

# INTERNATIONAL FIRE TRAINING CENTRE

## FIREFIGHTER INITIAL

### PUMPS AND PRIMERS

Throughout this note he means **he/she** and his means **his/hers**.

**Areas of bold type are considered to be of prime importance.**

#### INTRODUCTION

Pumps are continually in use. They move petrol, oil and water in a car, transfer gases and liquids in manufacturing processes and are also used by the emergency services at fires and other incidents.

#### AIM

To explain the various types of pumps and primers used within the Fire Service.

#### OBJECTIVES

At the end of this technical input and with detailed study of this training note the students will be able to:

- Define the principles of pumps
- Name the types of pumps
- Describe positive and non-positive pumps
- Explain how a centrifugal pump works
- Describe how a primer works
- State the gauges found on a pump
- Explain pump running faults

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## **PUMPS**

Pumps are machines which make fluids flow from one place to another. e.g. From a foam tender to the fire.

### **Principles of Pumps**

Certain principles must be grasped before considering the construction of pumps.

It is important that the word fluid is meant to include both liquid and gases. Air is a fluid. We could say that we are living at the bottom of a sea of air called the atmosphere. Air has weight so the atmosphere exerts a pressure on the earth's surface and all over the surface of objects on the earth.

The pressure in a tyre is higher than atmospheric pressure. When a tyre bursts, air flows out of the tyre into the atmosphere.

A **fluid** will flow from an area of **high pressure** to an area of **low pressure** until the two pressures **are equal**.

### **Types of Pumps**

**Force Pumps**

**Lift Pumps**

**Bucket and Plunger Pumps**

**Rotary and Semi-Rotary Pumps**

**Centrifugal Pumps**

**Ejector Pumps**

**Peripheral Pumps**

## **POSITIVE AND NON-POSITIVE PUMPS**

An example of a *positive pump* is a *force pump*. This type of pump will pump both gases and liquids. It has close fitting parts.

An example of a *non-positive pump* is a *centrifugal pump*. This type of pump will not pump gases and therefore requires a primer.

### **Ejector Pumps**

These types of pumps do not use either mechanical pistons or plungers to increase or decrease the pressure but use a fast moving jet of liquid or gas to do the same job. This jet is called a propellant. The ejector pump uses a venture effect within the throat of the pump. At the throat an area of low pressure is created by the fast moving propellant, any movement outside this area being at a higher pressure will flow into the pump. This fluid and the propellant are discharged at the outlet.

