbalanced, multiple-spring type.
5. To check the oil level.
6. At a minimum, the manufacturer's name, pump serial number, capacity in gpm, pumping head (feet of water), maximum specific gravity of fluid to be pumped, revolutions per minute, and horsepower of the driver.
7. With a flexible and self-aligning coupling.

8. Immediately downstream of the fueling pumps' discharge line. To lock the fueling pumps on after they are called on by the microprocessor and to notify the microprocessor that the pump is pumping fuel.
9. 650 gpm. Because it allows the fueling pump to operate efficiently.
10. In parallel and manifolded at the inlet and the outlet by 12-inch manifolds.
11. Two hytrol check valves were added to prevent reverse flow through the F/S.
12. The two solenoids. Once the ES button is pushed, the solenoids will deenergize, closing the 136AF–9B within 10 seconds.
13. The venturi tube is much more accurate.
14. Upstream of the 58AF–9 valve in the hydrant loop return line.
15. On the older style it is a dual opposed, liquid-filled, rupture-proof bellows type pressure-sensing element and the newer style pressure transmitters use a tantalum membrane with sensors.
16. Below 60 psi and at 175 psi; at 60 psi the lead pump is called on; at 175 psi, the lead pump is called off.
17. By verifying the mA signal sent to the microprocessor. Using an ammeter, you must ensure there is a 4 mA signal being sent to the microprocessor when there is zero psi on the system. Next you must ensure there is a 20 mA signal being sent to the microprocessor when the transmitter is at its maximum psi (250 psi on a 0–250 psi transmitter).
18. Two.
19. 0–100 gpm.
20. 0–800 gpm.
21. 0 gpm; 600 gpm; 1,200 gpm; 1,800 gpm; and 2,400 gpm.
22. 0 gpm, 560 gpm, and 700 gpm.

421

1. 75 psi.
2. 30 lbs of pull to open it, and 50 lbs of push to close it.
3. A Buna-N boot. By stainless steel clamps that are connected to a metal collar that is welded to the pipe riser and to a flange where the pipe penetrates the pit floor.
4. 45 psi for any flow rate from 50 to 600 gpm, or 50 to 1,200 gpm, depending on the system design.
5. 50 psi.
6. The Brooks valve.
7. The main valve closes in a maximum of five seconds.
8. 100 psi.
9. 3 seconds.
10. 50 gpm.
11. 75 psi. 3 seconds.
12. Deenergized, closed because it will not open anytime a fueling pump is energized.
13. Solenoid "A" energizes allowing the valve to open and remain open until the loop pressure drops to 80 psi.
14. By a defuel pump on the R–12 hydrant servicing vehicle.
15. From 600 to 2,400 gpm. The number of fueling pumps used determines the flow rate.
16. 4 inches in diameter.
17. 4.
18. To test the straight-throat nozzles, and to check the hydraulic lift provide with the R–12 when using these nozzles.

422

1. The Type III control room.
2. Green, yellow, and blue. The green lines indicate the receiving and hydrant loop return line. The yellow lines indicate the pump suction, from the storage tank discharge lines to the inlet of the pumps. Yellow lines also show the water draw-off lines from the F/Ss and pressure-relief valves that go to the product-recovery

tank. Blue lines are the pump discharge and hydrant loop up to and including the 58AF–9 BPCV, 58AF–3 PCV, and 58AF–9–1 D/FV.

3. By looking at the graphic display panel; a red light for the stopped pumps and a green light for the running pumps.
4. An emergency-stop, low-level operating tanks on #1 or #2 (if the outlet valve is not fully closed), high-high level operating tanks #1 or #2.
5. Push the acknowledge button.
6. 3, 4, 1, 2.
7. Two.
8. If the active microprocessor fails, the back-up microprocessor automatically assumes control without interrupting the process. Control can also be transferred from one microprocessor to the other manually with a lockout key system.
9. That the battery is fully charged.
10. One state is an "ON" condition represented by a closed contact, a voltage present, or a 1 in the PLC program. The second state is an "OFF" condition represented by an open contact, no voltage or a 0 in the PLC program.
11. It checks inputs, executes the program, and updates the outputs.
12. Page 6, rung 22.

423

1. So all pumps have approximately the same amount of running time.
2. PITs 1 and 2.
3. 100 psi.
4. The solenoid.
5. Two, solenoids A and B.
6. Once the hydrant loop pressure reaches 175 psi, PIT–1 or PIT–2 signals the microprocessor to call off the lead pump.
7. It bleeds back into the operating storage tank.

424

1. The hydrant servicing vehicle (R–12) coupler is connected to the 364AF–2, API adapter, and one of the R–12's single point nozzles is connected to the aircraft to be refueled.
2. 40 gpm or less.
3. When an aircraft being serviced receives fuel at a rate exceeding 560 gpm or when more than one aircraft is being refueled at a time.
4. Three, because the return venturi must flow greater than 700 gpm to shut the third one off.
5. It is called off and the next idle fueling pump in the predetermined sequence of the four pumps is called on.
6. When all four pumps (lead, second, third, and fourth pumps) run simultaneously, a flow rate of 2,400 gpm is produced through the issue venturi. This, in turn, causes the flow rate through the return venturi and 362AF–8 HCV to exceed 700 gpm. When the return flow exceeds 700 gpm on the return for at a continuous interval of 15 seconds, the system PLC will signal the fourth pump to shut off. As the demand for fuel flow through the 362AF–8 HCV decreases, the flow through the return venturi increases, turning off the pumps, one at a time in sequence, ending with the lead pump. When the pressure in the hydrant loop rises above 175 psi, the pressure will be sensed by PIT–1 or PIT–2 that, in turn, will send a signal to the microprocessor. The microprocessor will receive the signal and shut off the lead pump. The 58AF–9–1 D/FV solenoid "A" will energize simultaneously with the signal to call off the lead pump, bleeding the system pressure down to 80 psi. Lastly, the 58AF–3 PCV solenoid will deenergize, allowing the valve to open, relieving system pressure down to 75 psi.

425

1. The idle or refueling modes.
2. On the R–12.

3. 58AF–9–1 and 58AF–3.
4. Into the hydrant loop and once it gets in the loop the fuel either goes to other aircraft connected to the system that are being refueled, or to the 58AF–9 BPCV and into the operating tanks.

426

1. To clean the loop system.
2. It is flushed through the apron loop and routed back into the operating storage tanks.
3. Place AUTO-OFF-HAND selector switch to the hand position.

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.

42. (417) What type piping, 12 inches in diameter, is used in the hydrant loop of a Type III system?
 a. Carbon steel, schedule 80S.
 b. Carbon steel, schedule 40S.
 c. Stainless steel, schedule 20S.
 d. Stainless steel, schedule 10S.

43. (417) What type steel is used in the control tubing of the Type III system?
 a. Copper.
 b. Carbon.
 c. Galvanized.
 d. Seamless stainless.

44. (418) At what differential pressure *must* the receiving strainer in the Type III system be cleaned?
 a. 3 pounds per square inch (psi).
 b. 10 psi.
 c. 15 psi.
 d. 20 psi.

45. (418) The 40–28G bypass valve (BPV) opens and fuel bypasses the receiving separators when fuel is received from a cross-country pipeline on the Type III system. The differential pressure causing this action occurs when
 a. 15 pounds per square inch (psi) is sensed across the receiving separator.
 b. 15 psi is sensed across the orifice plate on the receiving separator.
 c. 10 psi is sensed across the receiving separator.
 d. 10 psi is sensed across the orifice plate on the receiving separator.

46. (418) Which is *not* a function of the 40–27G filter/separator control valve (FSCV)?
 a. Check valve.
 b. Flow control.
 c. Pressure reducer.
 d. Differential pressure shutoff.

47. (418) Once the 40–27G filter/separator (F/S) valve has closed due to high differential pressure, what *must* be done to get the valve to operate again?
 a. Reset the control panel.
 b. Clean the receiving strainer.
 c. Manually reset the 40–28G.
 d. Manually reset the pressure-differential shutoff (CDHS–3A).

48. (418) A gallons per minute (gpm) displacement meter is used in the receiving line of a Type III system. Which type does it use?
 a. 600; positive.
 b. 600; non-positive.
 c. 1,200; positive.
 d. 1,200; non-positive.

49. (419) When the nearest bulk storage tank is one mile from the fueling apron, which tank can be used on the Type III system as an operating storage tank?
    a. 10,000 barrel (bbl).
    b. 20,000 bbl.
    c. 30,000 bbl.
    d. 40,000 bbl.

50. (419) The ball float for the 413AF–5A high-level shutoff valve (HLV) on an operating storage tank is located on
    a. top of the tank in the float well.
    b. top of the tank in the gauging well.
    c. the exterior side of the tank at the required shutoff height.
    d. the interior side of the tank at the required shutoff height.

51. (419) The 413AF–5A high-level shutoff valve's (HLV) closing feature and rotary disc assembly can be tested without filling the tank up with fuel to the high-level shutoff point by
    a. using a manual tester on the HLV.
    b. pushing the test button in the pumphouse.
    c. pushing the test button on the pump control panel (PCP).
    d. using a manual tester on the high-level shutoff float assembly.

52. (419) A Type III operating storage tank level indicator servo compartment *must* be approved for hazardous locations and listed for use in Class I,
    a. Division I, Group C.
    b. Division I, Group D.
    c. Division II, Group C.
    d. Division II, Group D.

53. (419) When fuel reaches the *high-level alarm* setting on a Type III operating storage tank, one warning is given by the high-level alarm window on the pump control panel (PCP). You see and hear the warning when the PCP
    a. flashes and a vibrating horn sounds.
    b. illuminates and a vibrating horn sounds.
    c. flashes and a resonating horn sounds.
    d. illuminates and a resonating horn sounds.

54. (419) When fuel reaches the *high-high level alarm* setting, the high-high level alarm window on the pump control panel (PCP) is activated on a Type III operating storage tank. You see and hear the warnings by
    a. a flashing PCP and vibrating horn sounds.
    b. an illuminating PCP and vibrating horn sounds.
    c. a flashing PCP and resonating horn sounds.
    d. an illuminating and resonating horn sounds.

55. (419) Which valve is used as the tank outlet valve on a Type III operating storage tank?
    a. Ball valve.
    b. Lubricated plug valve.
    c. Rising stem gate valve.
    d. Non-lubricated double block and bleed valve.

56. (419) What size piping is used to connect the pressure reliefs and other drains to the product-recovery tank in a Type III system?
    a. $^{1}/_{2}$-inch.
    b. 1-inch.
    c. $1^{1}/_{2}$-inch.
    d. 2-inch.

57. (419) What type of pump is used as the fuel transfer pump on the product-recovery tank in the Type III system?
    a. An American Petroleum Institute (API) 1610, 50-gallon per minute (gpm) capacity.
    b. An API 1610, 100 gpm capacity.
    c. A deep-well turbine, 50 gpm capacity.
    d. A deep-well turbine, 100 gpm capacity.

58. (419) On the product-recovery tank in a Type III system, the switch assembly automatically energizes the fuel-transfer pump when the tank is what percent full?
    a. 65.
    b. 70.
    c. 75.
    d. 80.

59. (419) What valve is used as an overfill valve (OV) for the product-recovery tank in the Type III system?
    a. 129AF.
    b. 2029AF.
    c. 2129AF.
    d. 136AF–9B.

60. (420) What size suction header is used in the Type III system?
    a. 6-inch.
    b. 8-inch.
    c. 12-inch.
    d. 16-inch.

61. (420) What type American Petroleum Institute (API) pump is used as fueling pumps in the Type III system?
    a. 610, 600 gallons per minute (gpm).
    b. 610, 1,200 gpm.
    c. 1581, 600 gpm.
    d. 1581, 1,200 gpm.

62. (420) Leakage is *minimized* during a complete seal failure on the Type III fueling pump mechanical seal by using
    a. an O-ring.
    b. a Teflon packing.
    c. the end plate seal gland.
    d. a non-sparking throttle bushing.

63. (420) Defining the temperature rating for motors used with the fueling pumps in the Type III system is the responsibility of the
    a. National Fire Protection Agency (NFPA) 70.
    b. major command (MAJCOM) fuels engineer.
    c. American Petroleum Institute (API).
    d. National Society of Engineers.

64. (420) The fueling pump and motor in the Type III system *must* be aligned to within
    a. .2-inch.
    b. .02-inch.
    c. .002-inch.
    d. .0002-inch.

65. (420) One purpose of the flow switch in the Type III system is to
    a. call on the fueling pump.
    b. lock on the fueling pump.
    c. call on the secondary pump.
    d. lock on the secondary pump.

66. (420) Where is the issue venturi tube located on the Type III system?
    a. Upstream of the emergency shutoff (ESO) valve.
    b. Upstream of the two solenoids.
    c. Downstream of the two solenoids.
    d. Downstream of the ESO valve.

67. (420) What is the gallons per minute (gpm) rating of the return venturi in the Type III system?
    a. 600.
    b. 800.
    c. 100.
    d. 1,200.

68. (420) How many differential pressure transmitters (DPT) are piped into the return venturi on a 2,400 gallons per minute (gpm) Type III system?
    a. 2.
    b. 3.
    c. 4.
    d. 5.

69. (420) The *primary* purpose of the pressure indicating transmitters (PIT) in the Type III system is to
    a. lock on the lead pump.
    b. call on the lead pump.
    c. call on the second pump.
    d. call off the second pump.

70. (420) Which gallons per minute (gpm) rate flow can the *low-range* differential-pressure transmitters (DPT) sense and indicate on the return venturi in the Type III system?
    a. 0–40.
    b. 0–100.
    c. 0–700.
    d. 0–800.

71. (420) Which gallons per minute (gpm) points *must* be calibrated on the return venturi's high-range differential-pressure transmitter (DPT)?
    a. 0, 560, 700.
    b. 0, 560, 1200.
    c. 40, 600, 1200.
    d. 40, 600, 2400.

