



Government of **Western Australia**  
Fire & Emergency Services Authority



**Participant's Resource**

**Operate Pumps**

**Section 2**

**Pump Ancillary Equipment**

PUAFIR309 - Operate pumps

**Training Resource Kit**

**Version 4.0 – January 2012**

## SECTION 3 Pump Ancillary Equipment

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## Section 3.1 Introduction

### Introduction

Pumps are an item of fire fighting equipment used at almost every fire. Pump operators must be competent in the use of the pump and its ancillary equipment. It is the ancillary equipment that gives flexibility in the delivery of the extinguishing agent and safe control of operating pressures. This session covers the most important ancillary equipment that is normally fitted to fire pumps.

### Priming System

The centrifugal pump has no ability to pump air, so if gravity cannot fill the pump then an external priming device is required.

### Pump Gauges

All fire pumps are fitted with pressure and compound gauges that allow the operator to monitor pump operation. Additional gauges may be fitted to individual deliveries and accessories to provide accurate feedback to the operator.

### Collector & Delivery Valves

Discharge and intake lines are controlled by valves, usually of ball or butterfly construction as they permit full flow through the lines with a minimum of friction loss.

Pump inlets may also be fitted with drain valves on the hose line side of the discharge valve. These valves relieve pressure in the line when the discharge valve is closed.

### Engine Controls

These include the throttle and emergency stop controls.



Scania control panel

## Section 3.2 Priming Systems

### Primers

The various types of primers which are used with centrifugal pumps are themselves pumps, capable of pumping gases. These are termed "Positive Displacement Pumps".

There are three types of primers used within FESA:

- Diaphragm
- Water Ring
- Rotary Sliding Vane

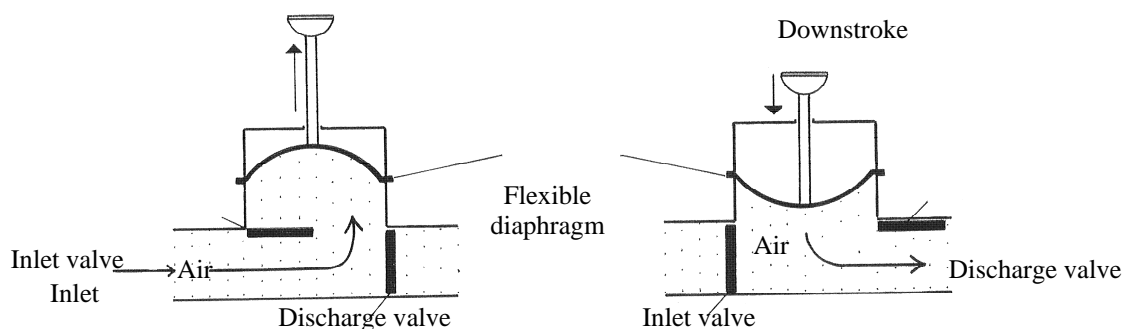
Primers are fitted to all pumps in FESA. The priming system may be hand or mechanically operated and primes the main pump with water.

- Diaphragm Hand primers are fitted to light tankers and some medium tankers.
- A water ring primer is a mechanical primer fitted on ACCO pumps and Scania Medium pumps that automatically engage and disengages. Rotary Sliding Vane Primers is an electrically operated primer fitted to Scania Heavy Pumps and the Mazda Light Pumps.

All three examples are discussed and illustrated below.

### Diaphragm Primer

These primers are fitted to some Light tankers and Medium and Heavy tankers in service with FESA. The priming system is hand operated excluding air by operating the diaphragm up and down in a vertical position by means of an attached handle. Air is forced out of the primer by a non return valve situated at the bottom of the primer. These primers usually have a valve fitted to the discharge side of the primer. If this valve is not opened, priming can not be carried out.



*How a diaphragm primer works*



*A diaphragm primer on the Mk16 Toyota Light Tanker*

A diaphragm primer consists of a metal housing (the chamber); an inlet and discharge port, each containing a one-way valve; a flexible diaphragm (a thin partition); diaphragm actuating rod and handle. It uses the same concept as a force pump, but a flexible diaphragm is used instead of a moving plunger. When the handle is pulled up, the rod pulls the centre of the diaphragm upwards. This creates a negative pressure in the chamber causing air from the pump and suction hose to be drawn into the chamber. A one-way valve prevents air entering the pump from the discharge port.

When the handle is pushed down, the centre of the diaphragm is pushed downwards. This causes a positive pressure within the chamber, below the diaphragm, forcing the inlet valve closed. The air inside the pump overcomes the tension of the spring-loaded discharge valve, and is expelled via the discharge port. Continuous operation of the handle will eventually remove all the air from the pump system.

On an appliance, the diaphragm actuating rod (sometimes called a plunger rod) may be attached to a motor which mechanically moves the diaphragm in and out. On portable pumps, however, it is usually hand-operated.

