FD International

Pump Theory

Pump Theory

Section Outline

- Types of water pressure
- Define terms related to basic principles of hydraulics
- Properties of water
- Positive displacement pumps
- Centrifugal pumps

Pump Theory

What are we talking about?

In order to be a competent engineer, it is important for us to understand the properties of water and the principles of pump operation.

Pump Theory

“Knob Turners” or “Handle Pullers”

If we only learn to turn the right knob or pull the right handle we are placing ourselves, our fellow firefighters, and the citizens we serve in grave danger. When an unusual situation occurs during a pumping operation, the engineer is responsible for making sure critical hose lines remain supplied with adequate water, systematically figure out the problem, and determine the ***SOLUTION***.

Pump Theory

Let us look at types of water pressure

Static pressure- The pressure exerted in all directions of a fluid at rest.

Normal operating pressure- The pressure found in a water distribution system during normal consumption demands.

Residual pressure- The part of the total available pressure not used to overcome friction loss and/or gravity while flowing water through pipe, fittings, fire hose and appliances.

Flow pressure- (Velocity pressure) The forward velocity pressure at a discharge opening when water is flowing. With the use of a pitot tube and knowing the size of an opening the engineer can calculate the GPM.

Pump Theory

Terms relating to the basic principles of pump operation

Atmospheric pressure- The atmosphere surrounding the earth has depth and density and exerts pressure upon everything on earth. Atmospheric pressure is greatest at low altitudes. At sea level atmospheric pressure is 14.7 psi.

Net pump discharge pressure (NPDP)- The actual amount of pressure being produced by the pump. When taking water from a hydrant, it is the difference between the intake pressure and the discharge pressure. When drafting, it is the sum of the intake pressure and the discharge pressure.

example with hydrant: You are pumping a single 2 ½” line with a fog nozzle. Your pumping this line at 150 PSI. Your intake pressure is 80 PSI.

This makes your NPDP…. 150 - 80= 70 NPDP.

example from a draft: You are pumping a single 2 ½” line with a fog nozzle. Your pumping this line at 150 PSI. Your intake gauge is reading a negative pressure of 10 PSI. This makes your NPDP….150 + 10= 160 NPDP

Pump Theory

Terms relating to the basic principles of pump operation

Pump discharge pressure (PDP)- The actual velocity pressure of water as it leaves the pump and enters the hoseline. Each discharge can have a different PDP depending on the hose size and hose length.

Nozzle reaction- The counterforce directed against the firefighter holding a nozzle by the velocity of water being discharged.

Friction loss- The loss of pressure created by the turbulence of water moving against the interior wall of hose or pipe. Appliances also cause friction loss.

Capacity- The maximum ability of a pump or water distribution system to deliver water.

Large diameter hose (LDH)- any size hose 4" and larger is typically considered LDH.

Pump Theory

Terms relating to the basic principles of pump operation

Pressure itself is defined as a unit (measurement) of force.

PSIG (pounds per square inch gauge)

PSIG is the measured pressure that does not include normal atmospheric pressure of 14.7 pounds.

PSIA (pounds per square inch absolute)

PSIA is the measured pressure that does include atmospheric pressure. It typically is used for very precise pressure measurements.

Pump Theory

Terms relating to the basic principles of pump operation

Velocity- Speed; the rate of motion in a given direction

Critical velocity- We must remember there are practical limits to the velocity at which water will travel through hose. If the velocity is increased beyond these limits, the *FRICTION* becomes so great that the entire water stream is agitated by resistance. This agitation causes a great degree of turbulence called ***Critical velocity.***

Pump Theory

Properties of water

There are two characteristics of water that the fire service engineer must be aware of.

- Its ability to change form

&

- Its inability to be compressed

We will first cover how it changes form and the effect these changes have on our pumps.

Pump Theory

Properties of water

Water is made up of two different molecules. They are hydrogen and oxygen. Prior to coming together to form water they are gases. Once two hydrogen molecules combine with one oxygen molecule they form what we know as water. When a molecule of water is formed, it is known as H2O. The hydrogen and oxygen molecules are not easily separated back into their original elements.

Pump Theory

Properties of water

Water can change in form from a solid to a liquid to a gas. Certain outside influences must occur for water to change its form.

We know water changes forms when temperatures go below 32 degrees F and

above 212 degrees F.

Are you thinking?….”Why does this matter?”

Pump Theory

Properties of water

Here is the ***WHY.***

Water boils at 212 degrees creating steam, (which is a form of a gas), when our atmospheric pressure is 14.7 psi.

And…….

Water's boiling point is decreased as atmospheric pressure is decreased.

So….What does this mean to us?

Pump Theory

Properties of water

Lets set up a scenario:

It is early August at 1600 hours. The outside temperature is 107 degrees and temperatures have been in the hundreds for the better part of the summer. You are the engineer and your apparatus (with a 1500 gpm pump) has been assigned to supply water for a relay operation of 800 feet. The drafting hydrant was recently installed on a small pond and has never been used for a fire suppression operation. Your pump's intake is approximately 8 feet above the water level. The apparatus at the fire scene needs a fire flow of 800gpm.

Pump Theory

Properties of water

After an hour into the relay operation you start to notice the pump is losing efficiency. A short time later the engineer of the attack engine request you to increase your flow to 1000gpm **BUT** as you increase your throttle, the master discharge gauge does not increase and the pump begins making a growling sound. The attack engine's engineer radios to you that he is not receiving enough water.

What is going on?

<u>Pump Theory</u>

Properties of water

<u>Lets track this situation:</u>

1st- It is very hot day and has been for some time.

2nd- It is a small pond. Possibly rather shallow.

3rd- We are pumping from a draft.

(because we are pumping from a draft our atmospheric pressure at the impeller is significantly less then outside atmospheric pressure)

4th- We are unable to see the fire scene or the hose lines.

(this is an important fact because we do not know if the water we are pumping to the fire scene is flowing constantly or not.)

5th- We notice a decrease of efficiency.

6th- When we attempt to increase the throttle the PDP (pump discharge pressure) does not increase.

Pump Theory

Properties of water

NOW

Lets put it all together

Water begins to boil at 212 degrees at 14.7 psi atmospheric pressure. During our pumping operation, our pump began to heat up. It's a possibility that the attack engine was not flowing water constantly. As the pump heats up so does the water entering the pump's impeller. At the eye of the impeller, the atmospheric pressure is low enough that the vaporization point of the water entering the impeller has decreased significantly and is now trying to convert to steam as it enters the pump.

What is happening to your pump?

Pump Theory

Properties of water

Cavitation

Pump Theory

Properties of water

What preventative measures can keep this from happening?

