JAMAICA FIRE BRIGADE

TRAINING DEPARTMENT

PUMPS Module

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PUMPS

INTRODUCTION

Pumps are continually in use. They move petrol, oil and water in a car; supply air to divers; transfer gases and liquids in manufacturing processes and are also used by the emergency service at fire and other incidents.

A pump is a machine driven by some external power, for transmitting energy to fluids and gases. This power maybe provided by the operator's own effort (i.e. in hand pumps) or by coupling the pump to a suitable engine or motor.

Although there are many different types of pumps, one in particular has come to be regarded as the best for Fire Brigade work. This pump is the Centrifugal Pump. It maybe found as a separate (portable) pump or mounted as an integral part of a firefighting appliance.

Pumps fall broadly under three (3) categories:

1. Positive Displacement Pumps
2. Centrifugal Pumps
3. Ejector Pumps

POSITIVES DISPLACEMENT PUMPS

Positive Displacement Pumps imparts energy to water or other fluid by displacement between a Plunger and Rotor and the casing of the pumps, the moving parts making an air watertight joint with the casing. All the examples of the Positive Displacement Pumps below refer to the ability to pump air as well as water (i.e. gases as well as liquids). They are therefore, capable of extinguishing the air from the suction and the pump to allow atmospheric pressure to push the water up into the pump and are termed self priming

a) Force Pumps:

These pumps having a solid piston, usually called the plunger which when pushed downwards or sideways, forces the fluid out, (displaces it) to make room for it's own bulk. The hand pump is a typical example.

b) Lift Pumps:

Pumps similar to the above, but having a hallow piston with a valve through which water can pass freely into one direction but cannot return. The pumps used for wells are often Lift Pumps.

c) Bucket & Plunger Pumps:

These pumps which are a combination of (1) and (2) above, having a hallow piston, which is mounted on a trunk or column in place of a Piston and Rod which on each down stroke, forces out a quantity of water. The stirrup Pump is a typical example of the Bucket & Plunger Pump.

d) Rotary & Semi-Rotary Pumps:

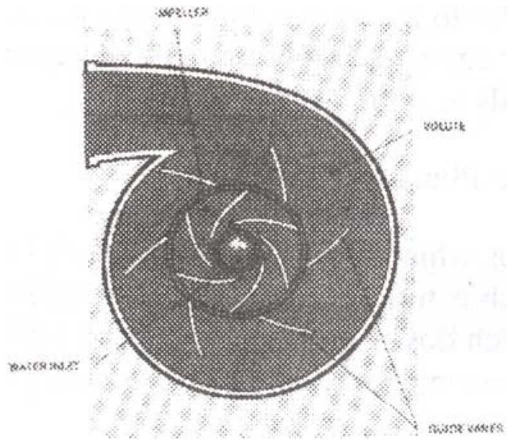
These pumps operates by means of a projection(s) from a concentric or an eccentric axis which move round a partially cylindrical chamber in such a way as to pick up water at one stage of their travel and discharge it at another. The gear pumps use to circulate oil in an internal combustion engine is an example of a full Rotary Pump.

CENTRIFUGAL PUMP

Centrifugal Pumps are operated by means of an impeller which received its supply at the centre and discharges it from the periphery. The centrifugal pump is incapable of pumping gases and must be filled with a liquid before it can pump. This process of extinguishing the air is known as 'Priming' and is done by separate device known as a Primer. .

These pumps have no valves, pistons or plungers and do not work by displacement. Instead they make use of Centrifugal Force i.e. the tendency of a revolving body to fly out from the centre of rotation.