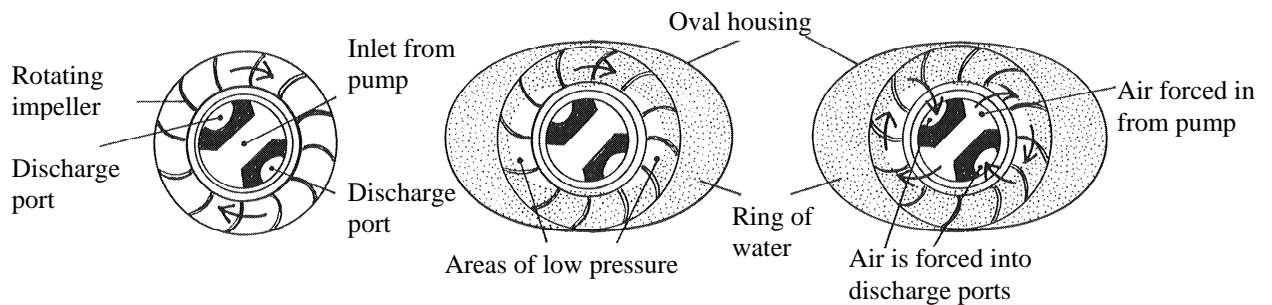
## **Water Ring Primer**

A water ring primer is a form of positive displacement pump. It is widely used in the Fire Service on ACCO pumps and Scania Medium pumps, and is engaged and disengaged automatically.

The principle of operation is very simple. An impeller, in an oval housing rotates around a stationary hollow axle, which contains an

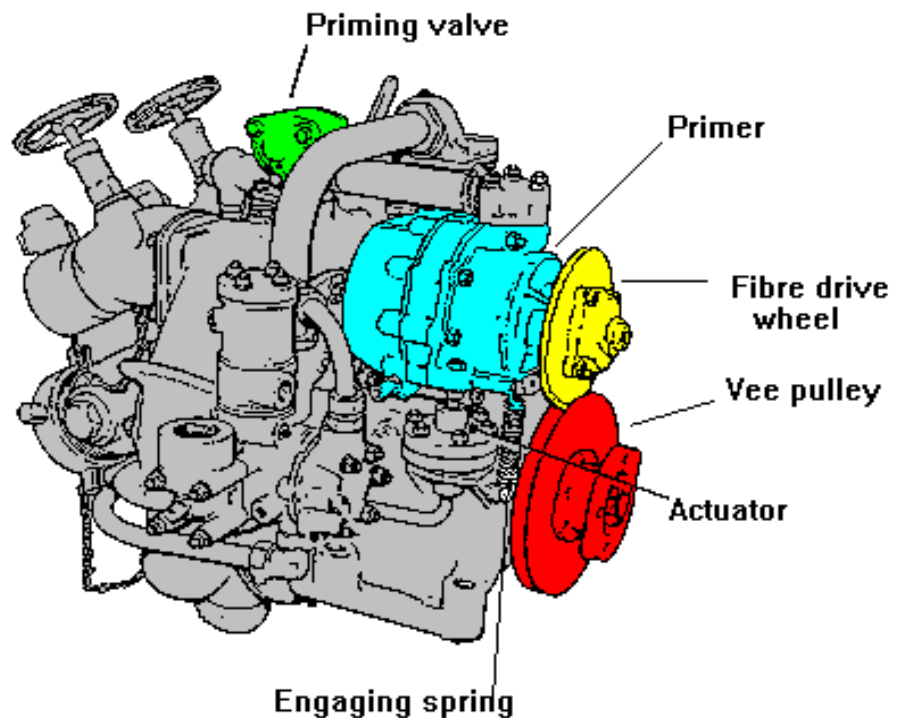


inlet from the pump and two outlets. When priming commences, water from a reservoir is automatically allowed to flow into the housing. The rotation of the impeller causes an oval ring of water to be formed due to centrifugal force. At the widest parts of the housing two areas are filled with air, forced in from the pump and suction hose by atmospheric pressure. As the ring of water rotates to the narrow parts of the housing, the size of the air-filled areas is reduced, and the air is therefore forced out of the primer through the two outlets. More air is drawn in from the pump and suction hose, and the process continues until the pump is primed.



*How a water ring primer works*

The most efficient engine speed for the operation of water ring primers is between 1,300 - 2,000 RPM. Water ring primers are driven by a fibre disc off the pump shaft. They engage automatically whenever the delivery pressure of the pump falls below 200 kPa (2 bar). Conversely, they disengage automatically when delivery pressure exceeds 200 kPa. It is therefore most important that water is maintained in the primer at all times.



*Location of the Water Ring Primer*

## Rotary Sliding Vane Primer

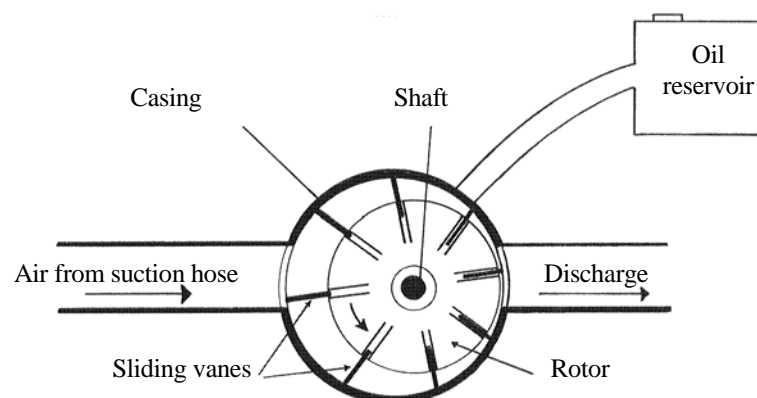
The rotary sliding vane primer (also known as a sliding vane pump or primer) is driven by an electric motor and controlled by a priming valve. They are independent of the main pump and the oil level is to be checked after use. These primers are fitted to Scania Heavy Pumps and the Mazda Light Pumps.