- If the pump is equipped with a “pump cooler” it can be utilized to help regulate the heat. Remember that the pump cooling line is normally no larger than 1½ inch in size and it typically is plumbed to dump into the booster tank.
- Another way to control the waters temperature is to discharge water through a hose line back into the pond. This will assure you that there is always water flow through the pump. Be cautious not to open an unmanned hose line to fast or to much. Something else to consider is the amount of water you are flowing back into the pump, because this amount of flow goes against your pumps total capacity. You may find it necessary to stop discharging from your cooling hose line at times when the fire flow needed is equal to or greater than the pumps capacity.

Pump Theory

Properties of water

Cavitation- A condition in which vacuum pockets in a pump and cause vibrations, loss of efficiency, and possible damage.

ALSO described as the pump discharging water faster than it is receiving it.

Bottom line:

Whether it's due to water temperature, a water main rupture, or hose line rupture.

We can only DISCHARGE the amount of water entering the intake side of the pump.

Pump Theory

Properties of water

Cavitation…what’s really happening.

Air cavities (bubbles) are created at the eye of the pump impeller and as they pass from this point of highest vacuum to the pressure side of the impeller. At this point these bubbles collapse and fill with water. The high velocity of the water filling these cavities cause a severe shock to the pump.

Pump Theory

Properties of water

Lets revisit our scenario

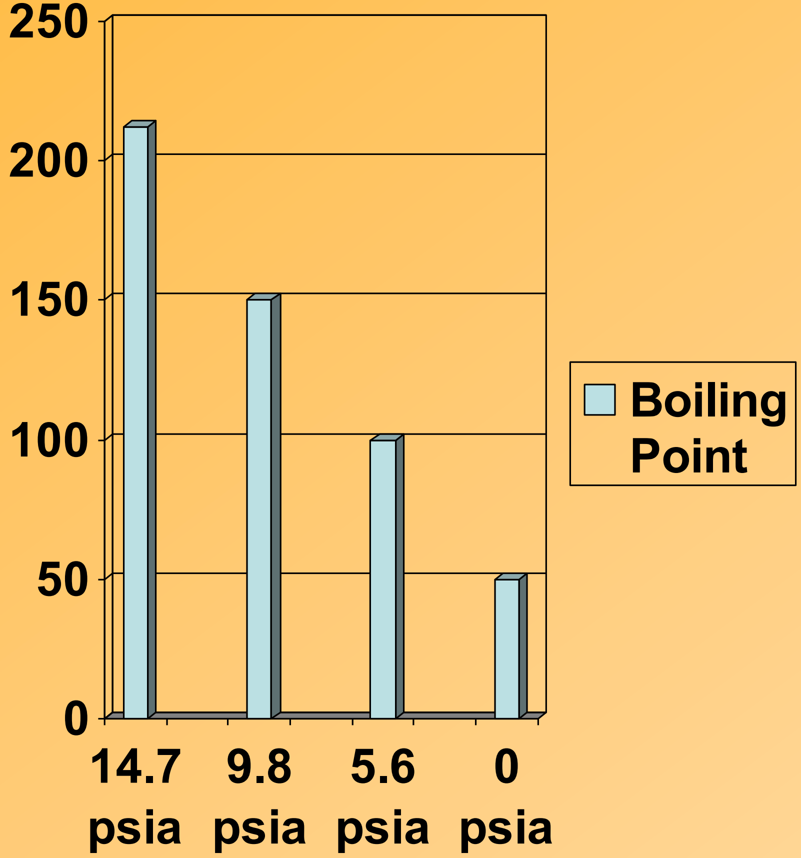
As the atmospheric pressure dropped within our pump, the water' s boiling point in turn also decreased enough to change water to a vapor. This created the air cavities. As those bubbles pass through the impeller, the pressure increases causing the vapor to ***CONDENSE.***

Making any sense yet?

Pump Theory

Properties of water

This is a great illustration of how atmospheric pressure affects the boiling point of water.



Pump Theory

Properties of water

Cavitation Indicators

- Fire streams and pump panel gauges will fluctuate.
- Popping or sputtering may be heard as the water leaves the nozzle.
- Under severe conditions the pump will sound like gravel is passing through it.
- The best indication is the ***LACK*** of reaction to the pressure gauge with an increase of the throttle setting.

Pump Theory

WARNING

Most electronic governors have a low supply pressure shutdown feature!!!!

It allows the engineer **5-7 seconds** to recognize and correct a low supply problem.

This feature does not take into account the fact that FIREFIGHTERS are inside.

The shutdown feature sole responsibility is to protect the pump and engine.