72. (421) Where does the remote-sensing pressure reducing control (CRA) on the 362AF–8 hydrant control valve (CV) sense pressure from?
    a. Issue venturi.
    b. Return venturi.
    c. Hydrant CV.
    d. Hydrant servicing vehicle venturi.

73. (421) An air sense pressure setting of 65 pounds per square inch (psi) on the Brooks valve relieves excess nozzle pressure when it reaches
    a. 40 psi.
    b. 45 psi.
    c. 50 psi.
    d. 55 psi.

74. (421) When an aircraft is refueling, the 362AF–8 hydrant control valve (CV) opens by using the
    a. remote-sensing pressure-reducing control (CRA).
    b. CV flow.
    c. hydraulic deadman.
    d. pneumatic deadman.

75. (421) When does the solenoid on the 58AF–3 pressure control valve (CV) energize to close the valve?
    a. Anytime a fueling pump is running.
    b. When all fueling pumps are deenergized.
    c. When a magnet is placed on the defuel keep it simple, system (KISS) switch.
    d. When a magnet is placed on the refuel KISS switch.

76. (421) At what pounds per square inch (psi) does the 58AF–3 pressure control valve (CV) close?
    a. 60.
    b. 65.
    c. 70.
    d. 75.

77. (421) After refueling an aircraft and the lead pump deenergizes, at what pounds per square inch (psi) does the 58AF–9–1 defuel/flush valve (D/FV) close?
    a. 70.
    b. 75.
    c. 80.
    d. 85.

78. (421) Solenoid "B" on the 58AF–9–1 defuel/flush valve (D/FV) energizes to allow the main valve to open only when the
    a. fueling pumps are started manually.
    b. fueling pumps are started automatically.
    c. system is placed in the flush mode.
    d. system is placed in the automatic mode.

79. (422) What do blue lines represent on the Type III pump control panel (PCP) line drawing?
    a. Pressure relief.
    b. Water draw off.
    c. Pump discharge.
    d. Hydrant loop return.

80. (422) Which problem would cause a vibrating horn to sound in the Type III system?
    a. When a fuel pump fails.
    b. When the emergency-stop button engages.
    c. Low-level activation on the operating storage tank.
    d. High-high level activation on the operating storage tank.

81. (422) What does the *first symbol* in a rung of ladder logic represent?
    a. Contacts.
    b. Timer.
    c. Output.
    d. Counter.

82. (422) What is the term for the three-step process of checking inputs, executing the program, and updating outputs in the programmable logic controller?
    a. Scan.
    b. Execute.
    c. Program.
    d. Process.

83. (423) What actions occur when the return venturi senses 560 gallons per minute (gpm) or more for 60 seconds once the issue venture has a 600 gpm flow on the 58AF–9 bypass control valve (CV)?
    a. It energizes, builds pressure up to 150 psi, and calls the lead pump off.
    b. It deenergizes, builds pressure up to 150 psi, and calls the lead pump is off.
    c. It energizes, builds pressure up to 175 psi, and calls the lead pump off.
    d. It deenergizes, builds pressure up to 175 psi, and calls the lead pump off.

84. (424) When the issue venturi senses 600 gallons per minute (gpm) and the return venturi senses 40 gpm or less for 10 seconds, the lead pump
    a. shuts down.
    b. shuts down and the second pump is called on.
    c. continues running and the second pump is called on.
    d. continues running only.

85. (424) What happens to the lead, second, and third fueling pumps when the issue venturi senses 1,800 gallons per minute (gpm) and the return venturi senses 100 gpm for 15 seconds?
    a. The three pumps continue to run.
    b. The third pump is called off; the others run.
    c. The fourth pump is called on; the others are off.
    d. Only the fourth pump continues to run.

86. (424) What happens if the third pump is called on automatically in a Type III system and fails to start?
    a. The next pump in the predetermined sequence is called on.
    b. Only the lead and second pump continue to run.
    c. An alarm will sound and the entire system shuts down.
    d. A light in the pumphouse illuminates and a vibrating horn sounds.

87. (425) Which component houses the defuel pump for the Type III system?
    a. Pumphouse.
    b. Lateral control pit.
    c. Hydrant outlet pit.
    d. Hydrant servicing vehicle.

88. (425) Which valve, during the idle mode, opens and allows defueling in the Type III system?
    a. 58AF–9.
    b. 2129AF.
    c. 58AF–9–1.
    d. 136AF–9B.

89. (425) When refueling and defueling at the same time, where does the fuel being defueled go in a Type III system?
    a. To the product-recovery tank.
    b. To other aircraft being refueled.
    c. To an R–11 refuel/defuel truck.
    d. To the issue venturi.

90. (426) How many gallons of fuel *must* be pumped to flush the hydrant loop of a Type III system containing 42,000 gallons?
    a. 42,000.
    b. 84,000.
    c. 126,000.
    d. 168,000.

Please read the unit menu for unit 4 and continue ➔

Unit 4. Type IV Fueling System

THE TYPE IV computer-controlled automatic hydrant system operates like the Type III system, but there are some significant differences. This microprocessor senses the need for flow and energizes only one or two pumps to establish flow rates that can vary anywhere between 40 and 1,200 gpm. With this new refueling system, several fighter aircraft can refuel at the same time.

The system is very much like the Type III, so as you go through this unit, there will be many familiar pieces of equipment. As stated before, there are differences with this system, so take your time. If you find yourself getting confused, think back to the other lessons you have already learned. Remember, this system must follow the hydraulics' same laws and principles as any other fueling system. This system may look different and have equipment you have not seen but if you allow yourself, you will be amazed at how much you have learned thus far and how much information you can easily transfer between fuel systems.

4–1. Type IV System Components and Equipment

Even though this system has a different delivery method, the basic design concept mirrors the Type III system developed by the Phillips Petroleum Company back in the mid-1950s. The Type IV system, more commonly known as a hot pit system, was developed to fuel fighter aircraft while their engines were running so time spent on the ground was minimized. The Type IV refueling system is a pressurized system that is automatically controlled on demand. It uses high-volume pumps, F/Ss, and a serial loop pipeline distribution system arranged to operate for extreme flexibility and simplicity.

As you travel from one base to another, you will likely encounter several different designs, but you will notice similarities. In 1990, AF definitive design statement 78–24–29 AF standardized future construction. The information you receive in this unit is from that established standard. Automatic valves used on this system have different manufacturers, but to simplify this area of study we will discuss the automatic valves made by the Cla-Val Company.

We begin by looking at the components used to make up this system by moving through the system methodically. We will briefly look at system piping, then discuss receiving equipment, move to storage tanks and components, then on to issuing, the refueling loop and return line equipment, and finally, to the "brain" or pump control room. Refer to foldout (FO) 1 as you study the discussion.

427. System piping

The main fuel line, from bulk storage to the issue F/Ss that is 12 inches or larger, has an internal, epoxy-coated carbon steel, ASTM A53, grade B with a .375-inch-thick wall. Lines that are 2½ inches through 10 inches are made of internal, epoxy-coated carbon steel and either Schedule 40, API 5L, Grade B, or ASTM A53; Grade B. Piping that is 2 inches or smaller is internal, epoxy-coated carbon steel, Schedule 80, API 5L, Grade B, or ASTM A53, Grade B.

The piping from the issue F/Ss, through the system loop, and back to the receiving loop that is 8 inches and larger, is seamless stainless steel, Schedule 10S, ASTM 312, Type 304L. Piping 6 inches or smaller is seamless stainless steel, Schedule 40 minimum, ASTM 312, Type 304L. Stainless steel is used because it is less susceptible to rust and ensures the fuel quality being delivered to the aircraft. Control tubing is seamless stainless steel, ASTM A269, Grade TP316, with a Rockwell hardness of B80 or less.

All pressure-relief and drain system piping is internal epoxy-coated carbon steel, Schedule 40, API 5L, Grade B or ASTM A53, Grade B.

428. Receiving equipment

The Type IV fuel system, like the Type III system, can receive fuel by truck, tank car, pipelines, or barges. The method of receipt depends on where the system is located on base and what receiving means is the most economical. Since most Type IV systems are located overseas, the primary method of receiving fuel is by either pipeline or barges.

The receiving equipment consists of a 60-mesh strainer, two 600 gpm horizontal API 1581 F/Ss, the 40–27G FSCV, the 40–28G BPV, a 1,200 gpm receiving meter, meter proving connections, and a receiving loop that directs where the fuel goes. There is no need to discuss the receiving equipment found in the Type IV system in detail because it is identical to the Type III system receiving equipment we covered earlier.

429. Tanks and components

The tanks used for storage in the Type IV system are also the operating tanks. You learned about the different type of tanks and components used by the AF earlier. Here you will learn about the Type IV operating storage tank and product recovery tanks’ requirements and components.

Operating storage tanks

The operating storage tanks can be cone-roof tanks with a floating pan cut-and-cover tanks with fixed roofs or horizontal underground tanks. These tanks must be internally coated in accordance with UFGS–09 97 13.16, *Interior Coating of Welded Steel Water Tanks*. The mission and the base location dictate what type and size tanks are used.

Tank HLV

All fuel received into the operating tanks must go through a HLV. On a cone roof with floating pan tank, the HLV is the 413AF–5A. On cut-and-cover tanks and underground tanks, the HLV is a 129AF–3F. We covered the 413AF–5A in the Type III system, so refer back to unit 3 to refresh your memory.

The 129AF–3F (fig. 4–1) is activated by a CFM2 float control located inside the tank at the required shutoff height. Fuel enters the control loop of the main valve and becomes the supply pressure that is eventually used to close the valve. The fuel that enters the control loop flows through a stainless steel 40-mesh flow clean strainer to a rotary disc assembly on the float control and discharges through an outlet pipe that extends down to within 3 inches of the bottom of the tank. When the float starts to rise, the rotary disc changes ports; thus, directing the supply pressure to the cover chamber of the 129AF–3F, closing it tightly to prevent drips. To manually test the valve’s closing feature, a manual valve is installed in the control tubing of the 129AF–3F.

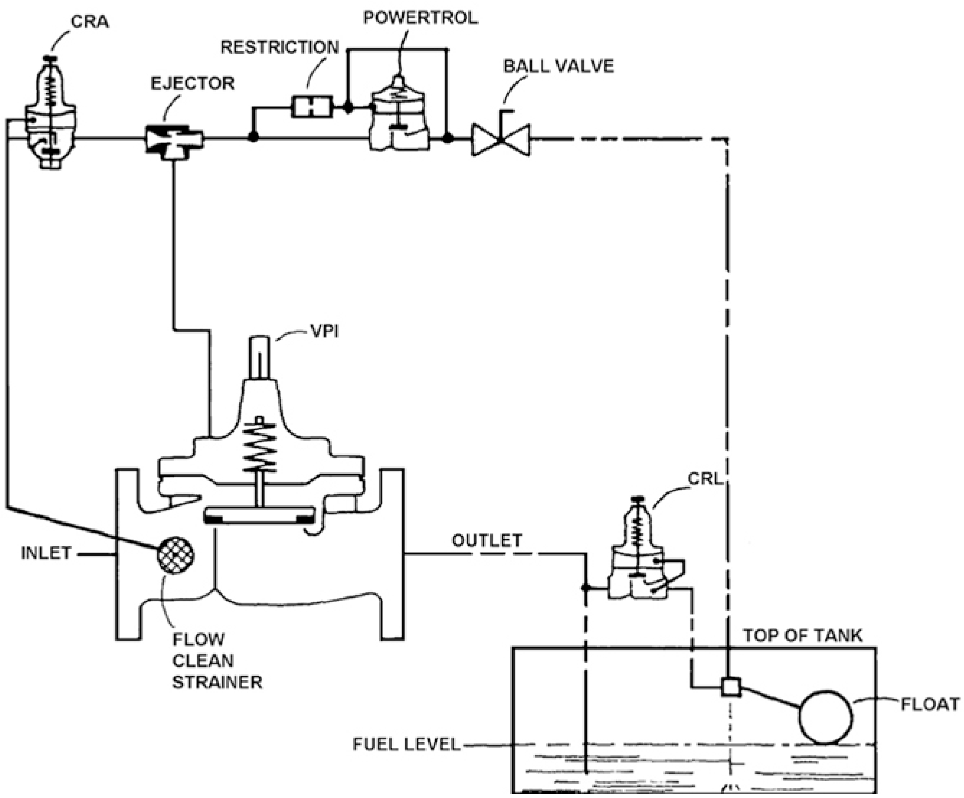


Figure 4–1. High-level shutoff valve, 129AF–3F. (By courtesy of Cla-Val Co.)

The 129AF–3F employs a failsafe, closed-pilot system. This means that if the control line were to rupture, the main valve would close. The powertrol and the CRL handle this function. The powertrol is a normally closed control that responds to pressure changes in the control line. It opens once 5 psi is in the control line. Should the pressure in the control line drop due to a break in the control line, the powertrol closes and inlet pressure is redirected to the cover chamber of the main valve, which closes the main valve. The powertrol remains closed until the normal 5 psi control line pressure is restored. The CRL is a normally closed control, which is designed to maintain the control line's backpressure at 8 psi.

Tank level indicators

The operating tanks have indicators that provide local and remote fuel level readings. Local reading means right at the tank; remote reading is a digital reading in the control room. Both units read in increments of feet and tenths of a foot. The servo compartment of the level indicator must be approved by Factory Mutual or UL and listed for use in Class 1, Division 1, Group D, for hazardous locations. It must also have a thermostatically controlled heater for condensation and freeze protection.

Tank level indicator alarms

Besides having a HLV, there are two high-level alarms on each tank. These alarms are an added precaution in case the 129AF–3F or the 413AF–5A fails to close. In addition, a low-level alarm protects the fueling pumps from running dry. These alarms are identical to those we covered in the last unit, so we will not go over them again in detail.