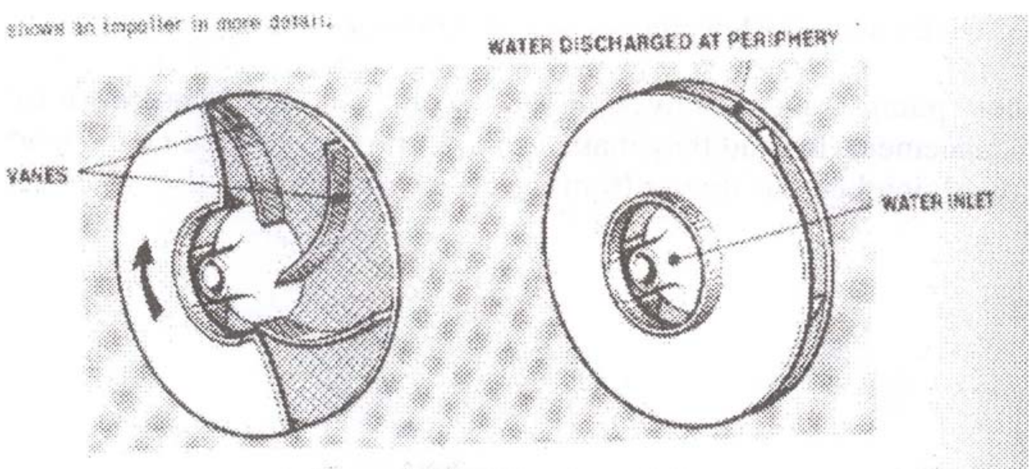
CONSTRUCTION



The centrifugal pump consists of two main parts, the impeller and the casing. The impeller consist essentially of a number of radial vanes embodied in a circular side plate, which receives the water at its centre and discharges it at it periphery.

Each part carries separate function, that of the impeller being to impart high velocity to the water, while the casing transforms this velocity energy into pressure energy.

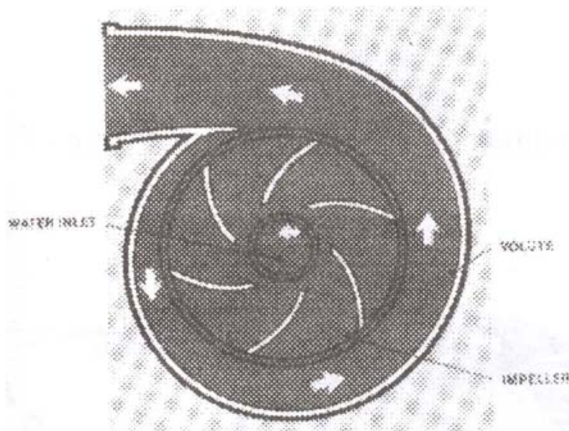
THE IMPELLER



The impeller is a circular metal casing mounted on and rigidly key to a central shaft by which it is rotated.

This impeller, which is driven by external power, is rotated at the speed required to provide the necessary pressure, thus inducing a flow through the pump. As the water passes through the impeller to its rim, the speed is greatly increased. The water at this point is discharge at such high velocity that the greater part of its energy is Kinetic or Velocity Energy, then it enters the casing where the velocity is greatly reduced and most of the energy is converted from the Kinetic Energy to the form required, "Pressure Energy".

THE CASING/VOLUTE



As already been stated, the important function of the casing is to convert the Kinetic Energy of the water when leaves the impeller to Pressure Energy. It does this by reducing the reducing the velocity of the water. When water is discharged from the impeller there is a considerable amount of turbulence. The casing is design to reduce turbulence and velocity (and in consequence, friction loss) and give as smooth and steady a flow to the water as possible.

The casing (or Volute) has the task of channeling water out of the pump, at the same time reducing its TURBULENCE and VELOCITY. Guide Vanes are sometimes fitted within the casing to help with these tasks.