Pump Theory

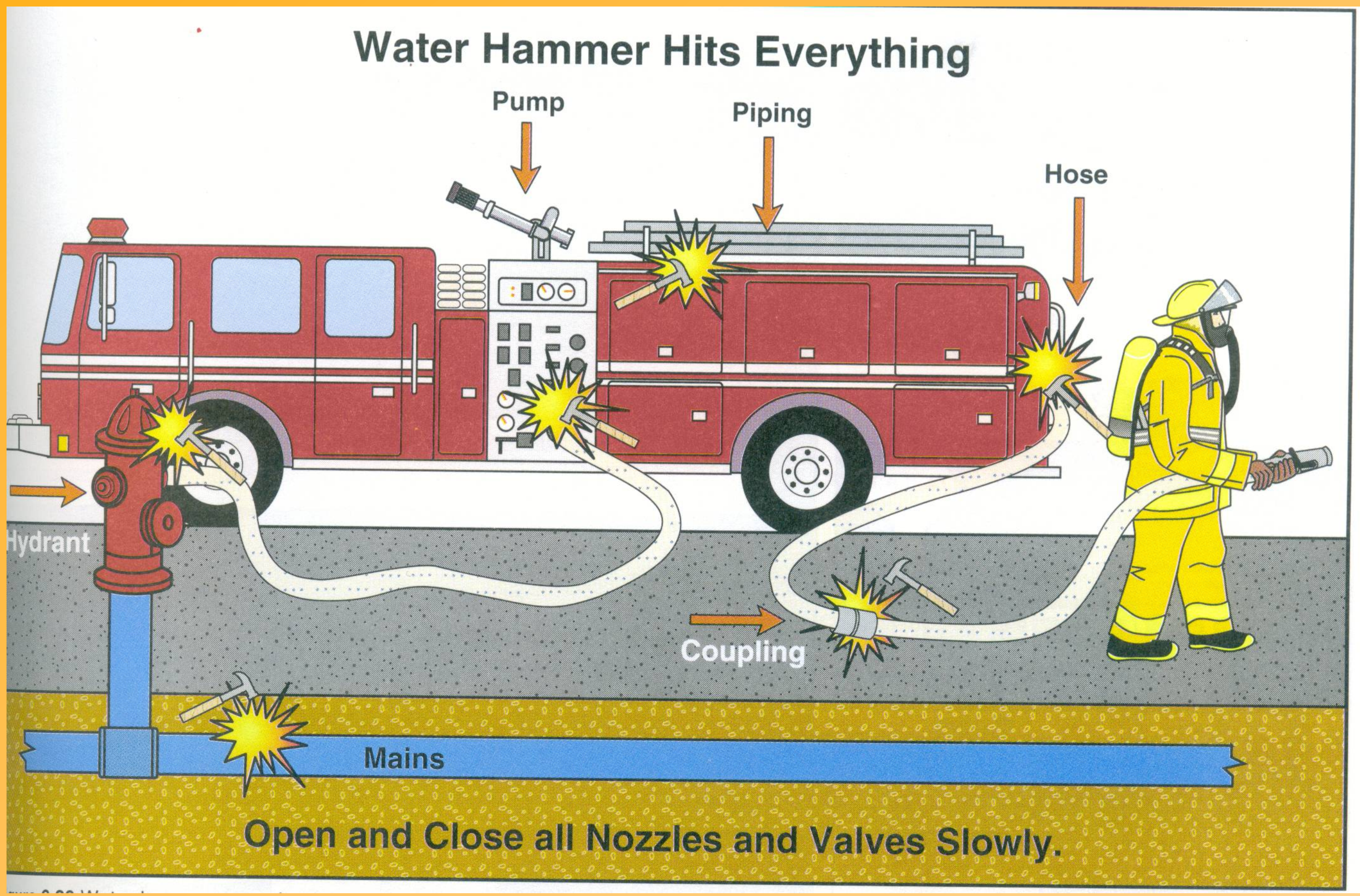
Properties of water

Water Hammer

The force created by the rapid deceleration of water. It generally results from closing a valve or nozzle too quickly.

BAD STUFF

Pump Theory


Water Hammer Hits Everything
Pump
Piping
Hose
Hydrant
Coupling
Mains
Open and Close all Nozzles and Valves Slowly.

Pump Theory

Properties of water

The second characteristic of water that is important for us to understand is….

Water is virtually

INCOMPRESSABLE.

Water requires 33,000 PSI of pressure to reduce its volume by 1%.

This means water it will not store or absorb energy.

Pump Theory

Properties of water

Water moving through the pipe and hose has both weight and velocity. The weight of the water increases as the pipe or hose size increases. If the water moving through a hose is suddenly stopped, the energy the water is carrying is transmitted in the opposite direction, typically it is many times the original pressure.

Pump Theory

Properties of water

Interesting Fact

During apparatus manufacturing tests, the pump and associated piping and valves are typically brought to a minimum of 500 PSI for hydrostatic testing.

Pump Theory

Properties of water

Lets illustrate water hammer in a scenario

We are relay pumping from a hydrant that is supplying us with 50 PSI to an attack engine. We are using 400 ft. of 4” LDH. The attack engine is supplying water to two separate master streams flowing 500 GPM each. The attack engine’s engineer has requested us to supply his intake with 50 PSI. Our friction loss is 80 PSI. This would make our PDP 130 PSI

but our NPDP is only 80 PSI.

RIGHT?

<u>Pump Theory</u>

Properties of water

<u>YES!</u>

This illustration of water hammer is going to astonish you!

Pump Theory

Here we go….

- 100 ft. of 4" LDH holds 65.2 gallons of water
- Each gallon weighs 8.33 pounds
- So….Each 100 ft. section of 4" has 543 pounds of water in it.
- **Remember:** The numbers above are constants. The velocity at which we pump water is what gives us the ability to flow the amounts of water needed.
- The water is still traveling 58 MPH (85 ft/sec) when it reaches the attack engine.
- We have 4 sections of LDH equaling 400 ft..

Pump Theory

Are you ready for this?

This is the amount of energy developed in our scenario!!!

<u>Pump Theory</u>

<u>395,140 Foot Pounds</u>
<u>Of</u>
<u>Kinetic Energy</u>

(The equivalent to this would be a regular sized passenger car hitting a solid brick wall at 53 MPH.)

Pump Theory

Properties of water

KINETIC ENERGY

This is the “Water Hammer” energy that is going to slam into our hoses, pump, plumbing, appliances and the water mains if these two 500 GPM lines are shut down to quickly.

Pump Theory

Positive displacement pumps

There are three kinds of PD pumps:

- Piston
- Rotary gear
- Rotary vane

We will discuss all three but will focus on the rotary vane since it is most common in the fire service.

Pump Theory

Positive displacement pumps

PD pumps were used in the early years of the fire service as the main water pump to supply fire hoses. Since then, PD pumps have been replaced by centrifugal pump as the main pump in modern fire apparatus. You will still find PD pumps, particularly the rotary vane, on fire apparatus for their ability to pump air. For this reason PD pumps are utilized as “**priming pumps**” on modern day fire apparatus.