Tank high-level indicator alarm

The first high-level alarm is really a warning that the fuel is about to reach the 129AF–3F float assembly. It is located just below the set point of the 129AF–3F float assembly. When fuel reaches the setting of the high-level alarm, the annunciator high-level alarm window on the PCP flashes and a vibrating horn sounds. After an operator acknowledges the alert condition, the visual indicator remains lit and the horn turns off. The light remains on until fuel is removed from the tank and the fuel level is below the high-level alarm setting.

Tank high-high-level indicator alarm

This second alarm is located just above the set point of the 129AF–3F float assembly and below the tank overflow vents. When the fuel level in the tank reaches the high-high-level alarm, a resonating horn, a light external to the control room, and the window on the PCP marked high-high-level alarm are all activated. After an operator acknowledges the alert condition, the visual indicator remains lit and the horn turns off. The light remains on until fuel is removed from the tank and the fuel level is below the high-high-level alarm setting.

Product recovery tank

This tank is a separate system used to collect liquid from the Type IV system. Two-inch piping connects the pressure reliefs, strainer drains, F/S automatic water drains, low/high point drains, and operating storage tanks water draw-off. Whenever the system components are opened automatically or manually for maintenance, you will drain the fuel or water into this tank. Fuel contained in the product recovery tank can be pumped through the receiving F/S back into the operating storage tanks.

The product recovery tank is the same type and uses the same equipment you learned about in the Type III system. The tank has a 4,000-gallon capacity. It has a leak detection system that continuously monitors for leaks. There is a 2129AF, HLV, installed in the tank's inlet piping. The 2129AF is equipped with a limit switch to signal the microprocessor when the main valve is closed so it can sound a high-level alarm. The fuel transfer pump is a 50 gpm, multistage, deep-well turbine pump, which returns fuel back through the receiving separators to the operating storage tanks. A hand pump is installed to pump water out of the tank for disposal.

430. Issuing equipment

Most of the issuing equipment in the Type IV system is similar to that in the Type III system. The main difference is the pumphouse and the type of pumps used. The type of tanks used dictates the type of pumps used.

Issue pumps

The fueling pumps used with cut-and-cover or underground tanks are deep-well turbine pumps. Their capacity is 600 gpm when driven at 3,600 rpm. They are statically and dynamically balanced for all flow rates from no flow to 120 percent of the designed flow rate. The design of these deep-well turbine pumps is the same as you learned earlier.

The fueling pumps used with cone roof tanks with a floating pan are the same type used in the Type III system. As you learned before, these pumps are the API 610, horizontal centrifugal, and are rated at 600 gpm when driven at 3,600 rpm.

Flow switches

The flow switches for the type IV fuel system are the same vane-type flow switches that you learned about in the Type III system. The flow switches' purpose is to lock the fueling pumps on after they have started. If the flow switch vane does not sense a flow within 5 seconds of the pumps being called on, the control circuit opens and calls the motor off. The microprocessor then calls on the next sequenced fueling pump.

Rate-of-flow, non-surge check valve

You learned about the 41AF–1A non-surge check valve earlier. Its primary purpose is to control the flow rate through the pump at 600 gpm. Controlling the flow rate is important because it allows the fueling pump to operate efficiently. Remember, the fueling pumps are manifold together so one or all pumps can pump through all the F/Ss at the same time. If only one pump was pumping through several F/Ss, the pump would operate outside of its pump capacity and eventually destroy itself.

Issue filter/separators

The issue F/Ss are the same type and housed as the same separator equipment we covered in the Type III system. They also use the 41AF–2C as the FSCV.

Emergency shutoff valve, 136AF–9B

The first component after the F/S discharge header is the ESO valve. This 6-inch automatic valve is solenoid operated. The two solenoids energize anytime the system is operating and deenergize anytime there is a power failure or when an emergency-stop button is pushed. When either of these conditions occurs, the 136AF–9B closes within 10 seconds.

The CDB–7 differential pressure control is responsible for the ESO valve closing quickly once the emergency-stop button is pressed. The CDB–7 senses pressure from upstream and downstream of the 136AF–9B (fig. 4–2). It is adjusted to a differential of 7 psi between upstream and downstream pressure of the ESO. This 7 psi is trapped in the control tubing of the main valve and is used to close the main valve when released.

When an emergency-stop button is engaged, the pumps are deenergized and the pressure from the pump is no longer available to close the valve. That is where the 7 psi comes into play. When the emergency-stop switch is engaged, the 7 psi trapped in the control tubing is directed to the main valve cover chamber, closing the valve.

The ESO also functions as a thermal relief valve. When outlet pressure exceeds inlet pressure, a ball check valve in the control tubing opens and relieves the higher outlet pressure to the normal inlet.

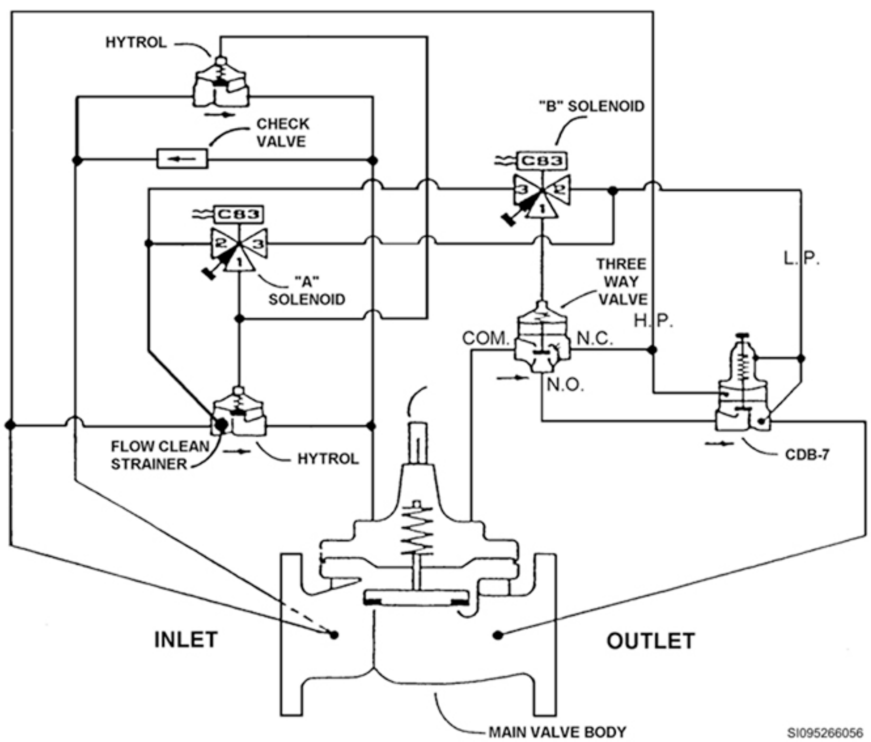


Figure 4–2. Emergency shutoff valve, 136AF–9B. (By courtesy of Cla-Val Co.)

Issue venturi tube

The issue venturi tube, located downstream of the 136AF–9B valve, is a low-loss differential-pressure producer. It operates the same as the venturi in the Type III system. The issue venturi for the Type IV system is rated at 1,200 gpm.

Transmitters

This system uses pressure transmitters to start and stop the fueling pumps. There are two—pressure indicating and differential pressure—and both serve two different functions. Two PITs are in the issue line upstream of the 136AF–9B ESO. There are two DPTs piped to the issue line venturi and four attached to the return venturi. The microprocessor actually cycles and reads each transmitter so it can get a clearer picture of how the system is operating and determines if a pump is needed or not.

Pressure indicating transmitters

The purpose of the PIT is to signal the microprocessor when system pressure drops below 60 psi to call on the lead pump, and to call off the lead pump when system pressure reaches 175 psi. Remember the PIT only calls the lead pump on; the flow switch locks the lead pump on after it has sensed flow.

Differential pressure transmitters

The purpose of the DPT is to sense the differential pressure created by the venturi, translate that differential pressure to gpm, and send a 4–20 mA signal to the microprocessor that represents the flow rate. The microprocessor uses this signal to call on or call off the second pump.

431. Refueling loop and return line equipment

In this lesson, we discuss the refueling loop and return line equipment.

Refueling loop

The refueling loop is exactly what the name implies—a loop. Fuel enters the loop, which is downstream from the 136AF–9B and issue venturi tube, and is routed out under the flight line, connecting all the hot pits. This loop is pressurized at 75 psi when it is idle. That is why some people refer to this system as a constant pressure system. Any time the pressure in the loop drops below 60 psi, a pressure transmitter senses the drop and calls on the designated lead pump to build up the pressure again. If the system develops pressure of 75 psi or greater, through thermal expansion, a valve opens and relieves pressure back to the operating storage tank.

Pantographs

The main difference between the Type III and Type IV systems is the method used to deliver fuel to the aircraft. Instead of a hydrant CV and an R–12 hydrant-servicing vehicle (HSV), the Type IV system uses a pantograph to fuel aircraft. A pantograph is nothing more than three sections of pipes flanged together with swivel joints. The inlet to the pantograph is flanged to the system piping, and the dispensing end has a single-point nozzle. The pantograph has wheels that allow it to roll out to the aircraft for fueling.

Hoseless type

The hoseless-type pantograph (fig. 4–3) consists of two 24-foot sections of pipe with a 5-foot dispensing end pipe. The piping is 3 inches in diameter and made of schedule-10 stainless steel. The 24-foot sections of piping are equipped with supporting structures welded to the underside to avoid sagging. The pantograph is mounted on spring-loaded casters made of steel or cast steel. The caster swivel head and the wheels are equipped with two lubricated ball bearings with grease nipples. A hydraulically actuated cylinder is used to counter-balance the weight of the fueling nozzle, swivel joints, and connecting pipe supports at the dispensing end. The counter-balance ensures one person can connect the single-point nozzle to the aircraft with minimum effort.

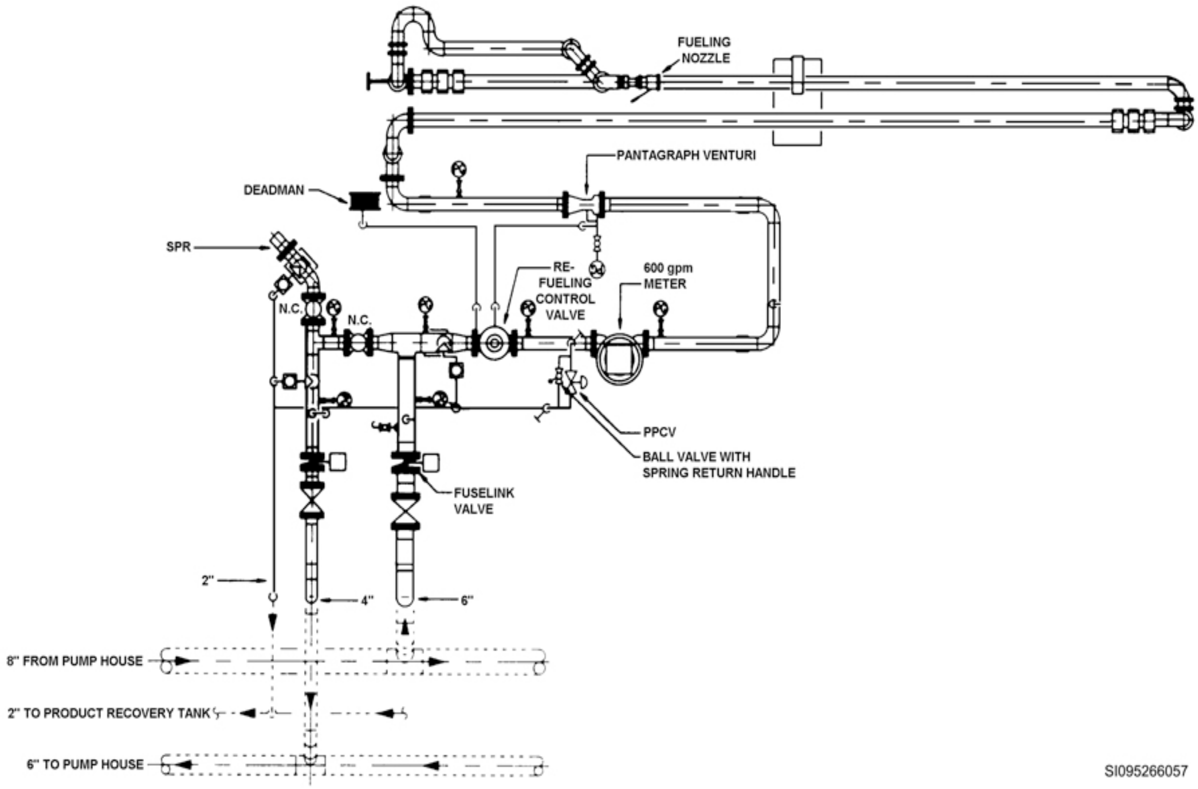


Figure 4–3. Hot pit hoseless pantograph. (By courtesy of Cla-Val Co.)

The swivel joints are made of stainless steel and are single-plane swivels with 360-degree rotation. They are non-lubricated and are connected to the pipe with flanges. Welding the swivel joints to the piping is not permitted. There are no leaks allowed from the swivel joint under positive or negative flow, or under high or low pressure. Lubricated swivel joints are not allowed on the pantograph because the pantograph connects directly to the aircraft. Since there is not a F/S installed after the pantograph, there is a chance that lubrication could get into the aircraft during refueling.

There is electrical continuity throughout the entire pantograph. The overall electrical resistance throughout the entire length of the pantograph cannot exceed 1,000 ohms. Bonding straps cannot be used across the swivel joints.

The pantograph has several pressure gauges installed at various locations. They are $4^{1}/_{12}$-inch metal case pressure gauges with a range of 0–275 psi. They are filled with silicone liquid to absorb shock and vibration.

The single-point nozzle is a 2½-inch straight (D–2) nozzle. It is designed to allow flow rates up to 600 gpm with a maximum pressure drop of 30 psi. The nozzle connects to the pantograph using a quick disconnect/dry-break coupler. A dust cover attached with a chain prevents contaminants from getting into the nozzle end.