*The primer lever on the Mazda tanker*

The shaft on which the rotor is mounted is off-centre, or eccentric, within the casing. Within the rotor are several slots in which the vanes are inserted. As the rotor turns, the vanes slide in and out due to centrifugal force, maintaining contact with the casing. When the pump is operating, oil from a reservoir automatically provides lubrication and an air seal between the vanes and pump casing.

The turning rotor causes the space between the vanes to increase, creating a partial vacuum, and drawing in air from the main centrifugal pump and suction hose before the next vane meets with the casing. Air is then carried between the vanes to the discharge, where the space between the vanes decreases, thus forcing the air out through the discharge. This action is repeated as each vane moves around.



*Rotary sliding vane primer*



## Summary

A priming pump is a pump capable of pumping air. It is used to prime (fill with water) a centrifugal pump and associated suction hose when working from static/open water.

Priming pumps used by FESA include:

- diaphragm primers
- rotary sliding vane primers
- water ring primers

The diaphragm primer uses the same concept of operation as a force pump, but a flexible diaphragm is used instead of a moving plunger.

A rotary sliding vane primer consists of an off-centre or eccentric turning shaft on which a rotor is mounted. Within the rotor are several slots in which vanes are inserted.

A water ring primer consists of an elliptical housing which contains a stationary hollow boss or axle, (incorporating an inlet from the pump and two discharge ports). The water in the housing is forced to move outwards by centrifugal force.

Further information on priming can be found in the section on Practical Pumping.

## Section 3.3 Pump Gauges

### Introduction

Gauges display information needed to operate and monitor the pump effectively. Gauges are sensitive pieces of equipment, and as with all firefighting equipment, care should be taken. Sudden opening or closing of valves may cause sufficient shock to damage some gauges, and should be avoided.

For pump operators, the most monitored gauges during pumping are:

- the compound (inlet) gauge
- the pressure gauge. On some pumps there may be more than one of each of these gauges.
- the delivery gauge. Some pumps may have more than one of these.



*Main pump gauges on the Scania*

### Compound Gauge

A compound gauge is used on the inlet or feed side of the pump, and can measure pressure below atmospheric (required when draughting from static/open water) as well as positive pressure (required when water is being supplied from a hydrant or other pressurised source).



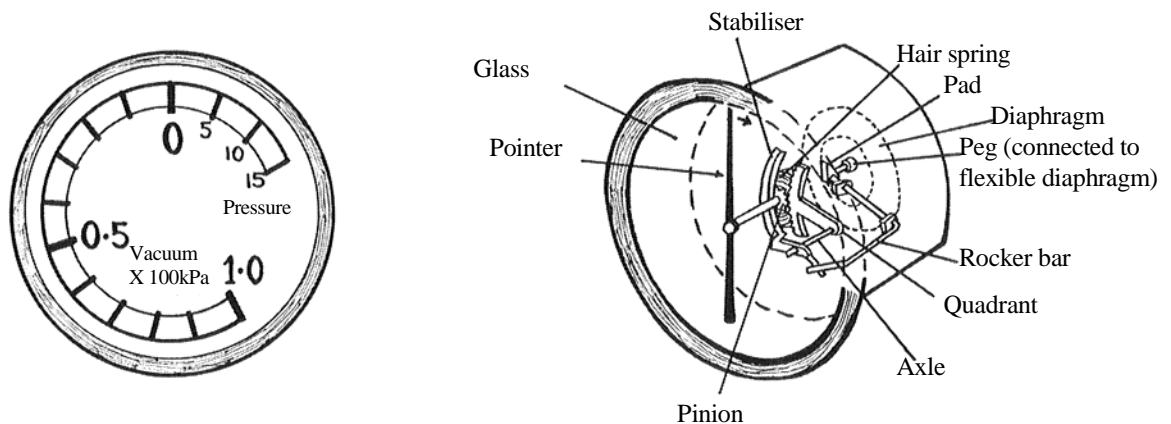
*Scania compound gauge*

Compound gauges are usually diaphragm-type gauges. A diaphragm gauge has a flexible diaphragm connected by a rocker bar and associated mechanisms which magnify the movement to a pointer (see Figure below).

As you look at the face of the diaphragm gauge, you will notice it has a long vacuum scale and a short pressure scale. The scale on the vacuum side typically measures zero to negative 100 kPa ( $1.00 \times 100$  kPa). This allows for more accuracy over a small range of vacuum readings. (See Figure)

When a positive pressure is applied, (from water supplied from a hydrant or another appliance) a small area of the diaphragm moves towards the small cavity in the front housing, thus giving a reading on the smaller area of the gauge.

On the other hand, if a negative (below atmospheric) pressure is applied, a large area of the diaphragm shifts in the opposite direction within the larger cavity of the rear housing, which magnifies the negative pressure reading.