Pump Theory

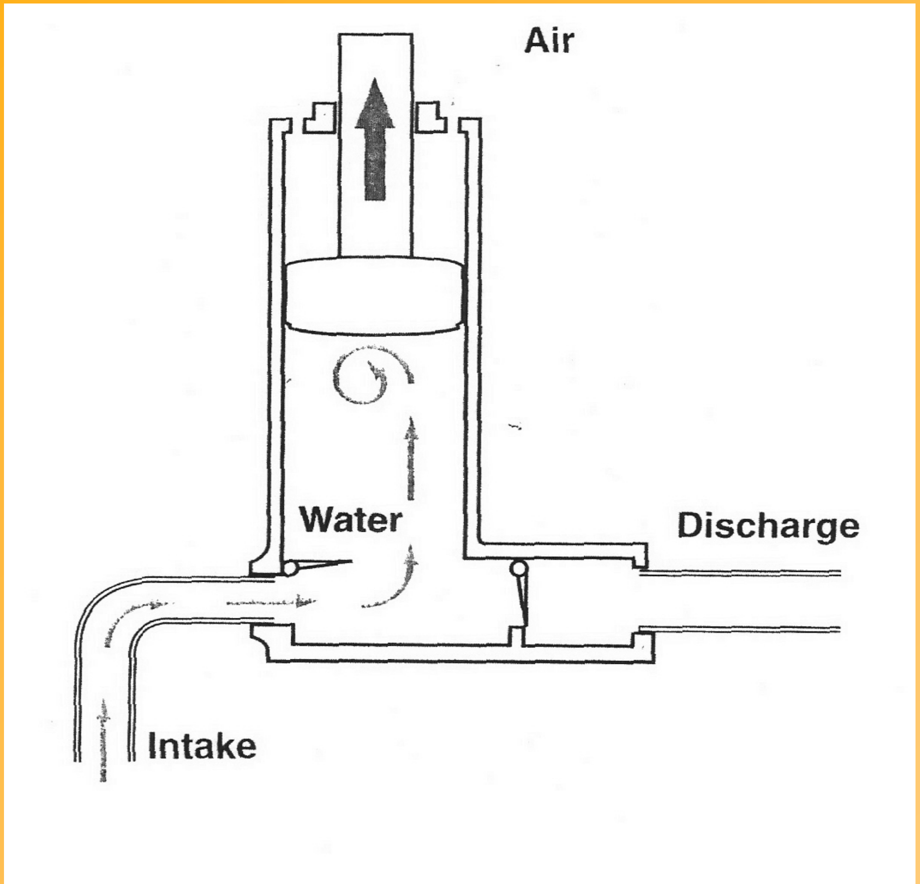
Positive displacement pumps

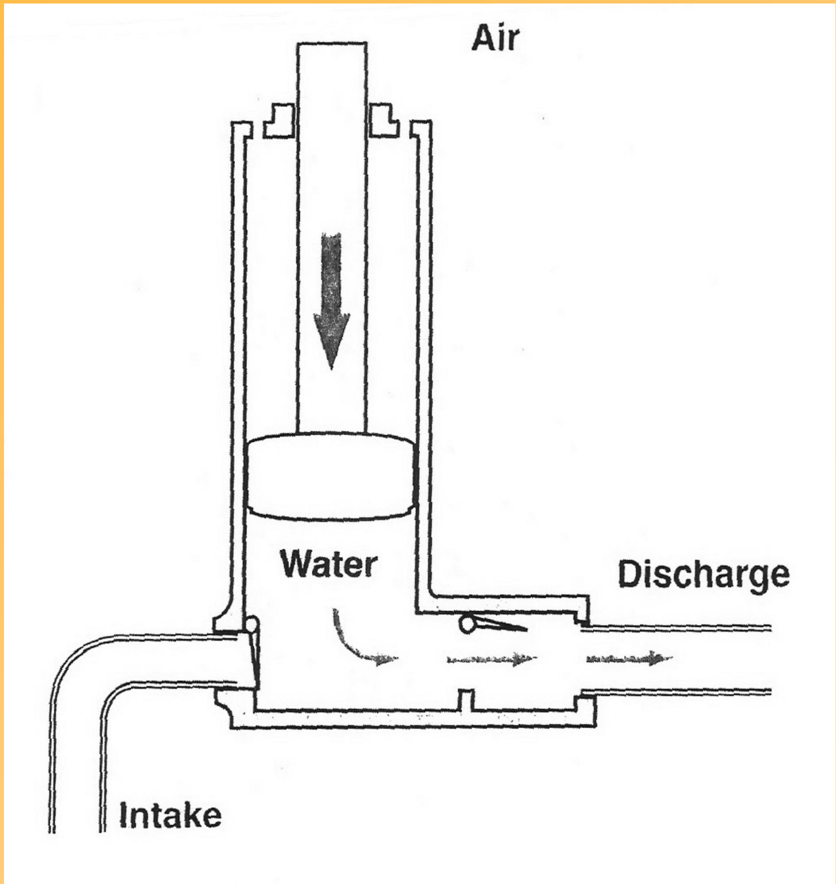
Piston pump

Used first in the fire service as a hand operated pump to boost pressure in fire hose. Their capacity was based on the size of the cylinder or cylinders. The first piston pumps delivered a pulsating stream due to the rhythm of a single acting piston being driven forward and back by men on the operating handle. Two things were done to combat this problem. The first was to develop a double acting piston. Opposed to the single acting piston, which only delivered water with the forward stroke, the double acting piston would deliver water on both the forward and back stroke. This helped with the pulsating water stream. The second development was the air expansion chamber. It was mounted on the discharge side of the pump and utilized the compression of air within this chamber to equalize water streams. Though no longer used as large capacity pumps in the modern fire service; piston pumps did serve our brother firefighters of long ago.

Pump Theory

Piston Pump



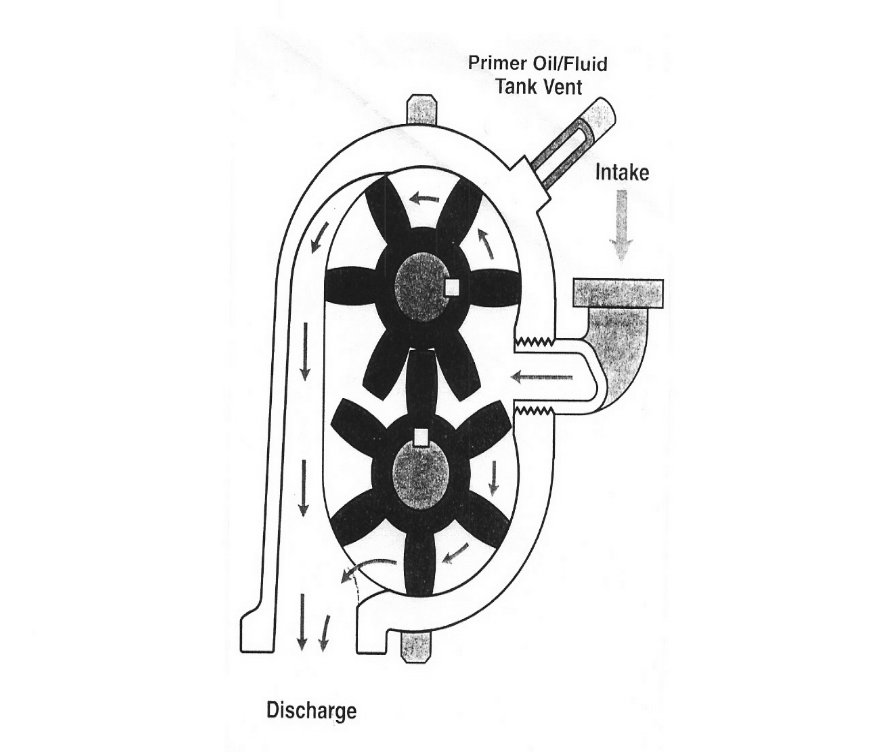


Pump Theory

Positive displacement pumps

Rotary Gear Pump

Rotary gear pumps are rather simple by design. The tightly meshed pattern inside the watertight case is what gives this pump the ability to pump water but also air. The total amount of water that can be pumped by the rotary gear pump is determined by the size of the pockets in the gear and the speed of rotation. They are very susceptible to damage from debris in the water.



Pump Theory

Positive displacement pumps

Rotary vane pump

The rotary vane pump is a popular PD pump in the fire service for several reasons.

1^{st}- Their ability to pump air.