### **Advantages of Ejector Pumps**

**Easy to handle**

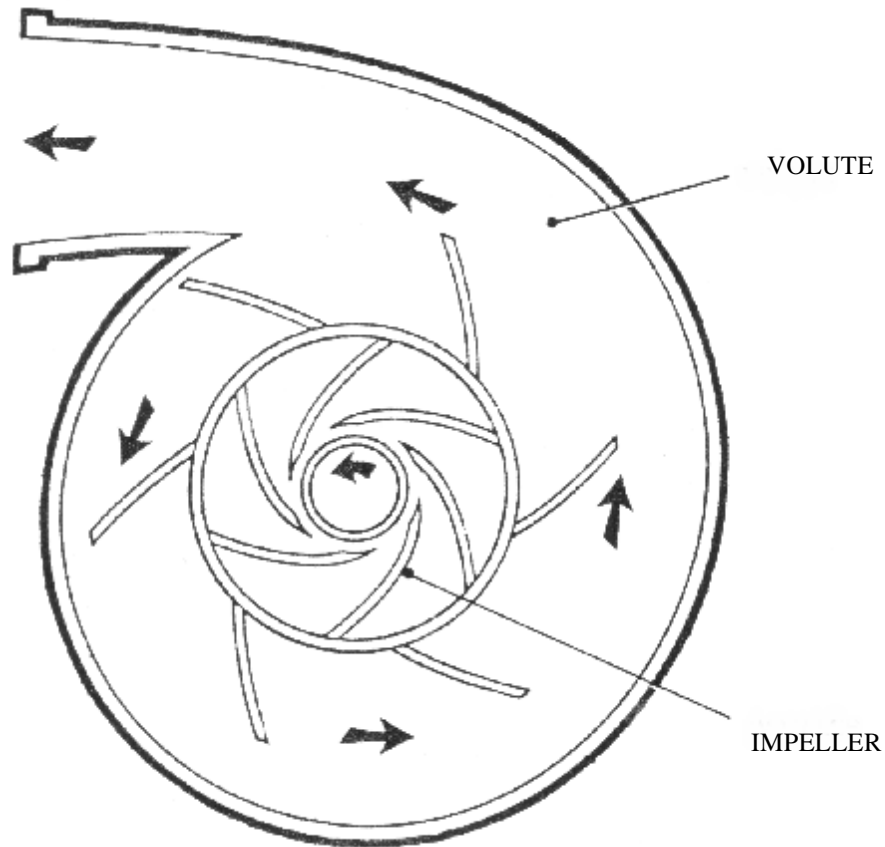
**Require little maintenance**

**Can pump liquids or gases**

## **CENTRIFUGAL PUMPS**

Centrifugal Pumps are the most widely used for fire fighting. They are unable to pump gases. They work on the principal of centrifugal force. The reasons that these are used in the Fire Service are that they have few moving parts, are simple to maintain, and are small, light and compact relative to output. They are usually driven by an internal combustion engine and are therefore portable.

These pumps have two main parts 1 Impeller and 2 Volute



The volute has three main tasks.

- 1 It channels water from the periphery of the impeller to the outlet.
- 2 It reduces the velocity of the water as it passes through.
- 3 It reduces the turbulence of the water created by the impeller.

**GUIDE VANES** within the volute assist with reducing the turbulence of the water and guiding the water along its correct path.

#### Centrifugal Force

**Example.** A spin dryer uses centrifugal force to remove water from wet clothes. The impeller rotates on a central shaft, water is spun outwards by centrifugal force and is discharged at the periphery. As the water is thrown outwards the pressure at the inlet decreases and more water is forced into the impeller from the supply.

**Centrifugal Force:** - A force which tends to make particles of a revolving body fly outwards.

**Periphery:** - Bounding line of round surface.

#### Pressure Changes

Pressure changes within the pump are considerable.

**Suction Hose:** Pressure decreases as it enters the pump impeller.

**Impeller:** Pressure increases as the water is thrown out by centrifugal force.

**Volute:** The pressure increases as the water is channelled through the volute.

#### Velocity Changes

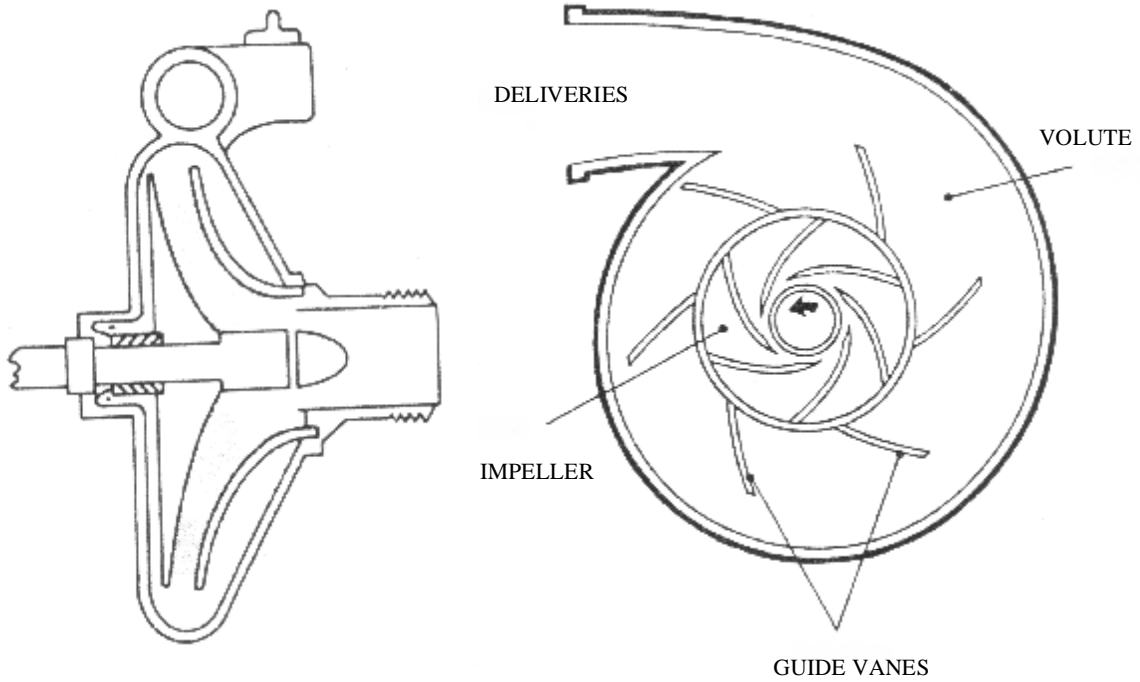
Velocity also changes within the pump.