*Face and operating principle of a diaphragm-type compound gauge*

## Pressure Gauge

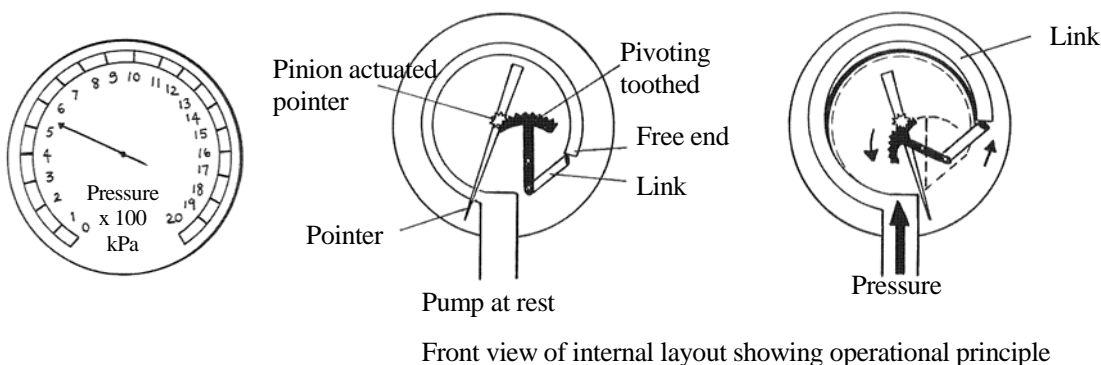
The pressure gauge is used to measure the pressure of water being delivered by the pump. Pressure gauges are usually of the Bourdon tube type.



*Scania pressure gauge*

A Bourdon tube is a pressure responsive tube, that is, it reacts to pressures above and below atmospheric pressure. This almost fully circular tube is oval in cross-section. At one end, it is connected to the delivery side of the pump and, at its other end, to the gauge pointer by a link and pivoting toothed quadrant. (See Figure below) A hairspring keeps the teeth of the pinion in close contact with those of the quadrant. This linkage magnifies the movement of the pointer on the gauge dial.

Changes in pressure cause the Bourdon tube to either straighten out (caused by greater pressure), or return to a more curved shape (lower pressure). More recent gauges are filled with glycerin, which acts as a damper and reduces the fluctuation in the pointer's movement to give a more accurate reading.



Front view of internal layout showing operational principle

Bourdon tube gauges are sometimes used for compound gauges, but the negative side (reading down to -100 kPa) will be to the same scale, and therefore much smaller in overall size, than the positive side of the gauge, which may read up to as much as several thousand kPa positive pressure.

## Delivery Gauge

All FESA appliances are fitted with delivery gauges, usually located above the delivery valves. Pressure measurements are read in both kPa and psi.



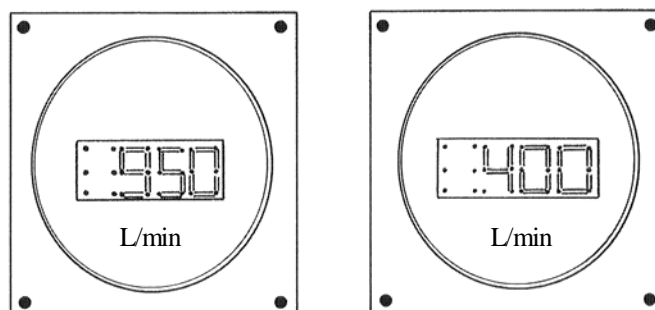
*The delivery gauge on a Scania in both kPa & psi*

## Flow Meter

Some types of fog nozzles are automatic in operation and will decrease or increase their flow, within a set range, to maintain 700 kPa (or sometimes another set pressure) at the nozzle. While adjusting the pump pressure is an effective means of controlling the flow to conventional nozzles, this is not the case with nozzles that automatically adjust to the changing pressure.

On some pumps, flow gauges or meters may be fitted. These indicate the rate of water flow being supplied. When used with automatic nozzles, a particular flow rate is supplied by the pump operator, rather than a particular pressure. Usually, there will be a separate flow meter for each outlet. (see Figure below)

Using a flow gauge or meter makes it possible to deliver the correct rate of flow to any type of nozzle, without having to calculate pressure loss due to friction or height.



*Flow meters showing different flow rates*

## Tachometer

The tachometer indicates the engine revolutions. The revolutions per minute (rpm) shown on the gauge help the pump operator when performing various pump operations. The correct rpm settings and/or limitations for your appliance will be indicated in the pump manufacturer's specifications.



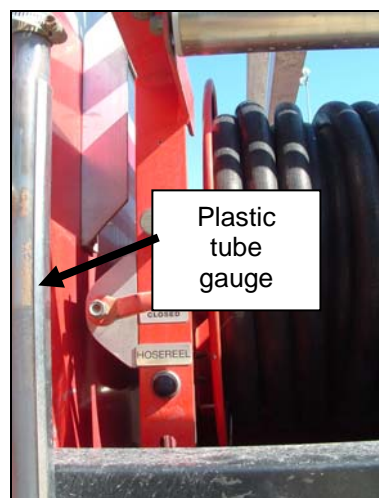
*Tachometer & engine controls on the Scania*

## Tank Gauge

Two types of gauges are typically used to indicate water level in an appliance's water tank:

- a sight gauge
- an indicator light panel.

The sight gauge, usually a clear plastic tube, is connected to the bottom and top of the water tank, set vertically and positioned where it is visible from the pump panel. Whatever the level of the water in the tank, it will be indicated in the tube (sight gauge). The Mazda light pumps are fitted with sight gauges.