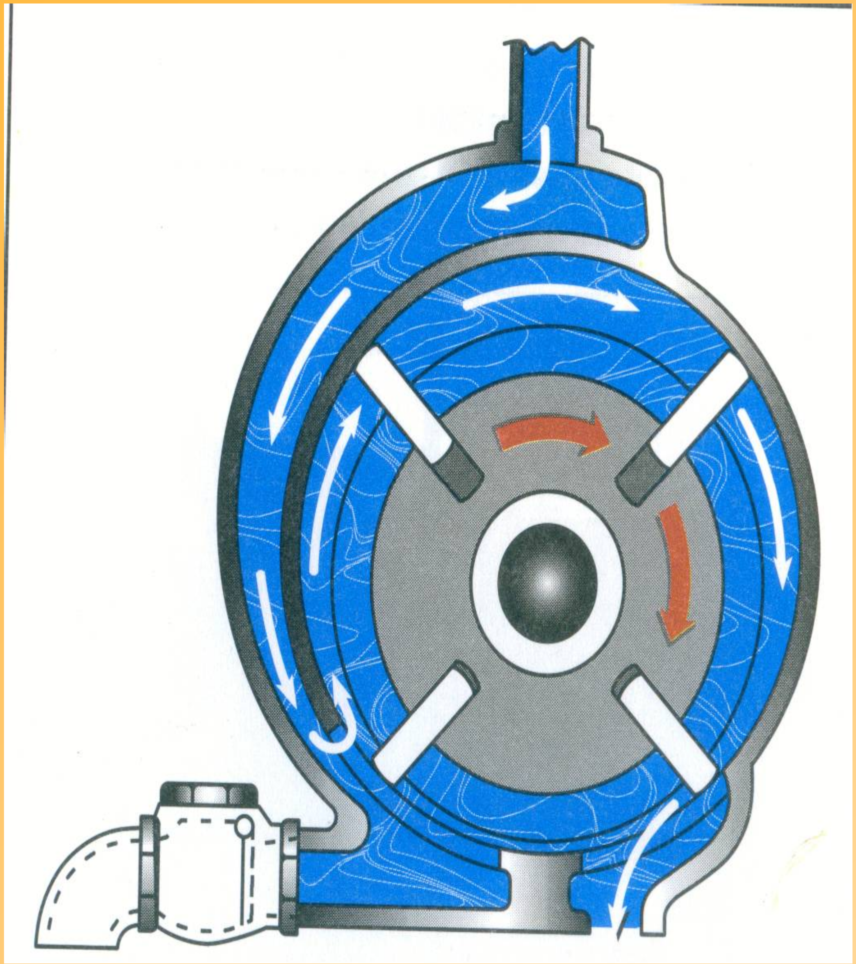
2^{nd}- It is constructed with movable elements that automatically compensate for wear and maintain a tighter fit with closer clearances as the pump is used.

3^{rd-} It is much more efficient at pumping than the rotary gear because of the ability for the vanes to self adjust.

Pump Theory

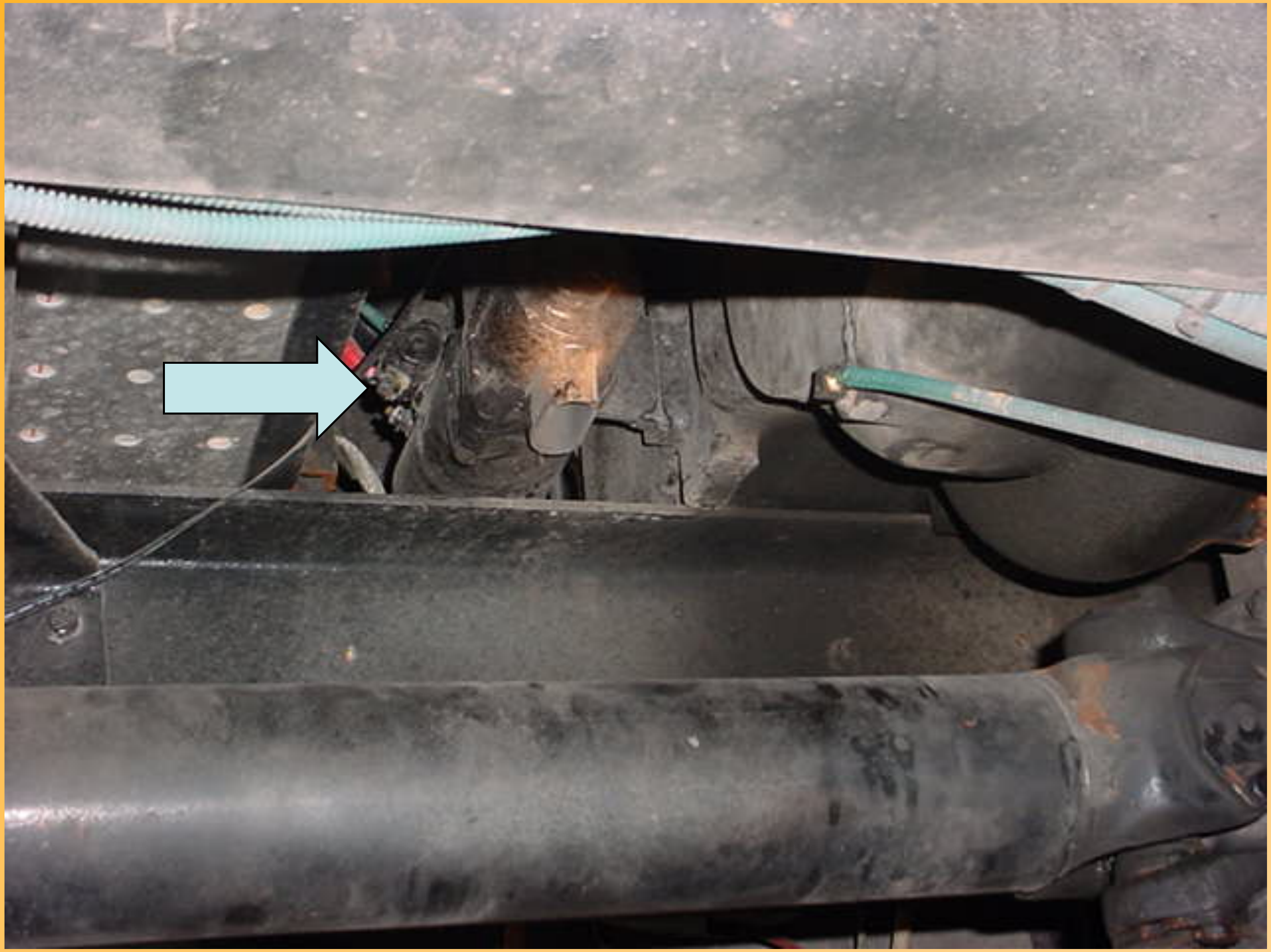
Rotary vane pump

It is used to evacuate air from the centrifugal pump. It pumps only a small volume of fluid but can pump high pressures. As the air is pumped out of the centrifugal pump, the atmospheric pressure within the pump is lowered. The water is forced up into the centrifugal pump by the outside atmospheric pressure.



Pump Theory

Rotary vane pump with electric motor attached.