The velocity is increased by the impeller.

The volute decreases the velocity of the water.

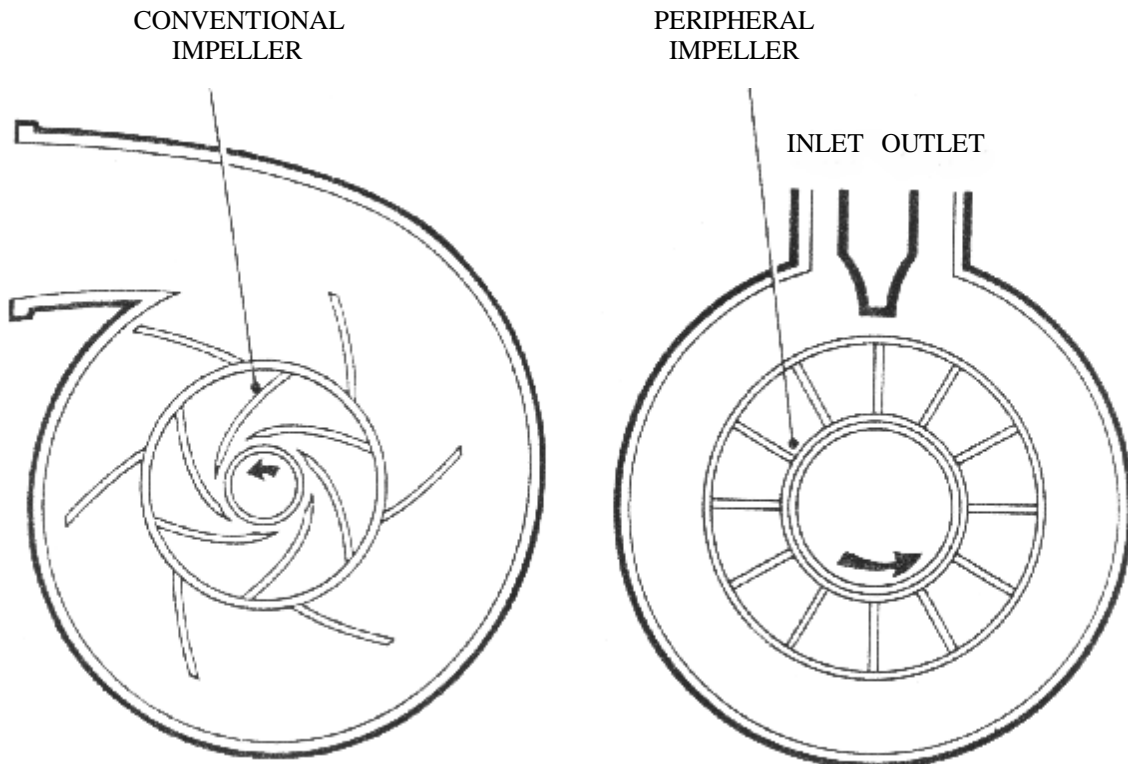
In practice the impeller speed is governed by the driving engine.

# CENTRIFUGAL PUMP



## *Peripheral pump* *The principle*

Peripheral pumps use a regenerative impeller that rotates within a channel and causes the water to take a spiral path as it is dragged around the channel by the impeller. Each time the water spirals from one vane to the next more and more energy and pressure is built up.



## PRIMERS

Centrifugal pumps cannot pump gases. They cannot rid themselves of the air inside the pump casing and as a result must be filled with water by some other means before they can work. This process is called **Priming**.

### Methods of Priming a Pump

- 1 If the water is higher than the pump then gravity ensures that water flows into the pump, pushing the air out.
- 2 When water is supplied by a hydrant, mains pressure is sufficient to force water into the pump, pushing the air out.
- 3 If the water supply is lower than the pump an extra piece of equipment is required. This is called a primer and its job is to remove the air from inside the pump, reducing the pressure so that atmospheric pressure will force water into the pump. **REMEMBER** fluids will flow from an area of high pressure to an area of low pressure.