Hose-end type

The hose-end-type pantograph (fig. 4–4) consists of two 24-foot sections of pipe with a 10-foot dispensing hose. The piping is 3 inches in diameter, schedule-10, and stainless steel. The 24-foot sections of piping are equipped with supporting structures welded to the underside to avoid sagging. The pantograph is mounted on spring-loaded casters made of steel or cast steel. The caster swivel head and the 8-inch diameter tires are equipped with two lubricated ball bearings with grease nipples. The dispensing hose is a 3-inch, API 1529, Grade 3, Type A or C, semi-hardwall designed for use with JP–8 for working pressure of 300 psi. The hose is connected to the pantograph with a 3-inch, axial-type emergency breakaway coupling that allows a dry breakaway at 200-pounds tensile loading.

The pantograph has several pressure gauges installed at various locations. They are $4^{1}/_{12}$-inch metal-case pressure gauges with a range of 0–100 psi. They are silicone liquid filled to absorb shock and vibration.

The single-point nozzle is a 2½-inch curved nozzle (D–1) type. It is designed to allow flow rates up to 600 gpm with a maximum pressure drop of 30 psi. The nozzle is attached to the hose with a dry-break, quick-disconnect coupler. The nozzle is equipped with a 40-mesh stainless steel strainer. A dust cover attached with a chain prevents contaminants from getting into the nozzle end.

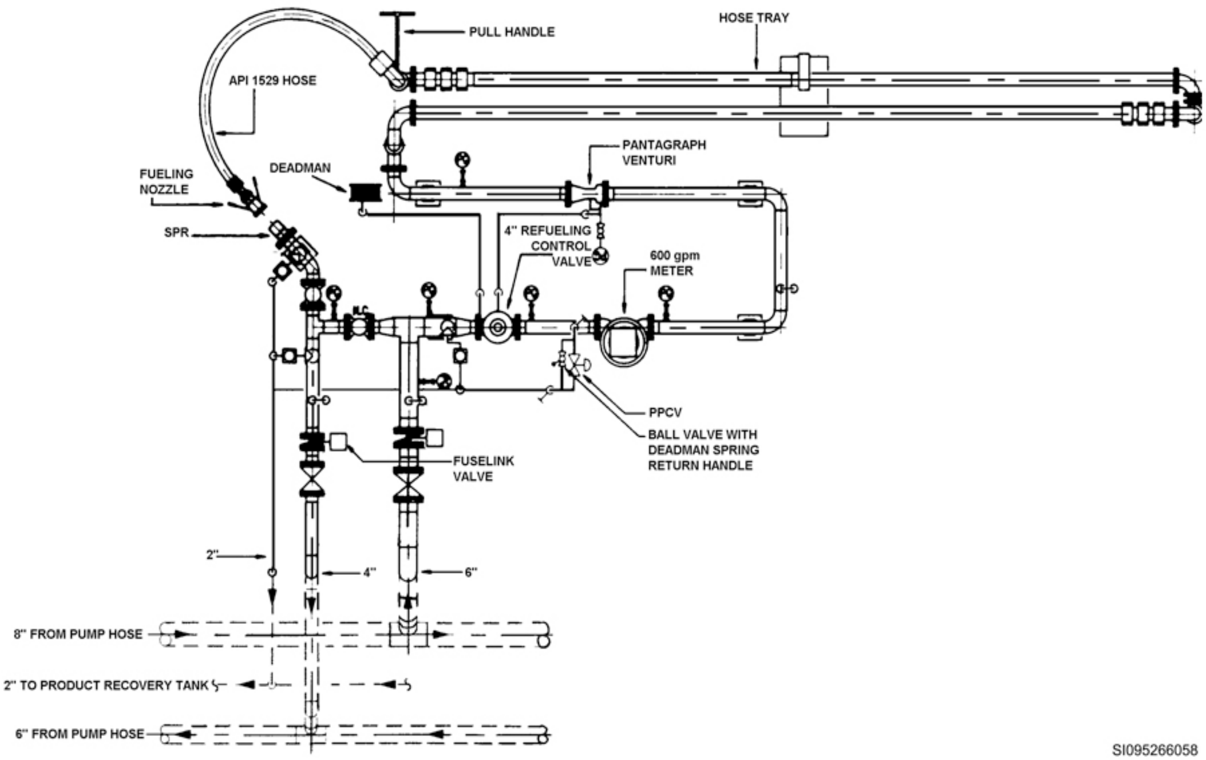


Figure 4–4. Hot pit hose end pantograph. (By courtesy of Cla-Val Co.)

Refueling control valve, 362AF–7

This RCV (fig. 4–5) is a 4-inch valve designed for 600 gpm. Using a sensing line connected to a venturi on the pantograph, the 362AF–7 regulates the system pressure at the skin of the aircraft. The pressure control pilot on the 362AF–7 has an adjustable range of 15 to 75 psi. Adjust it to maintain a pressure of 45 psi for any flow rate from 50 to 600 gpm. When fueling different types of aircraft with the pantograph, two different types of single-point adapters can be used. One is a straight throat (D–2), while the other has a 90-degree angle (D–1). When using the 90-degree angle single-point adapter, pressure drop across the valve should not exceed 9 psi.

The 362AF–7 limits pressure surges on the aircraft to a maximum of 50 psi anytime an aircraft tank valve closes within 0.5 seconds on a 600 gpm system. This valve closes rapidly anytime the outlet pressure exceeds the CRL’s set-point and re-opens when the pressure drops below the same set-point, but only if the deadman control is still activate.

The deadman control is hydraulically operated. This component is connected to the main valve’s pilot system. When the deadman lever is pressed, the 362AF–7 opens; when the lever is released, the 362AF–7 closes rapidly. If the deadman is disconnected from the main valve, the main valve will close in a maximum of 5 seconds.

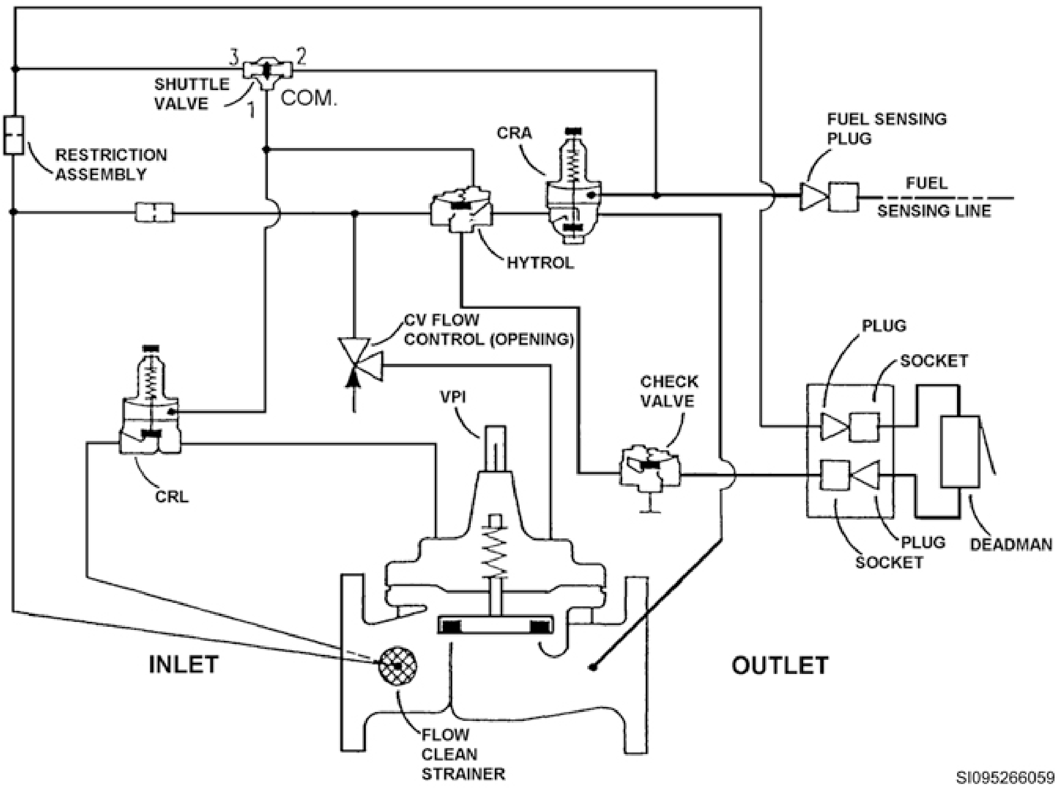


Figure 4–5. Refueling control valve, 362AF–7. (By courtesy of Cla-Val Co.)

Return line

The refueling loop remains pressurized because the return line has an automatic valve that keeps the loop closed. When this automatic valve opens, fuel returns to the operating storage tank. In the receiving line, there is a short loop with four valves in it. This loop not only determines which tank receives fuel from the receiving line but also which tank receives fuel from the return line. By routing fuel through this loop, the fuel passes through the HLV, which prevents the tank from overfilling.

Backpressure control/flushing valve 58AF–9–1

The 58AF–9–1 backpressure control/flushing valve (BPC/FV) (fig. 4–6) in the Type IV system is the same valve as in the Type III system except in the Type IV, it is used for backpressure control and system flushing. In the automatic refueling mode, the 58AF–9–1 is set to open when the pressure at the farthest pantograph reaches 100 psi; it modulates to control its inlet pressure or fueling loop pressure at 100 psi. In either the “loop flushing” or “pantograph flushing” mode, the valve opens wide and freefloats, which means the valve opens wide with any fuel flow.

This valve has two electrical solenoids. The table below shows the solenoid operations. Solenoid “A” energizes when the lead pump is automatically started and deenergizes when the return venturi creates a differential pressure that corresponds to a 560 gpm, or greater, flow rate for 60 seconds. The DPTs, which connect to the return venturi, sense the differential pressure. These transmitters send a signal to the microprocessor, which, in turn, deenergizes the solenoid. With solenoid A energized, the valve can open when the pressure control senses its set point of 100 psi that is measured at the most distant pantograph.

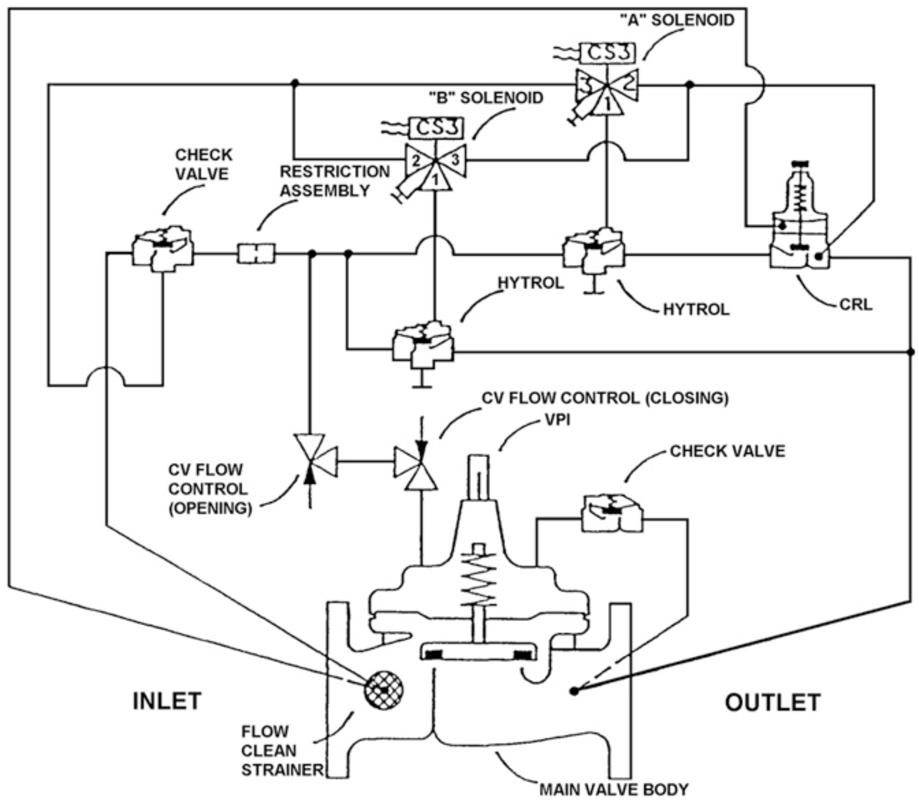


Figure 4–6. Backpressure control/flushing valve, 58A–9–1. (By courtesy of Cla-Val Co.)

58AF–9–1, BPC/FV solenoid operation			
Condition	***Valve action***	***Solenoid "A"***	***Solenoid "B"***
Refueling mode, pump start-up	Enable	Energized	Deenergized
Refueling mode prior to lead pump shutoff	Close	Deenergized	Deenergized
Loop flush and pantograph flush mode	Open	Deenergized	Energized

With solenoid A deenergized, the valve inlet pressure is applied to the main valve cover chamber, which holds the valve closed. Solenoid "B" energizes only when the system is placed in either the "loop flush" or "pantograph flush" mode. With solenoid "B" energized, the main valve opens wide and allows fuel to flow at maximum system flow rates.

Because of the amount of fuel moving in the loop and the possibility of a water hammer or hydraulic shock, the Type IV 58AF–9–1 has to close slowly and, therefore, has a speed control on it. This control has an adjustable range of 2 to 30 seconds; adjust it so the valve takes 3 seconds to close. The opening rate is also adjustable and the valve's opening time should be 1 second maximum.