Volute

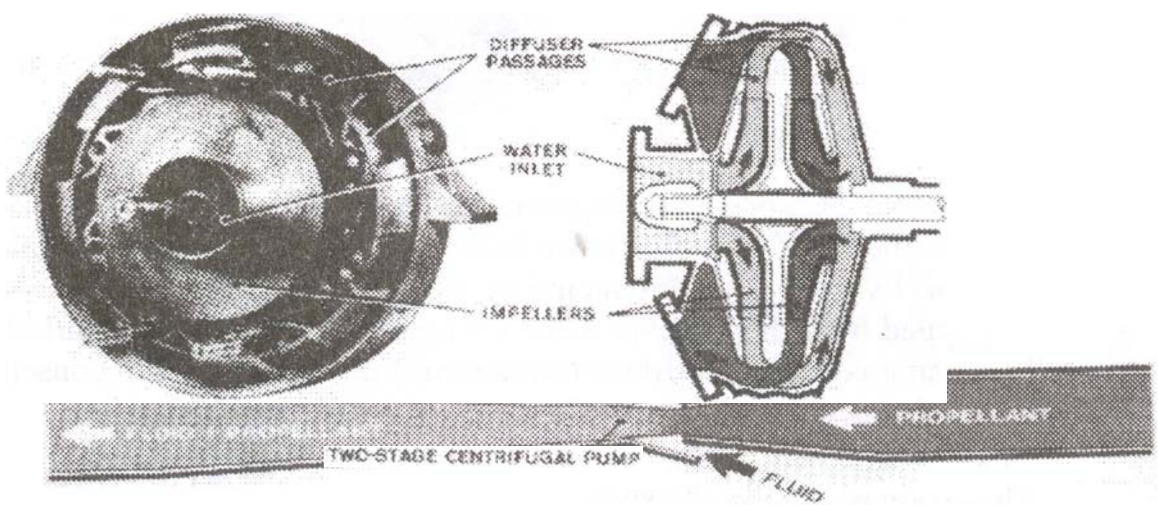
The volute is another name given to the centrifugal pump casing. It is shaped rather like a shell of a snail and water thrown from the impeller enters a passage which steadily increases in cross sectional areas until it reaches the delivery outlet. By this, it means that the velocity of the water is gradually reduced.

Guide Vanes These are fixed vane in the casing/volute adapted to guide the water along its correct path. A ring of guide vanes is sometimes referred to a guide ring of diffuser.

Instead of having a large impeller or using an impeller which rotates at a very high speed,

a pump with two or more impellers can be used. These pumps are called TWO-STAGE and MULTI-STAGE respectively. They can provide water higher pressure than pumps with one impeller (which are called single stage pumps).

The diagrams below show the structure of a two-stage pump:



TWO-STAGE CENTRIFUGAL PUMP

Advantages of the Centrifugal Pump

a. It gives a constant flow.
b. It is capable of handling large quantities of water.
c. Has only one moving part, the impeller, which can be easily balanced in motion with little vibration.
d. It is small, relatively light and compact.
e. It is easily maintained. .
f. It is adaptable to the internal combustion engine by direct drive.
g. No bypass or pressure relief valve is required and the pump can run at high speed, pumping against closed deliveries.

Disadvantages of the Centrifugal Pump

a. The efficiency of the centrifugal pump is generally lower than that of the reciprocating pump. b. It requires a separate priming device. c. It is not positive in action and does not give large quantities at high pressure.

THE EJECTOR PUMP

This pump that we are going to consider does not use a mechanical piston or plunger, etc. to increase or decrease the pressure, but uses a fast moving jet of liquid or gas to do the same job. This jet is called a PROPELLANT.

The propellant is channeled through the throat and a "Venturi" effect is created. In other words, the thin, fast moving stream of propellant travels through the throat, which is slightly wider than the jet of propellant. The propellant spreads out to fill the throat (and the tube beyond it). This reduces the pressure at the throat and any surrounding fluid (which is at a relatively higher pressure) is force in. This fluid and the propellant are discharged at the outlet.

N.B: PUMPS THAT USE A PROPELLANT TO ALTER THE PRESSURE ARE CALLED EJECTOR PUMPS.

The Venturi Principle:

The principle on which an ejector or jet pump works is extremely simple. A jet or water or gas is passed through a narrow throat at high velocity entraining air and reducing the pressure at this point. This allows atmospheric pressure to force the water up the suction.

This is known as the "Venturi Principle", and finds many practical applications in the fire service.

Common use of this principle is the exhaust gas ejector primer and the foam inductor.