*Tank gauges: Izusu & Mazda*



The indicator light panel uses a series of coloured lights to show when the water or foam concentrate tank is full, and when the level is at three-quarters, half, one-quarter or empty. These lights work as soon as the ignition is switched on. When the ignition is not on, a test can be made to check the water contents by pressing the 'test' button.



*The indicator light panel on the Scania*

In addition, some appliances are fitted with a low water level alarm which provides an audible alert that the water level has dropped to a particular level. FESA Toyota Landcruiser light tankers are fitted with this device (see below).

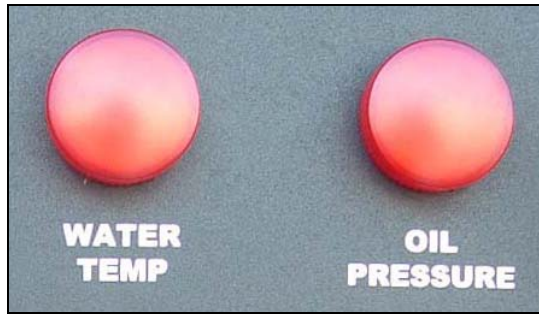


*Low water alarm systems on Light Tankers*

## Oil Pressure Indicator

An oil pressure indicator is on the panel of all modern appliances. It uses an electrically transmitted signal to indicate the oil pressure of the engine driving the pump. It is extremely important to check this indicator frequently during operations. If oil fails to circulate, the engine can seize, resulting in engine failure and extensive damage.

Any pronounced reduction in an oil pressure reading demands that the engine be closed down as soon as possible after the branch operators' safety has been assured. The Officer-in-Charge should be advised of the close-down as well as what alternative arrangements can be made to ensure that water continues to be delivered to the fireground.



*Scania panel warning indicators*

## Temperature Indicator

The temperature indicator monitors the engine temperature. An operator should be aware of the normal operating temperature; if the temperature indicator suggests a problem, investigate the possible cause and inform the Officer-in-Charge.

## Section 3.4 Collector & Delivery Valves

### Valves & Control Mechanisms

Valves are used to control and direct water flow and pressure. The arrangement of valves may vary, but they normally include:

- a main water valve between the water tank and the pump
- a valve controlling each pump delivery outlet
- a non-return collector valve controlling each external supply inlet
- collector and/or delivery valves controlling other features such as foam systems, secondary cooling systems or series/parallel mode selection.

### Construction of Valves

Valves and valve mechanisms typically found on FESA pumps include:

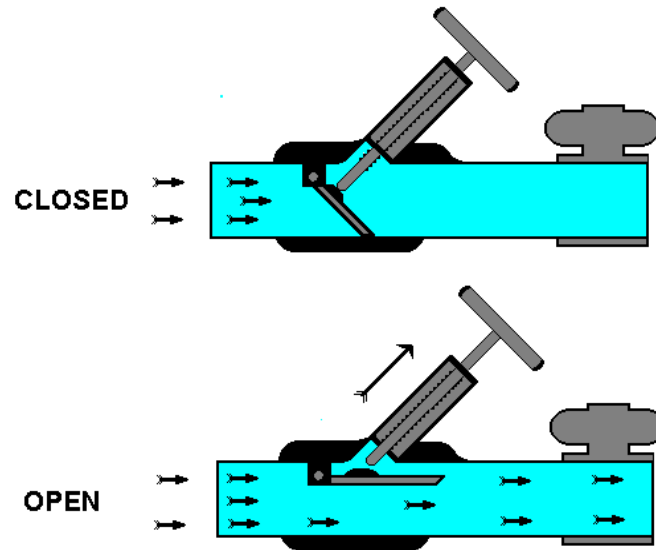
- clack valve
- ball valve
- mushroom valve
- butterfly valve
- gate valve
- drain valve
- pressure relief mechanism.

However, the main type of valve used on FESA appliances is the ball valve.

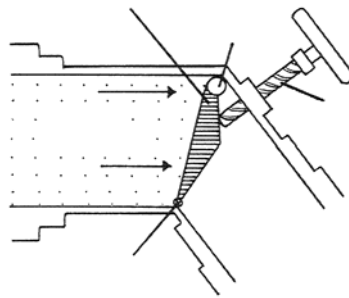
#### Clack Valve

The clack-type, non-return valve is a one-way valve often found in a collecting head or in a delivery outlet. This valve is attached to the surrounding casing by a hinge. When the flow of water ceases or tries to reverse, the clack valve returns to the closed position. A synthetic or rubber washer, set into the edge of the clack valve, creates a seal as the back pressure of the water pushes against the valve.

In a delivery outlet, a screw-down shaft controls the clack valve's movement. To open the delivery, the handle is turned anti-clockwise and water pressure raises the clack valve off its seat. The valve returns to its seat when the handle is turned in the clockwise direction.