58AF–3 PCV

The 58AF–3 PCV is the same 2-inch automatic valve found in the Type III system. It is capable of 50 gpm flow rates under normal operating conditions. It has a pressure relief and solenoid on it. The solenoid energizes anytime a pump is running and deenergizes when the pump stops, regardless of whether the pump was started automatically or manually. This solenoid holds the valve closed during refueling operations. When the solenoid is deenergized, the pressure-relief function operates. See the following table:

58AF–3, PCV solenoid operation		
Condition	***Valve action***	***Solenoid***
Any pump on (auto or manual)	Closed	Energized
All pumps off (auto or manual)	Enabled	Deenergized

The pressure relief has an adjustable range of 20 to 200 psi and is normally set to close the valve at 75 psi. Excess pressure bled through this valve literally bypasses the fueling loop and the 58AF–9–1. The inlet piping of the 58AF–3 valve is tapped into the issue piping downstream of the issue venturi, and the outlet piping taps into the return piping downstream of the return venturi.

This valve is opening, and closing rates are controlled. The speed controls (CV flow-controls) have an adjustable range of 2 to 30 seconds. Both are set at 3 seconds, meaning from the time the pressure relief senses 75 psi, it takes 3 seconds to open and it takes 3 seconds to close when loop pressure drops below 75 psi. The important point to remember is that this valve should not open at all when the lead pump or any other fueling pump is operating, regardless of how it was started.

136AF–5B Flush valve

The 136AF–5B flush valve (FV) (fig. 4–7) is a 6-inch solenoid CV, rated at 1,200 gpm, and is located in a valve pit outside the pump house. The FV’s primary purpose is to close the system loop; thus, redirecting the fuel for pantograph flushing. The following table shows the FV’s solenoid operation. The solenoid is energized when the system is placed in the “pantograph flush” mode. When the solenoid energizes, the main valve closes; when the solenoid deenergizes, the main valve free floats open.

136AF–5B FV solenoid operation		
Condition	***Solenoid***	***Valve position***
Loop flush mode	Deenergized	Open
Pantograph flush mode	Energized	Closed
Automatic refueling mode	Deenergized	Open

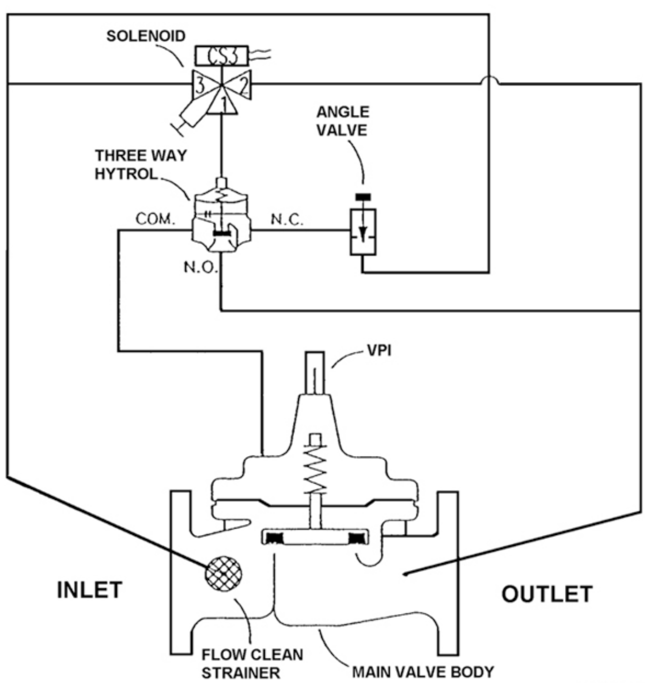


Figure 4–7. Flush valve, 136AF–5B. (By courtesy of Cla-Val Co.)

Pantograph pressure control valve 58E–47

The pantograph pressure control valve (PPCV) is located downstream of the 362AF–7 fueling CV (fig. 4–8). Its primary purpose is to relieve excess pressure during refueling from the pantograph back to the product recovery tank. The CRL is set to relieve excess pressure at 75 psi. The solenoid is a direct acting, three-port solenoid. Referring to the table below, notice how the solenoid is energized open to enable the valve to relieve excess pantograph pressure anytime a fueling pump is energized, and that it is deenergized to close the valve anytime a fueling pump is not running.

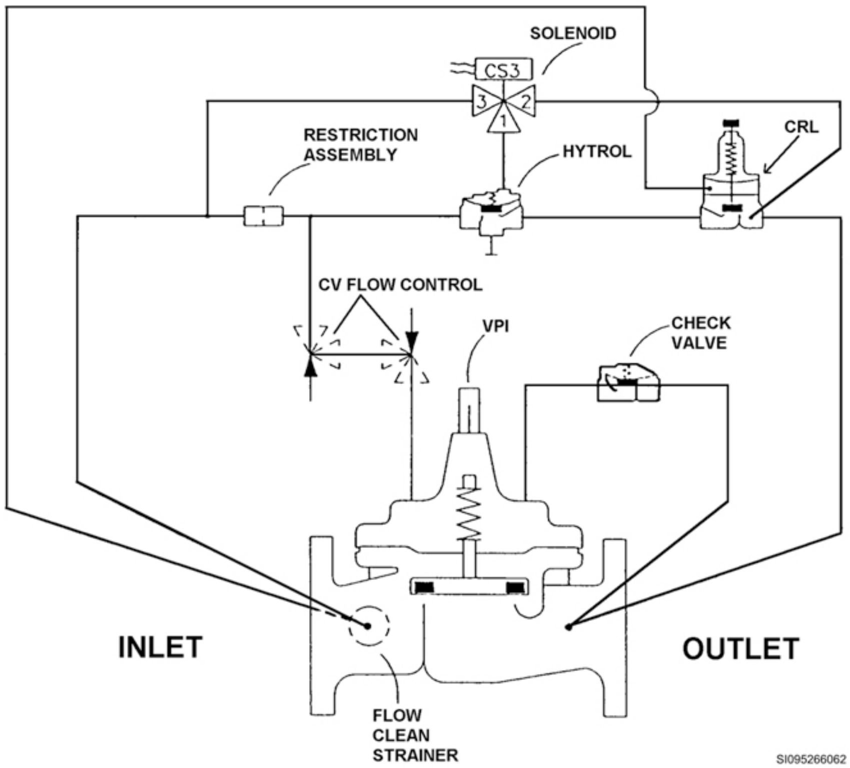


Figure 4–8. Pantograph pressure control valve, 58E-47. (By courtesy of Cla-Val Co.)

58E–47, PPCV solenoid operation		
Condition	***Solenoid***	***Valve action***
Any pump on (Auto or manual)	Energized	Enable
All pumps off (Auto or manual)	Deenergized	Close

Return venturi tube and differential pressure transmitters

Just upstream of the BPC/FV is a 4-inch return venturi tube. This venturi tube is identical to the issue venturi tube, only smaller. Connected to it are four DPTs, which are the same as the DPTs we mentioned earlier. Two of the DPTs are called low range, and the other two are called high-range. The low-range DPTs are used to sense and indicate flow ranges of 0 to 100 gpm, and the high-range DPTs are used to sense and indicate 0 to 800 gpm flow rates.

432. Pump control room equipment

You should now have a basic knowledge of the equipment used in the system to store, push, route, clean, and deliver the fuel. Now it is time to look at the brain—the control center. Earlier, you learned about the Type III pump control room. The Type IV pump control room is very similar.

Pump control panel

As soon as you walk into the pump control room, you will notice that it is set up similar to the Type III hydrant systems. The first thing you notice is the PCP (fig. 4–9).

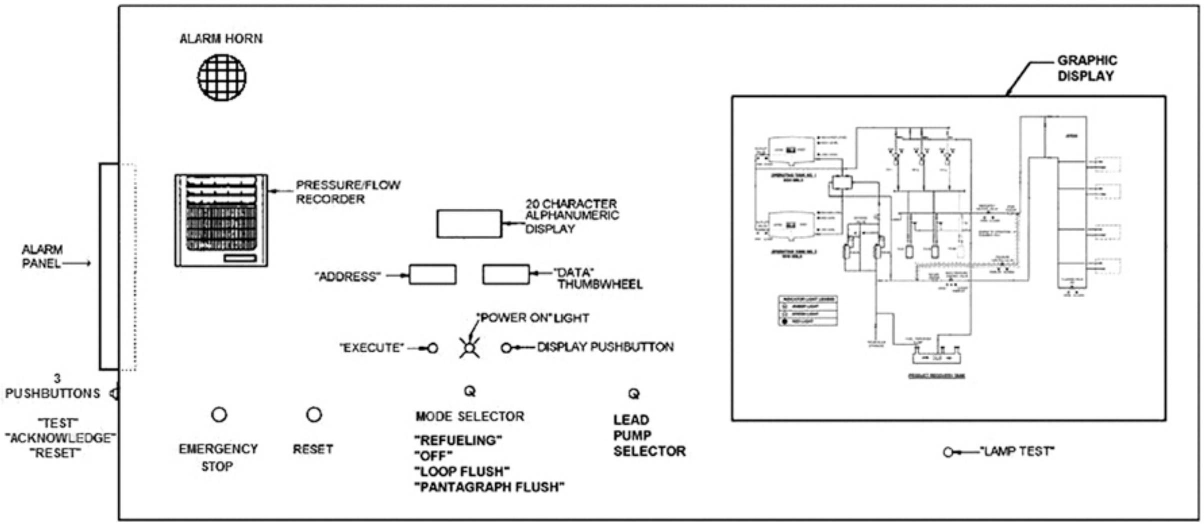


Figure 4–9. PCP.

On the front of this console or panel is a graphic display, a diagram showing the entire fuel system as a color-coded line drawing. The green lines on this graphic display indicate the receiving and system loop return line. The yellow lines indicate the pump suction from the storage tank discharge lines to the inlet of the pumps. Yellow lines also show the water draw-off lines from the F/Ss and pressure-relief valves that go to the product recovery tank. Blue lines are the pump discharge and fueling loop up to and including the 58AF–9–1 (BPC/FV), 58AF–3 (PCV), and 136AF–5B (FV).

It is not just a diagram, you are able to see how much fuel, to the tenth of a foot, is in each tank (including the product recovery tank), what valves are open (by a green light), and which valves are closed (by a red light). Just by looking at the panel, you know which pumps are running, as red lights indicate stopped pumps and green lights indicate running pumps. If the system is receiving fuel, you will be able to watch a counter and see exactly how much fuel is going through the meter. Should an emergency occur, like a tank overfill, red lights indicate which high-high-level alarm is activated.

Annunciator alarm

The alarm annunciator is flush mounted on the end wall of the PCP and is completely solid state with no moving parts. It operates on 120 volts, 60 hertz. Windows on the annunciator are arranged in rows and columns. The number of windows corresponds to the number of alarm points required by the system plus 15 percent more. Examples of required alarm points include low-level alarms, high-level alarms, high-high-level alarms, leak detectors, vapor detectors, receiving bypass valve open, pump failure, microprocessor system faults, and any other conditions that may be deemed important to that particular system. These windows are approximately $^{15}/_{16}$-inch high and at least $1^{5}/_{8}$ inches long. Each window is engraved and has painted lettering that states its purpose. The 15 percent extra windows are plain white and are there for system expansion. The windows are illuminated from the rear by 24 to 28 DC volt lamps. On the PCP is a push-to-test button so you can check all lamps. Besides the windows lighting up and flashing, there are two different audible alarm horns to alert personnel to the emergency—a vibrating horn and a resonating horn.

The following conditions cause the vibrating horn to sound:

- Pump # 1 failure.
- Pump # 2 failure.

- High-level oil/water separator.
- System 1 fault. *
- System 2 fault. *
- High-differential pressure drop receiving F/S.
- High-level product recovery tank.
- High-level alarm tank #1.
- High-level alarm tank #2.
- Product recovery tank overfill valve closed.
- Product recovery tank leak.
- Engine-generator fault.

*System fault alarms initiate when a system fault is detected.

The resonating horn sounds for any of the following conditions:

1. Emergency-stop.
2. Low-level operating tank #1 (if the outlet valve is not fully closed).
3. Low-level operating tank #2 (if the outlet valve is not fully closed).
4. High-high-level operating tank #1.
5. High-high-level operating tank #2.

Under normal conditions, the windows, visual indicators, and horns are off. When an alert condition occurs, the visual indicator flashes and the horn sounds. An alert condition locks in and must be acknowledged before the horn can be silenced. After the alert condition is acknowledged, the visual indicator remains on; however, now the light is steady instead of flashing.

Should another, different, alert start right after an alert is acknowledged, the horn will sound again, and the new condition will cause the appropriate window to flash. When the second alert is acknowledged, the horn will stop and the newly flashing window will be steady. Conditions will have to return to normal before the annunciator windows lamps turn off.

Operator controls

All the controls are mounted on the PCP door panel (previously mentioned in fig. 4–9) or panels and are arranged to easily see and operate. There is a four-position selector switch, which allows you to either select the Automatic, Off, Pantograph Flush, or Loop Flush mode. A second selector switch determines the lead pump. This switch has as many selections as there are pumps. In other words, if the system uses three fueling pumps, you could select either pump 1, 2, or 3 as the lead pump. Selecting the lead pump fixes the starting sequence for the rest of the pumps. If pump #1 is selected, then the sequence for starting the other pumps is 2 then 3. Selecting pump #2 as the lead pump changes the sequence to 3 then 1. The starting sequence simply follows in-turn: 3, 1, 2. If the system only has 2 fueling pumps, just disregard the number 3 in the examples above.

Of course, no control panel would be complete without pushbuttons, and this one has a few. The first button we cover is easily identifiable—the emergency-stop switch. This switch looks like a red mushroom push-button. When you press the emergency-stop button, all pumps stop, solenoid output deenergizes, and a 10 amp, 120 DC volt contact closes, sounding an alarm. In order for you to make the system operational again, you must press the reset button. There are three pushbuttons for the annunciator: Test, Reset, and Acknowledge. The test button ensures the annunciator lights and horn operates. You must push the reset button anytime the system shuts down due to an activated fire alarm or a pushed emergency-stop switch. The system cannot be started again until the reset button is pushed. Remember how the only way to stop the annunciator horn from sounding and change the flashing lights to steady lights was by acknowledging the problem; the way to do this is to push the acknowledge button.