Ejector pumps are regarded as special pumps and are use for removing water from an incident, e.g. flooded basement, ship's hold, etc.

Advantages of the Ejector Pump

1. Light and easy to handle.
2. Can be used in places inaccessible to conventional pumps, e.g. basements, ship's hold.
3. Can be used in oxygen deficient atmospheres.
4. They require little attention once set up.
5. A Primary Pump suitably mark sited for ease of refueling, etc.

These pumps are usually suspended above the water and the quantity of water lifted will vary with the height of the pump above the water of the height of the discharge point above the pump.

There are several types of ejector pumps available. Some pumps are provided with different size nozzle for use according to the output of the primary pump.

PRIMERS

A primer is a device for extinguishing air in the suction and the pump, enabling atmospheric pressure to force the water up the pump. Centrifugal pumps cannot pump air and therefore are not "self- priming".

There are three ways of priming a pump.

1. If the water supply is higher than the pump then gravity force water into the pump, pushing the air out.
2. When water is supplied by a hydrant the pressure at the hydrant is sufficient to force water into the pump.
3. If a static water supply is lower than the pump an extra piece of equipment must be used.

Atmospheric pressure caused water to rise from the supply to the pump. The height that the water has to rise is called the SUCTION LIFT.

In theory the maximum suction lift is 10 metres but in practical the figure is lower; 8 metres (the height of a small house) is about the highest lift that could be expected.

Priming devices suitable for use with centrifugal pumps are:

1. Reciprocating 2. Exhaust Ejector 3. Rotary 4. Water Seal

POWER TAKE OFF

Pumps have to be driven by some external source of power and must be designed in relation to the power available from the engine to which they are coupled. Built in pumps, which are powered by the engine which is used to propel the vehicle require the use of a "Power Take Off'.

The Power Take Off is a device by which the full power developed at the gear *box* of an appliance can be diverted, when required from its normal path down the transmission to the rear axle and use instead to drive a fire pump.

Three types of power take off normally used to drive fire pumps are:

1. From the gear box (side or top take off).
2. From the drive shaft to the gear box (sandwich take off).
3. From the transfer box.

In the case of appliances with automatic transmission, the drive to the pump may be taken from a side take off or from a transfer box.

PRACTICAL PUMP OPERATION

All Fire Brigades have a definite routine for drivers taking over an appliance at the beginning of each tour of duty. This routine invariably includes the following action:

1. Checking the level of petrol or fuel oil in the tame
2. Taking a dipstick reading of the oil in the pump.
3. Seeing that the radiator is fun.

Positioning of Appliances

On arrival at an incident the positioning of appliances which m \y become involved in pumping should be taken into consideration, i.e.'

a. Appliances should be parked in a manner so as not to cause t n obstruction to reinforcing appliances.
b. When pumping from open water, room must be left for further appliances to 'Set In'.
c. Parking on soft ground should be avoided due to the risk 01' the appliances getting 'Bogged Down'.'

d. Appliances should be positioned where they cannot be endangered by falling walls or masonry and where they can be easily extricated should the fire spread unexpectedly.

e. The possibility of exhaust fumes entering properties or confined spaces could be a potentially dangerous situation and where possible occupants should be warned to close doors and windows to avoid the risk of carbon-monoxide poisoning.

WORKING FROM HYDRANT

After the pump has been driven or manhandled into position, it should be coupled up to the hydrant by the necessary lengths of hard or soft suction. Soft suction is delivery hose connected from the hydrant to the suction inlet of the pump. Suction has the following advantages:

a. The pump need not be close up the hydrant and can be position and near the fire.

b. Delivery lines can be kept short, which simplifies control of inlet.

When using soft suction, care should be exercised in the use of the pump throttle as if the pump is allowed to overrun the supply, the hose will collapse. This is due to pressure in the suction falling below atmospheric pressure.

A collecting head should be used on the inlet of the pump in preference to a suction adaptor, so that supplies from additional hydrants can, if necessary, be connected without shutting down the pump.

The primer must never be used when working from a hydrant.