*Clack valve in straight pipe configuration*



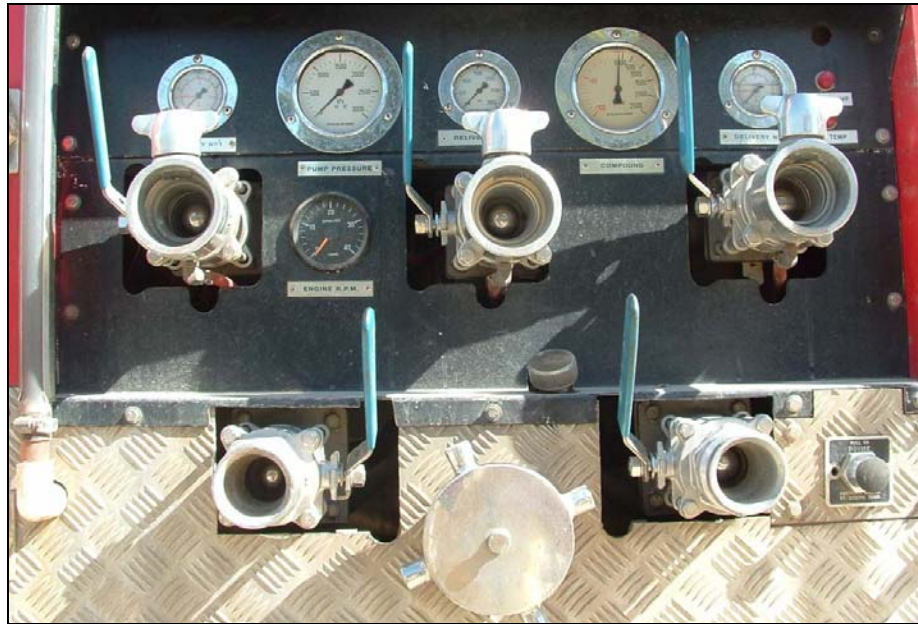
*Detail of Clack valve in delivery outlet*

## Ball Valve

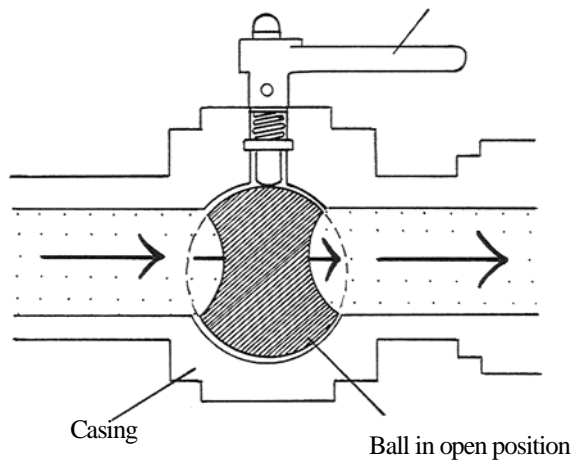
On many pumps, clack valves have been replaced by a ball valve. This is round, usually made of stainless steel, with a hole through its centre. The diameter of the hole is usually the same size as its associated pipes. The ball valve is encased between two seals and inserted within the valve casing. (See Figure below)

When the ball is at 90° to the water flow, the waterway is completely closed by the ball and the flow is cut off. Using a control lever, the ball valve can be turned through 90° so that the hole through its centre is completely opened.

In some cases, the control lever may incorporate a twist-lock mechanism. Before the lever can be operated, the handle needs to be twisted to unlock it. Once set to a new position, it can be twist-locked in that position.



*Ball construction collector & delivery valves on the Mazda light tanker*

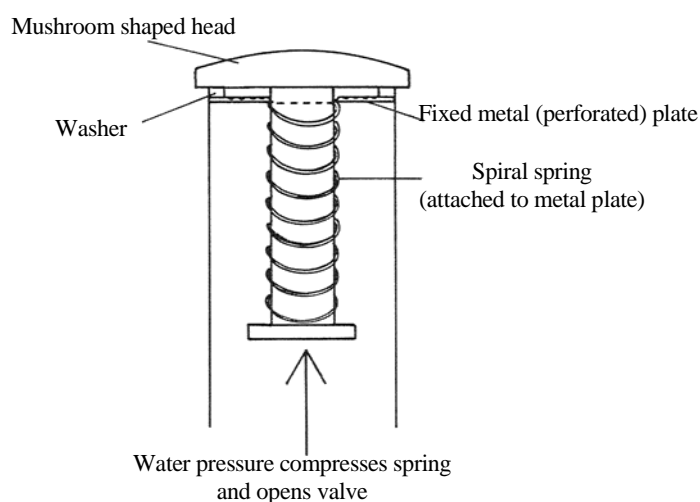


*Detail of Ball valve in open position*

## Mushroom Valve

A mushroom valve can be used in tank fill pipes and also in collecting heads. It is constructed of a mushroom-shaped metal head fixed to a stem. A spiral spring is fitted over the stem and fixed into the pipes.

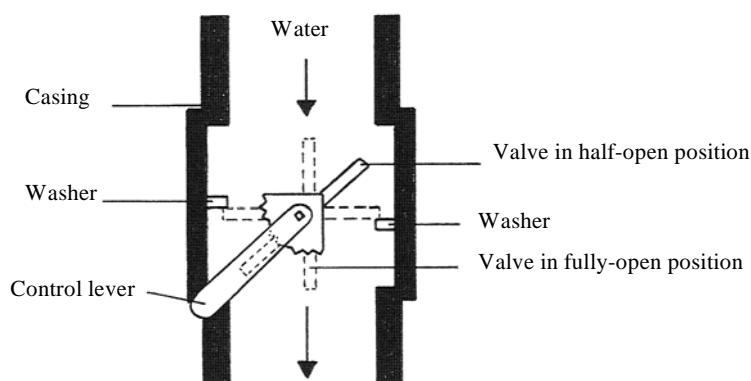
When no water is flowing, the valve is held in place by the tension of the spring and is sealed by a synthetic rubber washer around its edge. As water is delivered to one of these inlets, pressure against the mushroom valve unseats it and allows the water to flow into the pump or tank.