Microprocessors

The Type IV hot pit system uses a microprocessor to receive messages from transmitters installed in the system and then translates these messages into actions. As you learned earlier, the pressure transmitter in the issue line does not turn the lead pump on, it sends a message to the microprocessor, and the microprocessor energizes the lead pump. The DPTs, located at the issue and return venturi tubes, sense the flow rate and transmit their information to the processor, which, in-turn, either turn pumps on or off due to the demand of the system. Tank liquid-level sensors let the computer know how much fuel is in the tanks and whether their valves are open. With this information, the processor knows whether fueling pumps can run or not without damage. It is a complicated piece of equipment, but it is definitely to your advantage to understand its operations.

There are two microprocessor-based controllers in the PCP, just like the PCP in the Type III system.

Operating program

The microprocessor's operating program is stored in a battery-backed memory and is fully capable of cold starts without operator (POL personnel) intervention.

Look at the PCP in figure 4–9 for the address parameters and programmable range of the microprocessor's memory. If a value is entered into an address that is not within the range of that parameter, the 20-character alphanumeric display indicates "INVALID ENTRY".

Self-Test Questions

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

427. System piping

1. What type piping is used from bulk storage to the issue F/Ss if the piping is 16 inches?

2. What type piping is used from the issue F/Ss, through the system loop, and back to the receiving loop if the piping is 12 inches?

3. What type piping is used from the issue F/Ss, through the system loop, and back to the receiving loop if the piping is 4 inches?

4. Why is stainless steel piping used in a Type IV system?

5. What type piping is used for the pressure-relief and drain system in a Type IV system?

428. Receiving equipment

1. List the methods a Type IV system receives fuel.

2. What are the primary methods of receiving fuel into a Type IV system?

3. What size and type receiving F/Ss are used in the Type IV system?

4. What valve is used as the receiving FSCV?

429. Tanks and components

1. What valve is used as the HLV on a Type IV cut-and-cover tank?

2. What component activates the HLV and where is this component located on the Type IV cut-and-cover tank?

3. What is the purpose of the manual valve installed in the control tubing of the Type IV HLV?

4. How much control line pressure does it take to open the powertrol on a 129AF–3F?

5. In what increments do the tank-level indicators read?

6. What is the purpose of the low-level alarm on a Type IV cone roof with floating pan tank?

7. What happens when the fuel level reaches the high-level alarm setting on a Type IV underground tank?

8. What happens when the fuel level reaches the high-high-level alarm setting on a Type IV cut-and-cover tank?

9. What type pump is used to transfer fuel on a Type IV product recovery tank and where is the fuel transferred?

430. Issuing equipment

1. What type and capacity is the fueling pump used on a Type IV cut-and-cover tank?
2. What type and capacity is the fueling pump used on a Type IV cone roof with floating pan tank?
3. What is the purpose of the flow switches?
4. What is the primary purpose of the 41 AF–1A valve?
5. What valve is used as the Type IV issuing FSCV?
6. What happens to the ESO valve when there is system power loss or an ESO switch is engaged?
7. What happens to the 7 psi trapped in the ESO valve's control tubing when an ESO switch is engaged?
8. Where is the issue venturi located?
9. What is the issue venture rated?
10. How many pressure transmitters are found in the Type IV system and where are they piped?
11. What is the primary purpose of the PITs?

431. Refueling loop and return line equipment

1. What does the Type IV system use to connect to an aircraft for fueling?
2. What type swivel joints are used on a hoseless pantograph, and how are they connected?

3. What is the maximum electrical resistance throughout a hoseless pantograph?

4. What type pressure gauges are installed throughout a hoseless pantograph?

5. What type single-point nozzle is used on the hoseless pantograph?

6. What size piping is used on a hose end pantograph?

7. What type dispensing hose is used on a hose end pantograph?

8. Why are lubricated swivel joints not allowed on a hose end pantograph?

9. What type single-point nozzle is used on a hose end pantograph?

10. What valve is used as the RCV in a Type IV system?

11. What is the pressure control pilot adjusted to on the RCV?

12. What happens if the deadman is disconnected from the main valve?

13. What happens to the 58AF–9–1 when the Type IV system is placed in loop flushing mode?

14. What happens to the 58AF–9–1’s solenoid “A” when the Type IV system is automatically started?

15. Explain how the 58AF–3 PCV works.

16. Explain how the solenoid operates on the 136AF–5B valve.

17. Explain the 58E-47 valve’s solenoid operation.

432. Pump control room equipment

1. Explain what the color-coded lines represent on the PCP graphic display.

2. What alarm annunciators are required on the Type IV PCP?

3. List the conditions that cause the vibrating horn to sound in a Type IV system.

4. List the conditions that cause the resonating horn to sound in a Type IV system.

5. What are the four positions on the selector switch of a Type IV system?

6. How many microprocessors are in a Type IV system, and how are the microprocessors used?

7. When do you get an “INVALID ENTRY” indication on the PCP address parameter?

4–2. System Modes of Operation

Knowing the equipment and its location is important. What you learned in the last section is information contained in the present design criteria and is not necessarily the same for every base that has a Type IV hot pit system. You must study and learn the manufacturer’s manuals to understand the system at your base. The same is true about the way a system operates. You cannot troubleshoot or perform maintenance effectively unless you have a total and clear understanding of the system. This section covers how the present design criteria states the Type IV system should operate while in automatic mode (idle or fueling), pantograph flushing, and loop flushing. However, to perform maintenance on a system at any base you must read, understand, and consult the manufacturer’s training literature and operation manuals.

433. Automatic idle mode

Fuels (POL) personnel normally set up the system in the automatic mode, but as a maintenance person, you need to know as much, if not more, than the people who operate it.

Set-up procedures

Whenever a problem exists and a job order is created, your first task should be to make sure the system is set up correctly. This means you must become familiar with the operating instructions and the as-built drawings.

Of course, the first place to start is with the system itself. Here is where you must understand the layout of the system. Begin by making sure all the valves the operation manual requires to be opened during the automatic mode are open and those that must be closed are closed. This is when you select which operating storage tank is used to feed the pumps and which tank will receive the returning fuel.

The second place you check is the control room. Push the PCP test buttons to make sure all the lights and alarms work. Select which fueling pump is going to be the lead pump by turning the selector switch. Remember the lead pump should be changed and cycled through periodically so all pumps have approximately the same amount of running time. After selecting the lead pump, you must turn the rotary selector switch marked Automatic-Off-Pantograph Flush-Loop Flush to Automatic. The system is now ready to refuel automatically.

Pressurizing the system

As we mentioned before, this system is also known as a constant pressure system. It automatically pressurizes itself anytime the system is in the automatic mode. On the issue pipeline, and downstream of the 136AF–9B ESO, are two PITs (PIT 1 or PIT 2). Depending on the microprocessor's selection, PIT–1 or PIT–2 senses the system pressure and sends messages to the microprocessor. Earlier, you learned that a solenoid, depending on its operation, can cause a valve to open or close. You also learned how a solenoid enables a valve. To enable a valve means to give the valve the opportunity to open, even if it does not.

When system pressure drops below 60 psi, the control system starts the selected lead pump. At the same time, a signal is sent to the 58AF–9–1 BPC/FV, energizing solenoid "A" to the enable position and allowing the valve to modulate open at its setting of 100 psi. The solenoid on the 58AF–3 PCV also energizes, but it is energized closed to hold the valve in the closed position; thus, keeping it from opening while any of the fueling pumps is running. Solenoid "B," on the 58AF–9–1 BPC/FV, stays deenergized anytime the system is refueling in the automatic mode. The 58E–47 solenoid energizes to enable the valve to relieve excess pressure above 75 psi in the pantograph. The 136AF–5B flush valve solenoid is deenergized to open the valve.

The lead fueling pump establishes a flow rate of 600 gpm through the issue venturi tube. Pressure builds in the loop, and when the pressure at the farthest pantograph reaches 100 psi, the 58AF–9–1 BPC/FV starts to modulate open to maintain a loop pressure of 100 psi. If there is no fuel demand (no aircraft receiving fuel), the return venturi tube senses a total flow rate of roughly 600 gpm. If the DPTs (DPT 3H or DPT 4H) sense a flow rate of 560 gpm or greater for 60 seconds, the control system initiates a shut down. First, solenoid "A" on the 58AF–9–1 BPC/FV deenergizes, causing the main valve to close. When the BPC/FV closes, the loop pressure increases. Once the loop pressure reaches 175 psi on PIT 1 or PIT 2, depending on the microprocessor's selection, the lead pump is signaled to stop. The solenoid on the 58AF–3 PCV deenergizes, opening the valve and bleeding the system loop pressure to 75 psi. In addition, the solenoid on the 58E–47 PPCV deenergizes, closing the main valve.

Now the system is pressurized in the idle condition. Should pressure drop below 60 psi, the same process takes place. If pressure rises above 75 psi due to thermal expansion, the 58AF–3 PCV opens, allowing the excess pressure to bleed back to the tank.

434. Automatic refueling mode

When the system is in the idle mode, it is ready to refuel an aircraft. The single-point nozzle on the pantograph is connected to the aircraft to be refueled. Once the deadman control on the RCV is depressed, opening the 362AF–7, a low-pressure condition is sensed by the microprocessor, starting the preselected lead pump. The 58AF–9–1 BPC/FV solenoid "A" is energized to the enable position, allowing the valve to modulate, keeping the loop pressure at 100 psi. The 58AF–3 PCV solenoid is energized closed; closing the main valve, and the solenoid on the 58E–47 PPCV is energized to enable the valve to open at 75 psi. The 136AF–5B flush valve solenoid is deenergized to open the valve.

The lead pump establishes a flow rate of approximately 600 gpm through the issue venturi, and the pressure at the farthest pantograph increases to 100 psi. At this pressure, the 58AF–9–1 starts to modulate, passing the excess pressure through the return venturi. DPT 1 or DPT 2 senses differential pressure corresponding to the flow rate of 600 gpm through the issue venturi, and DPT 3L and DPT 3H or DPT 4L and DPT 4H sense differential pressure through the return venturi at a rate greater than 40 gpm and less than 560 gpm. As long as the system remains at this flow rate, only the lead pump continues to run, delivering fuel to the aircraft.

When the aircraft has received its required amount of fuel, DPT 3H or DPT 4H senses a flow rate greater than 560 gpm through the return venturi for more than 60 seconds. At this time, the 58AF–9–1 BPC/FV solenoid "A" deenergizes, closing the valve, which causes the pressure to rise above 175 psi. PIT 1 or PIT 2 senses this pressure and sends a signal to the microprocessor, turning the lead pump off. The 58AF–3 PCV solenoid deenergizes, allowing the valve to open, relieving system pressure down to 75 psi, deenergizing the 58E–47 solenoid, and closing the main valve. When the lead pump is running and the low-range DPTs, DPT 3L or DPT 4L, senses a flow rate of less than 40 gpm through the return venturi for a continuous 10-second interval, the second pump starts. This condition occurs when the serviced aircraft can receive fuel at a rate that exceeds 560 gpm or when more than one aircraft is being fueled at a time. With the flow rate through the return venturi greater than 700 gpm for a continuous interval of 15 seconds, and more than the lead pump is running, the second pump stops. The system then operates the same as it does at the 600 gpm flow rate. If the flow rate through the return venturi does not remain greater than 700 gpm for 15 seconds, the second pump continues to run until the system operating condition changes.

As the demand for fuel flow through the 362AF–7 RCV decreases, the flow through the return venturi increases, turning off the pumps in sequence, ending with the lead pump.

If a pump is automatically called on and fails to start or fails after successfully starting, it is called off and the next idle fueling pump in the predetermined sequence of pumps is called on automatically.

435. Loop flush mode

Loop flush mode is used if the system has not been used for more than 30 calendar days or if fuel samples indicate the presence of water or excessive sediment (eroded material). Fuel is flushed around the apron loop, through the receiving F/S, and back into the operating tanks.

Position the manually operated valves to direct fuel through the desired flow path. Place the system's (Auto-Off-Loop Flush-Pantograph Flush) selector switch on the PCP to "Loop Flush" mode. Solenoid "B" on the 58AF–9–1 BPC/FV energizes, allowing the valve to open with any fuel flow. The 136AF–5B FV solenoid deenergizes to allow the valve to open. Select the pumps to be used and place their Auto-Off-Hand selector switch to the "Hand" position. This starts the pump and energizes the 58AF–3 PCV to close. Additional pumps may be started manually to obtain the desired flushing flow rate.

Remember how in the Type III system we wanted to start all the available pumps for flushing to obtain the maximum feet per second through the pipeline? Well, we want to do the same thing in the Type IV system. Once you completely flush the system with twice the line capacity, return the system back to the automatic idle mode.

436. Pantograph flush mode

Use the pantograph flush mode prior to hot pitting an aircraft when the pantograph has not been used for more than 30 calendar days or when fuel samples indicate the presence of water or excessive sediment. The reason for system flushing is to move fuel through the pipeline as fast as possible and clean the loop. Energize all available fueling pumps to get the maximum (foot-per-second) flow in the hydrant loop.

Position the manually operated valves to direct fuel through the desired flow path. Place the system's (Auto-Off-Loop Flush-Pantograph Flush) selector switch on the PCP to the "Pantograph flush" mode. Connect the pantograph single point nozzle to the SPR. The SPR is located on a piping, stub-up, beside the pantograph. The 136AF–5B flush valve solenoid energizes to close the main valve.

Solenoid “B” on the 58AF–9–1 BPC/FV energizes, allowing the valve to open with any fuel flow. Select the pumps to be used and place their Auto-Off-Hand selector switch to the “Hand” position. This starts the pump. At the same time, the solenoid on the 58AF–3 energizes, closing the main valve, and the solenoid on the 58E–47 energizes, allowing the valve to open at 75 psi. You may manually start additional pumps to obtain the desired flushing flow rate. Once the pumps are started, the operator has 10 seconds to depress the hydraulic deadman control on the RCV before the pumps shut off due to high pressure.