Pump Theory

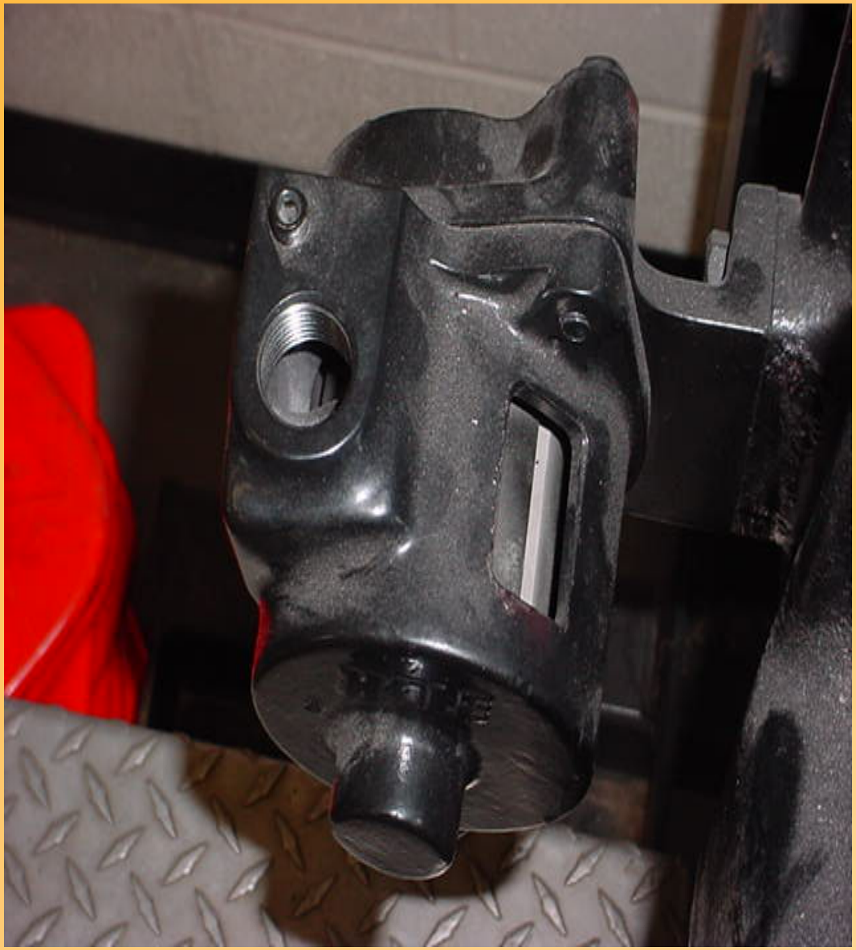
Rotary vane pump

- Oil reservoir for pump
- Used to create a tighter seal between the vanes and pump housing.
- Acts as a pump lubricant
- The pump creates a vacuum condition on the oil reservoir to siphon the oil into the pump.
- There is vacuum break on the reservoir tank outlet to prevent water from entering the tank.

Pump Theory

Rotary vane pump

- Pumps use between 30 weight & 90 Weight oil.
- Some apparatus with these priming pumps do not have an oil reservoir because the EPA deemed that during priming procedures, the oil that was ejected with the water created a hazmat area.



Pump Theory

Positive displacement pumps

Electricity & PD Pumps

- 12 volt D.C. motors are used to turn PD pumps
- When priming the centrifugal pump, only utilize the priming pump for 30-45 seconds at a time with one minute of rest.
- The priming process should be accomplished within the 30-45 seconds provided, if the pump and plumbing do not have any leaks.
- The priming motor uses the engines electrical system for power. Although it's a low voltage motor, it does require high amperage and will drain down a voltage system. When using the priming pump, pay attention to the engines volt meter and make sure it does not drop excessively.