*Detail of Mushroom valve*

## Butterfly Valve

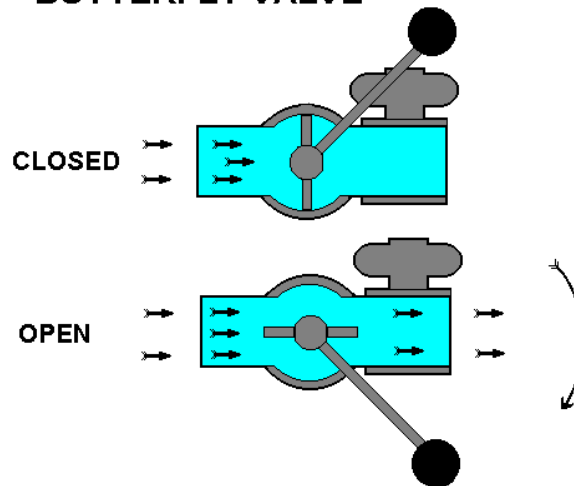
A butterfly valve, also known as a keystone valve, operates by a lever control. An example of this type of valve is found in the pipe between the tank supply and the pump on some appliances. When the butterfly valve is open, the control lever is aligned with the pipe.



*Detail of Butterfly valve*



## BUTTERFLY VALVE

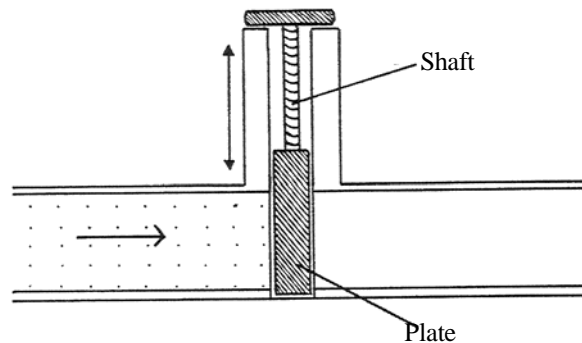


*A Butterfly valve in action*

## Gate Valve

A gate valve consists of a flat metal plate operated by a screw-down shaft. Depending on the direction the shaft is rotated, the gate can be raised or lowered across the pipe.

The gate valve can be set to allow full or partial flow. You may have seen gate valves on irrigation lines or large oil pipes. They are usually easily recognised by their screw-down operating mechanism. Some smaller gate valves can have a lever action to shut or open the gate.



*Detail of a Gate valve*

## Drain Valve

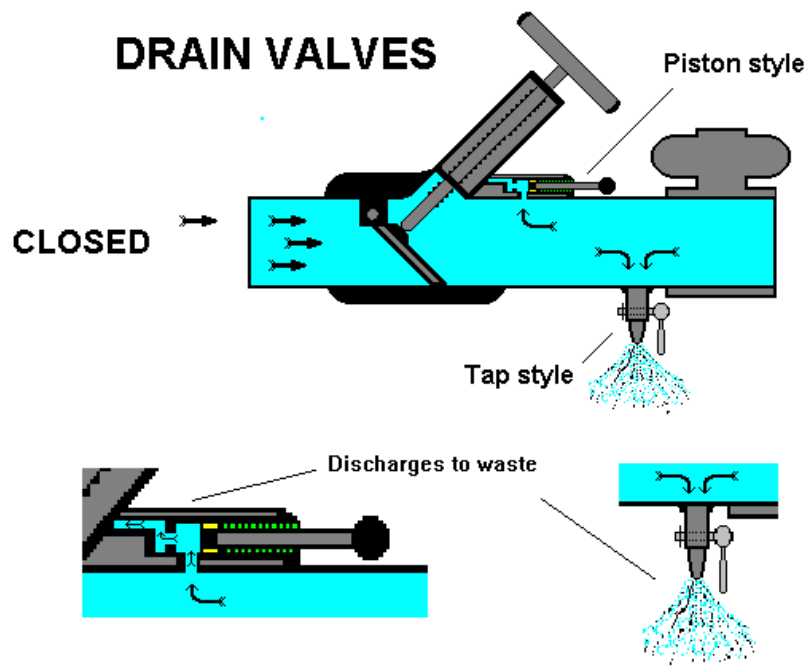
Drain valves are situated at the base of the pump and in some pipe work. They may take the form of a stop-cock (a small tap), a remotely controlled valve or a screw in the pump's base plate. Drain valves may be used to:

- drain the water out of the pump in cold weather to prevent freezing and resultant damage to pipes
- clear the pump of any foreign matter that may be left in the pump casing after pumping from salt water or taking water from a static/open supply.

Remember to close the drain valve immediately after any water has been released to prevent water being discharged from the drain valve when the pump is next operated.



*Drain valves on the Mazda & Scania appliances*



*Details of Drain valve*

## Pressure-Relief Mechanism

The pressure-relief mechanism fitted to some pumps is a safety device for branch operators. When operated correctly, the pressure-relief mechanism prevents sudden increases in pressure being transmitted to the branch operator.