Pantograph flushing is only performed on one pantograph at a time. Once you completely flush the first pantograph, repeat the flushing procedure at each pantograph, then return the system to the automatic idle mode.

Self-Test Questions

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

433. Automatic idle mode

1. Why should you rotate the pump you use as the lead pump?

2. Explain what happens when system pressure drops below 60 psi on a Type IV system.

434. Automatic refueling mode

1. Explain what happens when the deadman control on the RCV is depressed to refuel an aircraft in the automatic mode.

2. Explain what happens when an aircraft is finished refueling in a Type IV system.

435. Loop flush mode

1. Explain what happens to the 58AF–9–1 and the 136AF–5B valves when a Type IV system is placed in the “loop flush” mode.

2. When does the 58AF–3 solenoid energize during the “loop flush” mode?

436. Pantograph flush mode

1. What happens when a Type IV system is placed in the “pantograph flush” mode?

2. What happens to the 58AF–3 and the 58E–47 valves when a Type IV system is placed in the “pantograph flush” mode and the pumps are started?

3. In the “pantograph flush” mode, how many pantographs can be flushed at one time, and what happens after you completely flush the first pantograph?

Answers to Self-Test Questions

427

1. Internal, epoxy-coated carbon steel, ASTM A53, grade B with a .375-inch thick wall.
2. Seamless stainless steel, Schedule 10S, ASTM 312, Type 304L.
3. Seamless stainless steel, Schedule 40 minimum, ASTM 312, Type 304L.
4. Because it is less susceptible to rust and ensures the fuel quality being delivered to the aircraft.
5. Epoxy-coated carbon steel, Schedule 40, API 5L, Grade B or ASTM A53, Grade B.

428

1. By truck, tank car, pipeline, or barges.
2. Pipelines or barges.
3. Two 600-gpm, horizontal, API 1581 F/Ss.
4. The 40–27G FSCV.

429

1. 129AF–3F.
2. A CFM2 float control. It is located inside the tank at the required shutoff height.
3. To manually test the valve’s closing feature.
4. 5 psi.
5. Feet and tenths of a foot.
6. To protect the fueling pumps from running dry.
7. The annunciator high-level alarm window on the PCP flashes and a vibrating horn sounds.
8. A resonating horn, a light external to the control room, and the window on the PCP marked high-high-level alarm are all activated.
9. A 50 gpm, multi-stage, deep well turbine pump. It is transferred (returned) back through the receiving separators to the operating storage tanks.

430

1. Deep well turbine pumps rated at 600 gpm when driven at 3,600 rpm.
2. API 610, with a horizontal centrifugal, rated at 600 gpm when driven at 3,600 rpm.
3. To lock the fueling pumps on after they have started.
4. To control the flow rate through the pump at 650 gpm.
5. The 41AF–2C.
6. The 136AF–9B closes within 10 seconds.
7. It is directed to the main valve cover chamber, closing the valve.
8. Downstream of the 136AF–9B valve.
9. At 1,200 gpm.
10. There are two, one is a pressure indicating and the other is differential pressure. There are two DPTs piped to the issue line venturi and four attached to the return venturi.
11. To signal the microprocessor whenever system pressure drops below 60 psi, to call on the lead pump, and to call off the lead pump when system pressure reaches 175 psi.

431

1. A pantograph.

2. Stainless steel, single-plane, non-lubricated. They are connected to the pipe with flanges.
3. 1, 000 ohms.
4. $4^{1}/_{12}$-inch metal case, silicone liquid filled, with a range of 0–275 psi.
5. A $2^{1}/_{2}$-inch straight nozzle (D–2)
6. 3 inches in diameter, schedule-10 stainless steel.
7. 3-inch, API 1529, Grade 3, Type A or C, semi-hardwall designed for use with JP–8 for working pressure of 300 psi.
8. Because there is no filter separator after the pantograph. The pantograph connects directly to the aircraft and there is a chance the lubrication could get into the aircraft during refueling.
9. A $2^{1}/_{2}$-inch curved nozzle (D–1).
10. The 362AF–7 valve.
11. 45 psi for any flow rate from 50 to 600 gpm.
12. The main valve will close in a maximum of 5 seconds.
13. The valve opens wide and freefloats, which means the valve opens wide with any fuel flow.
14. It is energized.
15. The solenoid energizes anytime a pump is running and deenergizes when the pump stops, regardless of whether the pump was started automatically or manually and holds the valve closed during refueling operations.
16. The solenoid is energized when the system is placed in the “pantograph flush” mode. When it energizes, the main valve closes; when the solenoid deenergizes, the main valve freefloats open.
17. The solenoid is energized open, enabling the valve to relieve excess pantograph pressure anytime a fueling pump is energized and it is deenergized to close anytime a fueling pump is not running.

432

1. The green lines on this graphic display indicate the receiving and system loop return line. The yellow lines indicate the pump suction, from the storage tank discharge lines to the inlet of the pumps. Yellow lines also show the water draw-off lines from the F/Ss and pressure-relief valves that go to the product recovery tank. Blue lines are the pump discharge and fueling loop up to and including the 58AF–9–1 (BPC/FV), 58AF–3 (PCV), and 136AF–5B (FV).
2. Low-level alarms, high-level alarms, high-high-level alarms, leak detectors, vapor detectors, receiving bypass valve open, pump failure, microprocessor system faults, and any other conditions that may be deemed important to that particular system.
3. Pump # 1 failure, pump # 2 failure, high-level oil/water separator, system 1 fault, system 2 fault, high-differential pressure drop receiving F/S, high-level product recovery tank, high-level alarm tank #1, high-level alarm tank #2, product recovery tank overfill valve closed, product recovery tank leak, engine-generator fault.
4. Emergency-stop, low-level operating tank #1 (if the outlet valve is not fully closed), low-level operating tank #2 (if the outlet valve is not fully closed), high-high-level operating tank #1, high-high-level operating tank #2.
5. Automatic, Off, Pantograph Flush, or Loop Flush mode operation.
6. Two. Used to receive messages from transmitters installed in the system and then translates these messages into action.
7. When entering a value into an address that is not within the range of that parameter.

433

1. So all pumps have approximately the same amount of running time.
2. The control system starts the selected lead pump, and at the same time, a signal is sent to the 58AF–9–1 BPC/FV energizing solenoid “A” to the enable position and allowing the valve to modulate open to maintain 100 psi at the farthest pantograph. The solenoid on the 58AF–3 PCV energizes closed to hold the valve in the closed position to keep it from opening while any of the fueling pumps are running. Solenoid “B” on the 58AF–9–1 BPC/FV stays deenergized anytime the system is refueling in the automatic mode.

434

1. The 362AF–7 opens, a low-pressure condition is sensed by the microprocessor, starting the preselected lead pump. The 58AF–9–1 BPC/FV solenoid “A” is energized to the enable position, allowing the valve to modulate, keeping the pressure at 100 psi. The 58AF–3 PCV solenoid is energized closed; closing the main valve and the solenoid on the 58E–47 PPCV is energized to enable the valve to open at 75 psi. The 136AF–5B flush valve solenoid is deenergized to open the valve.
2. DPT 3H or DPT 4H senses a flow rate greater than 560 gpm through the return venturi for more than 60 seconds. At this time, the 58AF–9–1 BPC/FV solenoid “A” deenergizes, closing the valve, which causes the pressure to rise above 175 psi. PIT 1 or PIT 2 senses this pressure and sends a signal to the microprocessor, turning the lead pump off. The 58AF–3 PCV solenoid deenergizes, allowing the valve to open, relieving system pressure down to 75 psi, deenergizing the 58E–47 solenoid, closing the main valve.

435

1. Solenoid “B” on the 58AF–9–1 BPC/FV energizes, allowing the valve to open with any fuel flow. The 136AF–5B FV solenoid deenergizes to allow the valve to open.
2. When the Auto-Off-Hand selector switch is placed in the “Hand” position. This starts the pump and energizes 58AF–3 PCV to close.

436

1. After connecting the pantograph single point nozzle to the SPR, the 136AF–5B flush valve solenoid energizes to close the main valve. Solenoid “B,” on the 58AF–9–1 BPC/FV energizes, allowing the valve to open with any fuel flow.
2. The solenoid on the 58AF–3 energizes to close the main valve, and the solenoid on the 58E–47 energizes to allow the valve to open at 75 psi.
3. One pantograph at a time. Then repeat the flushing procedure at each pantograph.

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.

91. (427) What type of piping is used with the Type IV issue filter/separators (F/S), the system loop, and receiving loop when a 6-inch pipe is used?
    a. Seamless stainless steel, schedule 40.
    b. Seamless stainless steel, schedule 80.
    c. Epoxy-coated carbon steel, schedule 40.
    d. Epoxy-coated carbon steel, schedule 80.

92. (427) What type piping is used on the pressure-relief and drain system for a 2-inch pipe in a Type IV system?
    a. Seamless stainless steel, schedule 40.
    b. Seamless stainless steel, schedule 80.
    c. Epoxy-coated carbon steel, schedule 40.
    d. Epoxy-coated carbon steel, schedule 80

93. (428) What is the *primary* method of receiving fuel in a Type IV system?
    a. Barges or pipelines.
    b. Commercial trucks.
    c. Air Force truck.
    d. Railroad.

94. (428) What size mesh screen is used in the receiving strainer of a Type IV system?
    a. 40.
    b. 60.
    c. 80.
    d. 100.

95. (428) Which valve is used as the receiving filter/separator control valve (FSCV) in a Type IV system?
    a. 41AF–2E.
    b. 41AF–2C.
    c. 40–27G.
    d. 40–28A.

96. (429) Which valve is used on a Type IV cut-and-cover tank for high-level shutoff?
    a. 129AF–1A.
    b. 129AF–3F.
    c. 413AF–5A.
    d. 413AF–9–1.

97. (429) What pounds per square inch (psi) backpressure does the pressure-relief control (CRL) maintain on the high-level shutoff valve (HLV) on a Type IV underground operating storage tank?
    a. 5.
    b. 6.
    c. 7.
    d. 8.

98. (429) When does the high-level light go out once the operator has acknowledged an activated alarm on?
   a Type IV operating storage tank?
   a. As soon as the high-high-level alarm is activated.
   b. Immediately after the operator acknowledges the alarm.
   c. When fuel is removed to below the low-level alarm setting.
   d. When fuel is removed to below the high-level alarm setting.

99. (430) What type fueling pumps are used in a Type IV cut-and-cover tank and what is the capacity?
   a. Deep-well turbine pumps, 600 gallons per minute (gpm).
   b. Deep-well turbine pumps, 1,200 gpm.
   c. Horizontal centrifugal pumps, 600 gpm.
   d. Horizontal centrifugal pumps, 1,200 gpm.

100. (430) To what pounds per square inch (psi) differential is the differential pressure control on the Type IV emergency shutoff (ESO) valve adjusted?
   a. 5.
   b. 7.
   c. 10.
   d. 12.

101. (431) The swivel joints installed on a Type IV hoseless pantograph are stainless steel,
   a. lubricated, and welded.
   b. lubricated, and flanged.
   c. non-lubricated, and welded.
   d. non-lubricated, and flanged.

102. (431) What is the *maximum* electrical resistance, measured in ohms, allowed through the entire Type IV pantograph?
   a. 500.
   b. 1,000.
   c. 5,000.
   d. 10,000.

103. (431) Which type of single-point nozzle is used on the Type IV hose-end pantograph?
   a. $2^1/_2$-inch, D–1 type curved nozzle.
   b. $2^1/_2$-inch, D–2 type straight nozzle.
   c. 3-inch, D–1 type curved nozzle.
   d. 3-inch, D–2 type straight nozzle.

104. (431) Which type fuel dispensing hose is installed on a Type IV hose-end pantograph?
   a. 3-inch, American Petroleum Institute (API) 1529, hardwall.
   b. 4-inch, API 1581, hardwall.
   c. 3-inch, API 1529, semi-hardwall.
   d. 4-inch, API 1581, semi-hardwall.

105. (431) How much pressure, in pounds per square inch (psi), is the Type IV refueling control valve (RCV) adjusted to maintain pressure at the skin of the aircraft?
   a. 40.
   b. 45.
   c. 50.
   d. 55.

106. (431) What is the purpose of the 58AF–9–1 defuel/flush valve (D/FV) in the Type IV system?
   a. Loop flushing.
   b. Pantograph flushing.
   c. Backpressure control and defueling.
   d. Backpressure control and system flushing.

107. (431) What happens to the main valve, during pantograph flushing, based on action from solenoid “B” on the 58AF–9–1 defuel/flush valve (D/FV)?
   a. It opens when the solenoid energizes.
   b. It closes when the solenoid energizes.
   c. It opens when the solenoid is deenergized.
   d. It closes when the solenoid is deenergized.

108. (431) When is the solenoid on the 58AF–3 pressure control valve (PCV) on the Type IV system deenergized?
   a. When any pump is in the manual mode.
   b. When any pump is in the automatic mode.
   c. When any pump is off.
   d. When all pumps are off.

109. (431) Which valve is used as the flush valve (FV) in a Type IV system?
   a. 58E–47.
   b. 58F–47.
   c. 136AF–5B.
   d. 136AF–9B.

110. (431) When the flush valve (FV) on a Type IV system is placed in the pantograph flush mode, the solenoid is
   a. energized and the main valve opens.
   b. energized and the main valve closes.
   c. deenergized and the main valve opens.
   d. deenergized and the main valve closes.

111. (431) During refueling, at what pressure, in pounds per square inch (psi), does the pantograph pressure control valve (PCV) relieve excess pressure?
   a. 45.
   b. 55.
   c. 65.
   d. 75.

112. (432) What do blue lines on the Type IV pump control panel (PCP) graphic display represent?
   a. The receiving line.
   b. The pump suction line.
   c. The pump discharge and fueling loop.
   d. The system refueling loop return line.