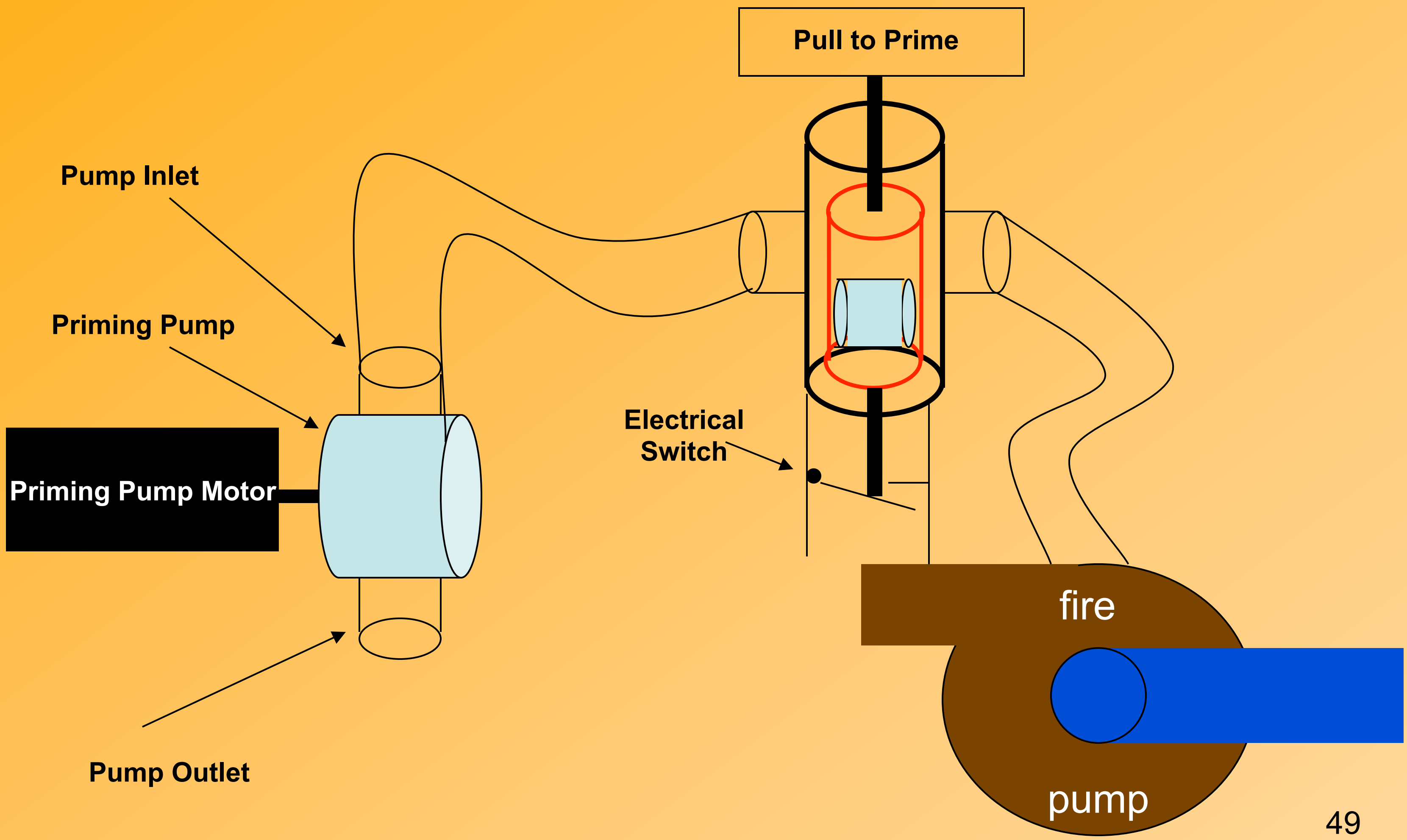
Pump Theory

Electricity & PD Pumps

***Reminder*:**

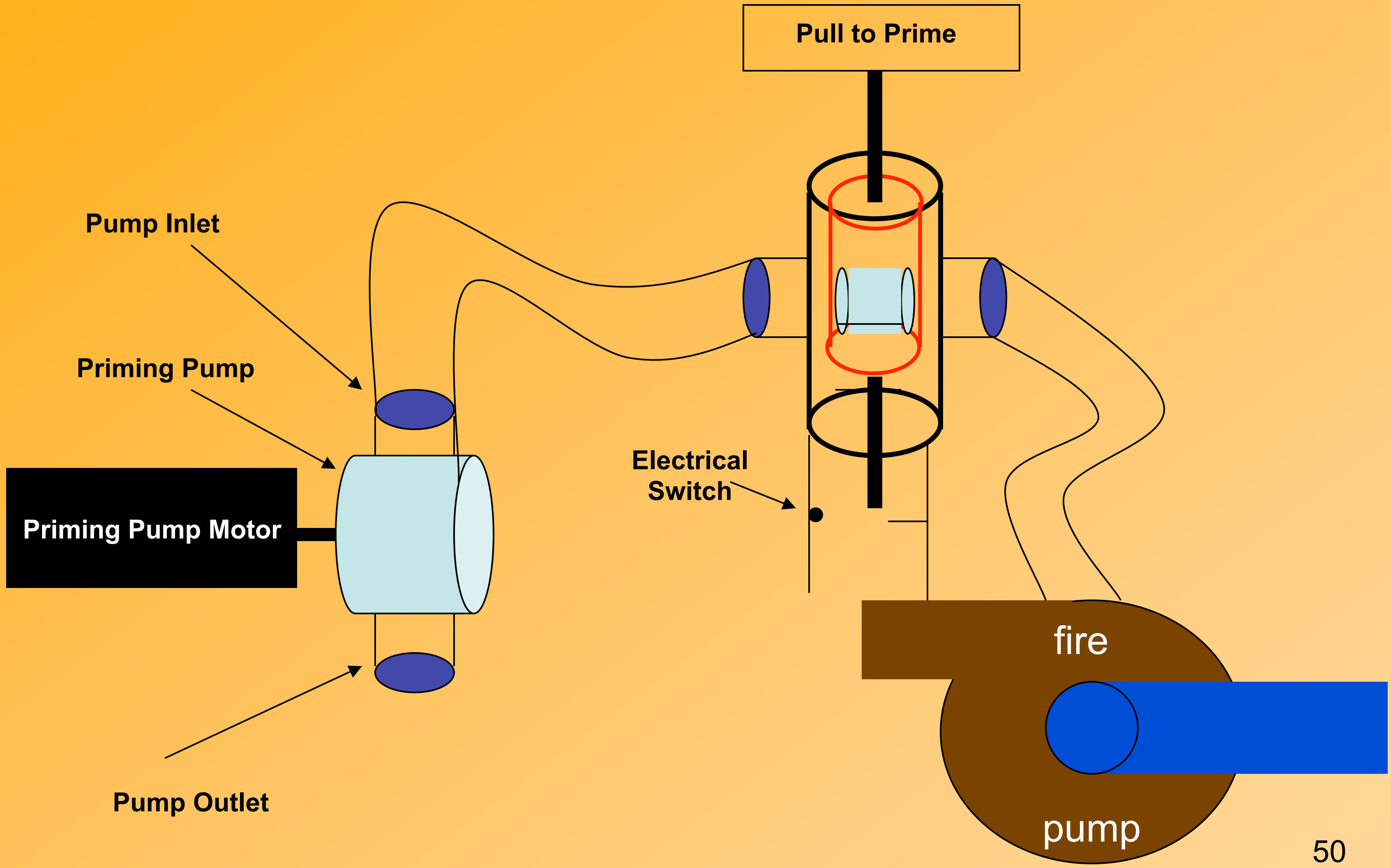
NFPA 1901 says that gauges on a pump panel that are related to the pump will have a white back ground. The gauges that relate to the engine will have a black back ground.

Pump Theory



Pull to Prime
Pump Inlet
Priming Pump
Electrical
Switch
Priming Pump Motor
Pump Outlet
fire
pump

Pump Theory



Pull to Prime
Pump Inlet
Priming Pump
Priming Pump Motor
Electrical
Switch
Pump Outlet
fire
pump

Pump Theory

Practical Application Quiz

Scenario:

You are pumping two 1 ¾" hose lines flowing 125 gpm each and two 2 ½" hose lines flowing 250 gpm each. Suddenly the PDP's drop on all four lines, one hose line's pressure drops more than the others and an interior crew on one of the hose lines calls to you on the radio advising they have totally lost all their water.

What has just occurred?

What are you going to do?

&

Why?

You could very well be faced with this scenario during the hands on portion of the class. You're the engineer and their safety is in your hands!!