The primer, by removing the air from inside the suction hose, permits atmospheric pressure to push water up the hose and into the eye of the pump. The distance or height that water can be moved by atmospheric pressure is theoretically 10m. However, in practice, the figure is closer to 8m. Refer to Fire Service Manual, Vol. 1, Fire Service Technology, Equipment & Media, Hydraulics, Pumps and Water Supplies, for detailed information.

The various types of primers which are used with centrifugal pumps are themselves pumps.

### Exhaust Gas Ejector Primer

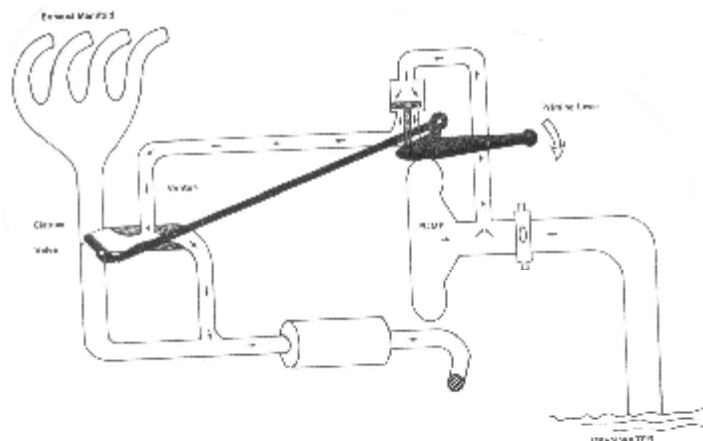
This is a form of ejector pump which provides a venturi effect.

#### Advantages are:

- **Easy to operate.**
- **Few moving parts compared to reciprocating primers.**
- **Light weight.**

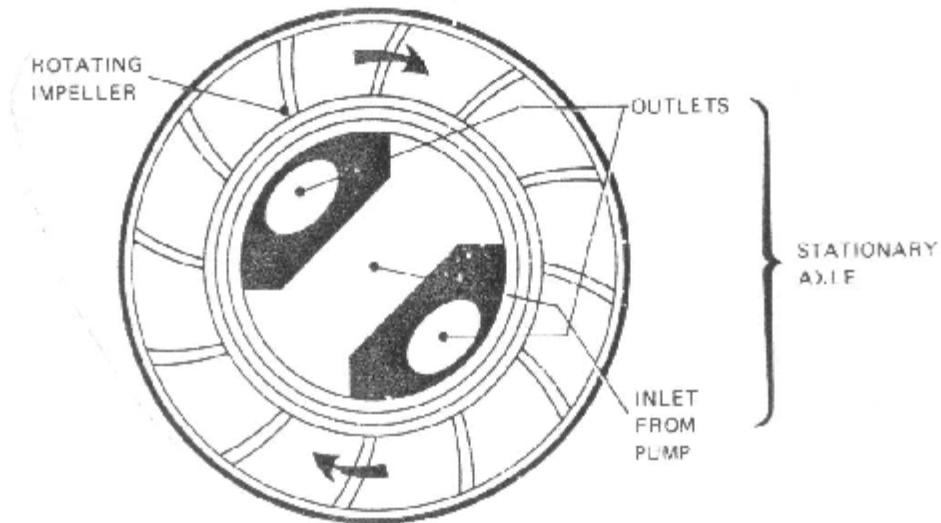
#### Disadvantages are:

- **High engine revs required.**
- **Clapper Valve not seating correctly due to build up of carbon.**
- **Over priming water enters exhaust system causing rust.**
- **Priming valve and lever prone to damage mainly caused by misuse.**
- **Efficiency of this type of primer depends on the speed at which the gases leave the ejector nozzle.**



## Water Ring Primer

This primer is a form of positive displacement pump. An impeller rotates around a stationary axle which is hollow, containing an inlet from the pump and two outlets to atmosphere.



The rotation of the impeller causes an oval ring of water to be formed around the inside of the housing. At the widest parts of the housing an area of low pressure is formed inside the ring of water. This area is filled by air forced in from the pump by atmospheric pressure. As the ring of water rotates to the narrow parts of the casing, the size of the air space is reduced, forcing the air out of the pump through the outlet ports to atmosphere.

### REMEMBER

Fluids will flow from an area of high pressure to an area of low pressure.

#### Advantages are:

- Easy to operate
- Can be automatically engaged and disengaged
- Fast rapid priming
- Lightweight

#### Disadvantages are:

- Fibre Wheel will wear very quickly if primer does not disengage.
- Tension Spring can weaken
- Frost may damage close fitting parts
- Water supply required either from header tank or direct supply.