*The pressure relief valve on the Scania*

Pressure-relief mechanisms vary in design, but usually consist of a valve that automatically dumps some pressurised water back to the inlet side of the pump to prevent excessive pressure reaching the branch operators.

The pressure at which the relief mechanism operates can be set by the pump operator once hose lines are in operation. Typically, a control wheel is turned until the relief mechanism begins to operate (usually indicated by a light), and then the wheel is turned back until the light goes out.

As an alternative to a pressure-relief mechanism, some larger pumps may be fitted with a pre-set pressure-relief mechanism which dumps water underneath the pumper. If water is dumped underneath your appliance, you may need to confirm whether it is from this type of relief valve (if fitted) or is simply from the appliance water tank over filling.

## Section 3.5 Engine Controls

### Introduction

Located at the pump panel are the engine controls which include the throttle and, usually, an emergency stop switch.

### Throttle

The throttle controls the speed of the engine (indicated on the tachometer) driving the pump. It is usually operated by hand and, once set, remains in position until the operator adjusts it.

There are two types of pump throttle control commonly used, the lever slide control and a button adjusted throttle. These are usually connected to the engine by a cable.



*Lever slide throttle control on the Mazda*

The lever slide throttle operates simply by moving the throttle lever in the appropriate direction to increase or decrease engine rpm. The slide mechanism should be adjusted so that it can move freely but can be set in any position.

Button adjusted throttles such as that found on the Scania allow far greater control of engine rpms. The location of both the idle button and the tachometer right next to the throttle also provide greater control.



*The button adjusted throttle control on the Scania*

## Emergency Stop

The second engine control feature is the engine stop, sometimes called an emergency stop. Not all appliances have this particular feature, but you still need to know how it operates and when to operate it.

The emergency stop can be operated by either a push-button or toggle-switch control. In most designs, when either of these controls is operated, an electric current is passed on to a solenoid, which activates a plunger to close off the fuel supply.

To restart the appliance, returning the shut-off control switch or button to its original position will deactivate the plunger and allow the fuel to flow again for the engine to start.

These shut-off switches are situated on the pump panel to allow the operator to shut down the engine in the case of an emergency. As the name suggests, an emergency engine stop should only be used in an emergency and not each time the engine is to be turned off.



Remember to ensure the safety of the branch operator/s before shutting off the engine, and to alert the Officer-in-Charge immediately the engine is shut down.

## Section 3.6 Summary & Activities

1. List the four (4) main categories of ancillary equipment related to pumps

Answer:

2. Identify the three (3) types of priming systems used by FESA

Answer:

3. What type of primer is fitted to a Mk16 Toyota Light Tanker?

Answer:

4. Name at least three (3) **construction methods** of valves found on fire appliances

Answers:

5. What is the main purpose of the following gauges:

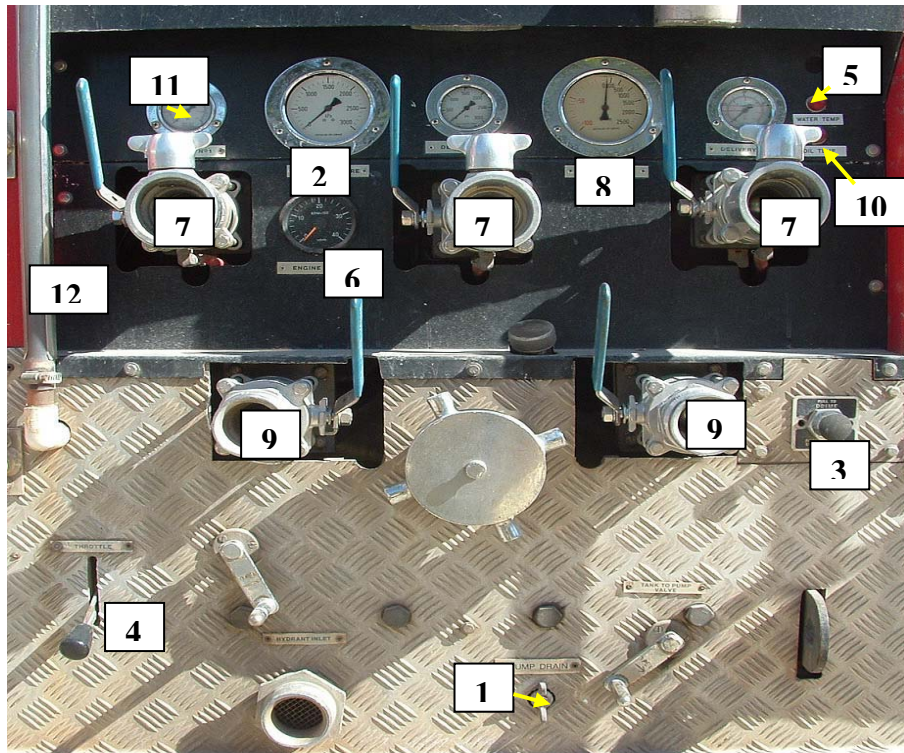
a. compound gauges

b. pressure gauges

c. delivery gauges



6. Identify the numbered parts of the pump panel below



Answer:

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.
- 11.
- 12.

7. What are the two (2) main types of throttle controls used in FESA?  
Answer:



### Drills

Under supervision, you will be required to complete a number of pump drills. During these drills you will be assessed for your knowledge and use of pump ancillary equipment.