WORKING FROM OPEN WATER

When working from open water, hard suction must be used as the vacuum required to obtain water at the suction inlet, will cause the hose to collapse unless it is specially designed to withstand external pressure.

Once the pump is in position, the necessary lengths of suction has should be laid out in a straight line between pump and supply and coupled up. Suction should never be acutely bent or strained as, owing to its restricted flexibility, it is more liable to damage from mishandling than delivery hose. Suction wrenches should be used to obtain air tight joints at the couplings. The metal strainer is usually kept permanently attached to one length of suction hose.

Before the suction is lowered into the water, it should be' secured by a line to take the greater part of the weight off the inlet coupling and also to enable the hose to be drawn up to clean the strainer, or at the end of the operation.

PUMP CONTROL OUTLET

The pump discharge pressure should be carefully controlled and any changes should be made gradually. This is important because branch may be in difficult and dangerous positions where they cannot cope with the sudden unexpected change in jet reaction.

It is also important that the supply of water should be maintained, especially when firefighters are in a building as they maybe faced with anyone of a dozen different situations where water from the branch is essential to their safety. If it should ever become necessary to cut the water, every effort should be made to warn the branch man.

COMMON FAULTS WHICH MAY OCCUR DURING PUMPING

The following are faults which may occur during pumping and the possible causes when working from a hydrant or pressure fed supply:

a. Failure of Water
  l. Due to failure of supplying itself, i.e. fractured main
  2. Burst length between supply and the pump
  3. A blocked internal strainer
  4. Overdrawing water supply (soft suction flat)

b. Increased Delivery Pressure
  l. A controlled branch shut down
  2. Kinks in delivery hose
  3. Something blocking delivery hose, i.e. fallen masonry, parked vehicles, etc.
  4. Branch blocked by stones

c. Decreased Delivery Pressure
  1. Burst length at delivery hose
  2. A controlled branch opened

Working from Open Water

a. Failure to Prime - No Vacuum Reading

1. The strainer not be submerged
2. Loose or faulty suction joints
3. Pump casing drain plug loose or open
4. Delivery valve open (should be able to prime a pump with delivery valve open)
5. Air leak on suction hose (see test on hydrants)
6. Defect in priming system

b. Failure to Prime - High Vacuum Reading

1. Blocked Strainer
2. Blocked Suction

c. Decreased Vacuum

1. Level of static water risen (tidal wave)
2. Less water being delivered (shutting down at branch)

d. Increase Vacuum

1. Drop in level of static water (canal and tidal)
2. More water being delivered (branch open)
3. Partially or wholly blocked strainer

SAFETY POINTS

a. Exhaust fumes from a pump operating in a confined space can be lethal. Always make arrangements to disperse fumes before starting the pump.

b. When refilling water tanks on appliances pressure should not be allowed to build up after the tank is full. Quite a small internal pressure is capable of doing substantial damage. Equally, where a tank is fitted with an overflow, the continual out flow are not only wasteful but may cause flooding elsewhere or where an appliance is standing on soft ground; cause it to be "bogged down".

c. Pumps should not be run without water in the casing, longer than is necessary; this cause damage by water on the impeller neck, rings and in some cases to the pump gland.

d. Stand clear when releasing a blank cap from a spare delivery of a pump. Even though the valve is shut there may be sufficient leakage to build up a pressure high enough to project the cap violently forward and cause injury.

Care should be taken when releasing couplings, pressure release couplings or collecting heads from hose or pumps whilst they are under pressure. When making up after hose has been working aloft, first release the pressure from the pump and then the couplings at the base of the building.

e. Engine oil and water temperature gauges should be monitored.

f. Whenever practicably the pump operator should position himself/herself where he/she can see the pump and see the branch man or alternatively see the Officer in Charge of the incident or other member of the crew detailed to relay signals. Consider the use of portable radios.

g. If the pump operator see a branch go out of control his/her actions should be:

1. Immediately close the throttle.
2. Close the delivery
3. If the supply is from a hydrant, carefully release the pressure, release the coupling or stand pipe head or close the hydrant valve.