113. (432) What condition would cause a resonating horn to sound on a Type IV system?
   a. Emergency stop.
   b. Engine-generator fault.
   c. Product-recovery tank leak.
   d. High-level oil/water separator.

114. (432) Which switch on the Type IV pump control panel (PCP) looks like a red mushroom?
   a. Light test.
   b. Fire alarm.
   c. System reset.
   d. Emergency stop.

115. (433) In a Type IV system, pressure-indicating transmitters (PIT) are located on the
   a. issue line upstream of the 136AF–9B.
   b. issue line downstream of the 136AF–9B.
   c. return line upstream of the 58AF–9–1.
   d. return line downstream of the 58AF–9–1.

116. (433) What position is solenoid “A” in, on the 58AF–9–1 defuel/flush valve (D/FV), when refueling in the automatic mode of a Type IV system?
   a. Energized, closed.
   b. Energized, enabled.
   c. Deenergized, closed.
   d. Deenergized, enabled.

117. (434) During aircraft refueling in a Type IV system, only the lead pump continues running when the issue and return venturi senses
   a. 600 gallons per minute (gpm) and 25 gpm.
   b. 600 gpm and more than 40 gpm.
   c. 1,200 gpm and 25 gpm.
   d. 1,200 gpm and more than 40 gpm.

118. (434) How many seconds *must* the flow rate stay above 700 gallons per minute (gpm), through the Type IV return venturi before the second pump is called off?
   a. 0.
   b. 10.
   c. 15.
   d. 60.

119. (434) During an aircraft refueling, as demand for fuel flowing through the 362AF–7 refueling control valve (RCV) decreases in a Type IV system, flow increases through the
   a. issue venturi.
   b. return venturi.
   c. 41AF–2C valve.
   d. 136AF–9B valve.

120. (435) When a Type IV system is placed in the *loop flush* mode, what happens to one of the solenoids on the 58AF–9–1 defuel/flush valve (D/FV)?
   a. “A” energizes to close the main valve.
   b. “B” energizes to close the main valve.
   c. “A” energizes to open the main valve.
   d. “B” energizes to open the main valve.

121. (435) When a Type IV system is placed in the *loop flush* mode, the solenoid on the 136AF–5B flush valve (FV)
   a. energizes to open the main valve.
   b. energizes to close the main valve.
   c. deenergizes to close the main valve.
   d. deenergizes to open the main valve.

122. (436) When a Type IV system is placed in the *pantograph flush* mode, the solenoid on the 136AF–5B flush valve (FV)
   a. energizes to open the main valve.
   b. energizes to close the main valve.
   c. deenergizes to open the main valve.
   d. deenergizes to close the main valve.

123. (436) During pantograph flushing, how many seconds does the operator have to depress the deadman control on the refueling control valve (RCV) before the pumps shut off due to high pressure?
   a. 5.
   b. 10.
   c. 15.
   d. 20.

Glossary of Terms, Abbreviations, and Acronyms

Terms

ammeter—Instrument to measure amperes.

ampere—A unit of electrical current. Current is the amount of electricity that moves past a point.

atmosphere—The mass of air surrounding the Earth. The pressure of the air at sea level is used as a unit of measure.

atmospheric pressure—The pressure of air exerted equally in all directions. The standard pressure is that at sea level under which a mercury barometer stands at 760 mm equal to 14.7 lb./sq.

automatic valve—A fuel system component which operates hydraulically using system or pneumatic pressure.

AVGAS—Common expression for aviation gasoline, the fuel used for aircraft reciprocating engines.

barrel—A unit measurement of liquid. Petroleum industry uses 42-gallon barrel as the standard barrel.

bonding—A term used to describe equalizing the static electrical potential between two different components or piece of equipment. This is done by connecting both pieces of equipment by a bonding wire.

bulk storage tank—Storage tank for fuel normally received by pipeline, tank truck, or tank car.

calibration—The act of adjusting a piece of equipment. Calibrate a meter register with a given quantity passing through the meter. Calibrate a pressure gauge with a known specific pressure.

cap—A pipe fitting with female threads used to cap off open pipes. Usually on 2-inch or smaller pipes.

cathodic protection—A method for preventing corrosion of metals by electrolysis.

centrifugal force—A force that tends to impel a thing or parts of a thing outward from the center of rotation.

centrifugal pump—A rotating device which moves liquids and develops liquid pressure by imparting centrifugal force.

closed circuit—An electrical circuit or path that is complete. When a switch or circuit breaker is placed in the ON position the circuit is said to be closed.

combustible liquid—Any liquid having a flash point at or above 100°F (38°C).

contamination—The addition to a petroleum product of some material not normally present, as dirt, rust, water, or another petroleum product.

control center—POL's control center which is manned 24 hours a day, 365 days a year.

corrosion—The process of metal dissolving due to exposure to electrolytes.

cut-and-cover tanks—Vertical storage tanks mounded over with dirt. Used primarily in overseas locations.

deadhead—A term used to describe the act of pumping against a closed pipeline.

deadman control—A control device, such as a valve or switch, designed to interrupt flow if the operator leaves their position.

deenergized—A term used to describe a component which has no electrical power applied to it.

differential pressure transmitter—A device that senses a difference in high and low pressure as created by a venturi or orifice plate, convert the differential pressure to an electrical signal, and send the electrical signal through a wire.

differential pressure—The difference between high and low pressure. A term used to describe pressure created by a venturi or orifice plate. Filter/Separators use differential pressure gauges to sense the condition of the filter elements.

downstream—A term used to describe the direction of flow in a pipeline in reference to an object. Downstream is in the direction the fuel is moving. Downstream of the pump would be anywhere after the pump discharge.

enable—The ability of an automatic valve to open when the conditions of its components are met.

energized—A term used to describe a component which has electrical power applied to it.

epoxy coating—A coating of thermosetting resins having strong adhesion to the parent structure, toughness, and high corrosion and chemical resistance.

filter/separator—A fuel system component used to remove solid particles and water from the fuel.

flash point—The temperature at which a combustible or flammable liquid produces enough vapor to support combustion.

flight line—This is an area on a base where aircraft are parked and serviced.

fluid—A substance tending to flow or conform to the shape of a container. Fluid can be in a liquid or gaseous state.

free water—Undissolved water content in fuel.

freeze point—The temperature at which wax crystals form in distillate fuels and jet fuels.

friction—The resistance to motion between two bodies in contact.

gas—A fluid that has no particular shape or volume but tends to expand indefinitely. Will take the shape of the container it is in and can be compressed.

gasoline—A volatile liquid hydrocarbon fuel generally made from petroleum.

gravity—A pulling force generated by a planet, moon, or any other large mass spinning in the universe.

ground rod—A rod, normally $^3/_4$” X 8’ made of galvanized steel, driven into the earth for the purpose of grounding.

grounding—A term used to describe the equalizing of static electrical potential between a component or piece of equipment and the earth. This is done by connecting the equipment by wire to a ground rod.

header—A term describing a loading/offloading connection or coupler.

horsepower—A unit of power equal in the United States to 746 watts and nearly equivalent to the English gravitational unit of the same name that equals 550 foot pounds of work per second.

hot pit system—An aircraft direct fueling system where aircraft can refuel while their engines are still running.

hydrant system—Distribution and dispensing system for aviation fuels consisting of a series of fixed flush type outlets or hydrants connected by piping.

hydraulics—The science used to study fluids or gases at rest or in motion. Originally used for the study of fluids and gases in motion only.

hydrocarbons—Any of the components made up exclusively of hydrogen and carbon in various ratios.

hydrostatic—The science used to study fluids or gases at rest. (See hydraulics.)

immediate operating storage tank—See Operating Storage Tank.

inch of water pressure—The amount of pressure exerted by a one inch column of water. Equal to .036 psi.

jet fuel—Fuel used in jet aircraft engines.

JP–8—A grade of jet fuel. Vapor pressure=<1, Flash point=100 degrees F., Freeze point=–58 degrees F, Specific gravity=0.81.

liquid—A fluid which pours easy and will take the shape of the container it fills. Liquid is almost incompressible where gas is compressible.

loading—A fuel issue connection, where fuel is loaded on refueling units.

lubricants—Material, especially oils, grease, and solids such as graphite, used to decrease friction.

micron—A unit of length equal to one millionth (1/1,000,000) of a meter.

military specification (Mil Spec)—Guides for determining the quality requirements for materials and equipment used by the military service.

non-sparking—Made of metal alloy which, when struck against other objects, will not usually cause sparks of sufficient temperature to ignite flammable vapors.

nozzle—A spout or connection through which fuel is discharged.

offloading—A receiving connection, where fuel can be unloaded by tank truck or tank car.

ohmmeter—An instrument to read ohms or resistance.

oil/water separator—A device used to separate mixtures of oil and water.

operating storage tank—Storage tank from which fuel is issued directly to the final-use vehicle, such as aircraft.

orifice plate—A component used to create a differential pressure for automatic valves. See Bernoulli's Principle.

Panero System—Type I fuel system. Single outlet hydrant system.

pantograph—A series of pipes, joined by flexible joints, used to connect fueling equipment to aircraft or vehicles.

petroleum—A compound consisting of a mixture of hydrocarbons.

plug—A pipe fitting with male threads used to plug the end of a pipe. Usually used on pipes 2 inches and smaller.

power—A source or means of supplying energy. The time or rate at which work is accomplished or energy is transmitted or emitted.

pressure drop—The loss in pressure of a liquid flowing through a piping system caused by friction of pipe and fittings, velocity, and change in elevation.

pressure gauge—An instrument used to measure pipeline pressure at the point where it is installed. Some gauges can read differential pressure and some read vacuum.

pressure indicating transmitter—A device used to measure pressure, convert the pressure to an electrical signal, and sent the electrical signal through a wire.

pressure surge (hydraulic shock)—Sudden increase in fluid pressure caused by a sudden stop of flow.

pressure—The application of force to something by something else in direct contact with it. The force exerted over a surface divided by its area.

Pritchard System—Type II fuel system. Multi outlet hydrant system.

R–12—hydrant servicing vehicle used in conjunction with a Type III Hydrant System to refuel aircraft.

resistance—An opposing or retarding force, the opposition offered by a body or substance to its passage.

specific gravity—The ratio of the weight of a given volume of material at 60 °F to the weight of an equal amount of distilled water at the same temperature, both weights being corrected for the buoyancy of air.

static electricity—An electrical charge produced by objects rubbing together creating negative and positive electrons.

Type I Hydrant System—See Panero system.

Type II Hydrant System—See Pritchard system.

Type III Hydrant System—See Phillips system.

Type IV Refueling System—See hot pit system.

upstream—A term used to describe the direction of flow in a pipeline. Upstream is when the flow is moving toward the pump or component.

valve position indicator (VPI)—A valve component which indicates the position of the valve (open or closed).

vapor pressure—Internal pressure of vapor in a liquid usually in psi; usually an indication of volatility.

venturi—A tube that creates differential pressure similar to an orifice plate but much more accurate.

volatility—Measure of the tendency of a liquid to vaporize; measured as vapor pressure.

voltage—Electrical potential or potential difference.

volume—The amount of space occupied by a three dimensional figure as measured in cubic units: inches, feet, quarts, gallons, etc. Cubic capacity.

water slug shutoff—A valve in the filter separator discharge piping which closes automatically when the water in the filter separator rises above a set level.

weatherproof—Electrical enclosure used for outdoor service in nonhazardous areas.

weight—The force with which a body is attracted toward the Earth or a celestial body by gravitation and it's equal to the product of the mass and the local gravitational acceleration.

Abbreviations and Acronyms

°	degrees
AC	alternating current
AF	Air Force
amp	ampere
ANSI	American National Standards Institute
API	American Petroleum Institute
APU	aircraft pump unit
ASME	American Society of Mechanical Engineers
ASTM	American Standard of Testing Material
AVGAS	aviation gasoline
AW	Air Wing
bbl.	barrel
BPC/FV	backpressure control/flush valve
BPCV	backpressure control valve
BPV	bypass valve
CDHS–2	pressure-differential control
CDHS–3	pressure-differential shutoff
Cla-Val	Clayton Valve
COM.	common
CRA	remote-sensing pressure-reducing control
CRD	pressure-reducing control
CRL	pressure-relief control
CV	control valve
D	drain
D/FV	defuel/flush valve
DBB	double-block-and-bleed
DC	direct current
DPDT	double pole, double throw
DPT	differential-pressure transmitter
ESO	emergency shutoff
F	Fahrenheit; flush
F/S	filter/separator
FO	foldout
fps	feet per second
FSCV	filter/separator control valve
FV	flush valve
gpm	gallons per minute
H.P.	high pressure

HCV	hydrant control valve
HLV	high-level shutoff valve
HSV	hydrant-servicing vehicle
I/O	input/output
IC	integrated circuit
KISS	keep it simple, system
L.P.	low pressure
LCP	lateral control pit
LED	light-emitting diode
mA	milliamps
MIL-S	military specification
N.C.	normally closed
N.O.	normally open
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Agency
NIP	normal inlet pressure
NOP	normal operating pressure
NPS	nominal pipe size
O&M	operation and maintenance
OL	open lead
OSHA	Occupational Safety and Health Administration
OV	overfill valve
PCP	pump control panel
PCV	pressure control valve
PIT	pressure-indicating transmitter
PLC	programmable logic controller
POL	petroleum, oil, and lubricants
PPCV	pantograph pressure control valve
PPE	personal protective equipment
psi	pounds per square inch
Q	quench
RAM	random access memory
RCV	refueling control valve
rpm	revolutions per minute
SOP	standard operating procedures
SPR	single-point receptacle
UFGS	United Facilities Guide Specifications
UL	Underwriters Laboratories
UST	underground storage tank
VPI	valve position indicator
WDV	water drain valve
WFSM	Water and Fuel Systems Maintenance

Student Notes

Student Notes

AFSC 3E451
3E451B 03 1805
Edit Code 04