### PRIMERS GENERAL

Firefighters should pay particular attention to the cleaning and lubrication of primers, in accordance with the manufacturer's instructions.

They should also be aware of the damage to primers by incorrect priming speeds, lack of oil or anti-freeze etc.

## COOLING SYSTEMS

The internal combustion engines used to propel appliances in the UK are usually water cooled. This is achieved by water circulating through the engine block and radiator assisted by a water pump. Cooling is achieved by the induced draught set up by a fan behind the radiator and by movement of the appliance during which the ram effect of the air assists further in keeping the radiator, engine block and sump cool. When the appliance is stationary this latter condition does not exist and it is usual to provide supplementary means of cooling for Fire Brigade appliances.

### **Indirect Cooling - Closed Circuit**

With modern engines the cooling systems are usually thermostatically controlled. This allows the operating temperature to be reached very quickly. In a closed circuit system water is supplied through piping from the delivery side of the pumps, instead of being discharged to waste it is returned to the inlet side of the pump after extracting heat from the engine cooling water.

These systems are fully automatic in action, having no valves, filters, or controls, and come into operation as soon as water in the pump is under pressure.

This type of cooling utilises the pump under pressure and more importantly requires a flow of water to be maintained, otherwise with static pressure in the pump, this would only generate increased temperatures within the pump.

To alleviate this, pump operators must be mindful that when pumping over long periods it is advisable to occasionally open a free delivery, operate the monitor or connect a spur line from a spare delivery and back into the pump to ensure enough water is flowing through the pump to reduce the temperature build up.

## GAUGES

Fitted to almost every fire appliance or pump we usually find three gauges for indication:

*Oil Pressure* - Within the engine or power unit.

*A Compound Gauge* - Which has both vacuum and pressure readings used on what is sometimes called the suction side of the pump.

*A Pressure Gauge* - Sometimes termed a delivery gauge.

### **Compound Gauge**

*Mainly Diaphragm Type Gauges*

For a vacuum reading a large surface area is used with the gauge. For the pressure reading a small surface area is used within the gauge.

### **Pressure Gauge**

Bourdon tube type gauges. Pressure within a tube tends to try to straighten the tube which relays the movement to the pointer.

## PUMP RUNNING FAULTS

### **Priming**

#### **Failure To Prime - No Vacuum Reading**

- **Strainer insufficiently submerged**
- **Loose suction joints**
- **Pump drain plug loose or washer missing**
- **Pump filler plug loose or washer missing**
- **Delivery valve not closed or not seating**
- **Air leak in suction hose**
- **Packing gland to pump shaft loose**
- **Air leaks in gauge pipes**
- **Primer clapper valve not seating**

### **Failure To Prime - High Vacuum Reading**

- **Choked strainer**
- **Faulty suction hose**
- **Blockage in suction hose**
- **Lift too great**

### **Whilst At Work - Open Water Supply**

#### **Increased Vacuum Reading**

- **Falling level of static water**
- **Increase in water being delivered**
- **Partial blockage of strainer**

#### **Decreased Vacuum Reading**

- **Rise in level of water supply**
- **Less water being pumped**

#### **Increased Delivery Pressure**

- **Blockage in hose, may be caused by vehicle parking on or debris falling across hose line**
- **Blocked jet, usually caused by a small stone**
- **Adjustable or hand-controlled branch closed**
- **Kinks in hose**

#### **Decreased Delivery Pressure**

- **Burst in delivery hose**
- **Coupling disconnected**
- **Adjustable or hand-controlled branch opened**

#### **Crackling Jet**

- **Strainer insufficiently submerged**
- **Slight leak on suction side of pump**

**NB** Air is drawn into the pump at atmospheric pressure, is compressed in its passage to the branch and then re-expands with slight explosive force to its original pressure.

### **Whilst at Work - Pressure Supply**

#### **Failure Of Water - Pressure Fed Supply**

- **Failure of supply, fracture of main or burst suction**
- **Choked strainer in pump suction eye**
- **Choked stand pipe head**
- **Over-running of supply causing suction hose to collapse, if soft suction in use**
- **Failure at pumping station if relay working**

### **SUMMARY**

Pumps are an integral aspect of any fire service operation. However, only with correct operation, maintenance and recognition of running faults can we ensure that they will not fail when required.