Pump Theory

Centrifugal pumps

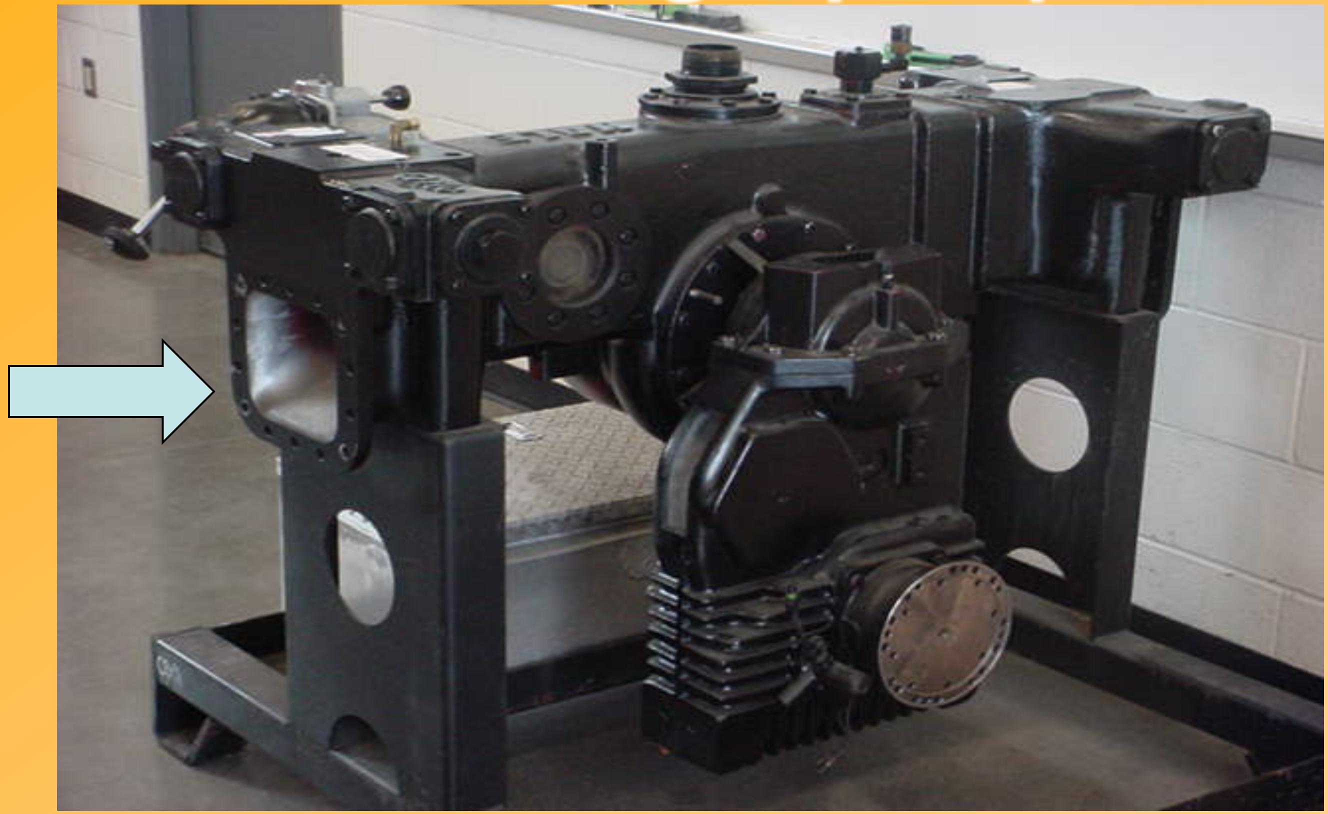
There are two major types of centrifugal pumps used in the fire service today.

- Single-stage pumps
- Multi-stage pumps

We will begin with terminology specific to these two types of pumps.

Pump Theory

Centrifugal pump



Note the square shape of the intake. This is to assist in avoiding a water vortex.

Pump Theory

Centrifugal Pumps Terminology

Impeller (Disk)- The vaned component within the pump that creates the velocity of the water.

Casing (Container)- This is the housing around the impeller that catches the water after leaving the impeller. The purpose of the casing is to turn the velocity into pressure by "containing or confining" the water.

Impeller Eye- The intake orifice at the center of a centrifugal pump impeller.

Volute- The spiral chamber within the pump which converts the energy of the water to pressure once it has left the impeller.

Transfer valve- The valve used for placing a multistage pump into volume or pressure mode.

Single stage pump- A pump containing only one impeller.

Multi stage pump or two stage pump- A pump containing two impellers.

Volume mode- Sometimes referred to as "***Parallel mode***"**.** When operating a fire pump in volume mode each impeller receives water from the source and delivers it to the discharges.

Pressure mode- Sometimes referred to as "***Series mode***"**.** When operating in pressure mode the first impeller receives water from the source and delivers it to the eye of the second impeller.

Pump Theory

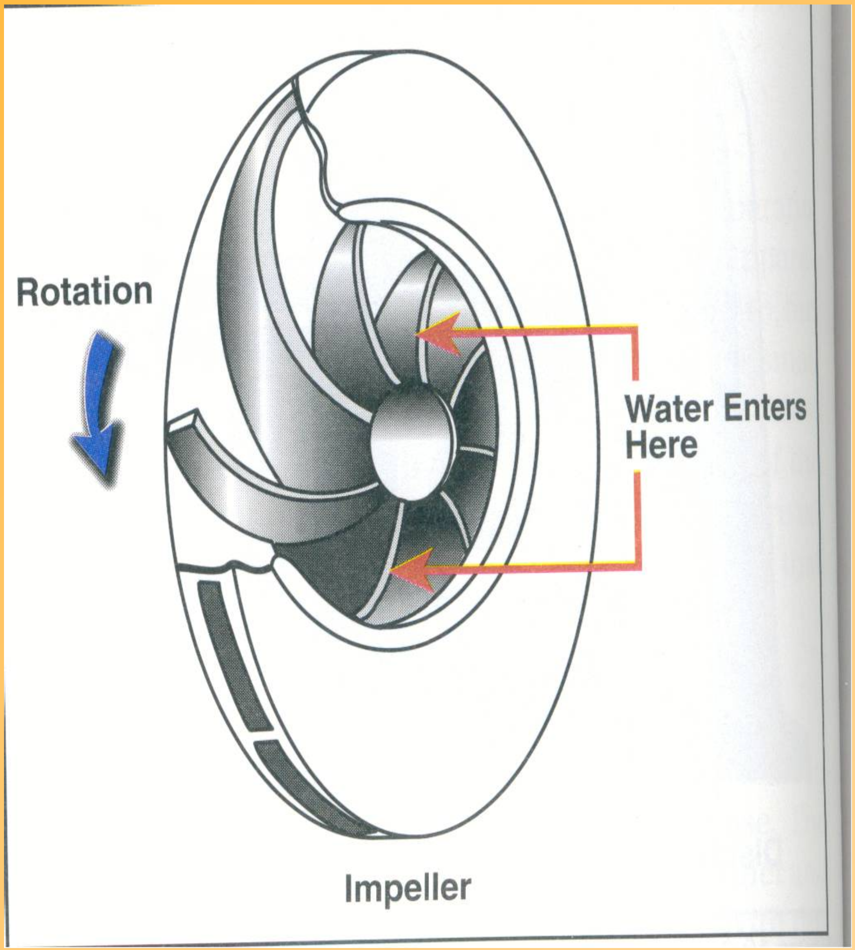
Centrifugal pumps

Nearly all modern fire apparatus utilize centrifugal pumps as their major pump. They are classified as a non-positive displacement pump because it does not pump a definite amount of water with each revolution. The impeller spins very rapidly within the pump, generally from 2000-4000 RPM. The capacity of a centrifugal pump is directly related to the size of the impeller. The larger the impeller, the higher the volume capability.

Pump Theory

Centrifugal pumps

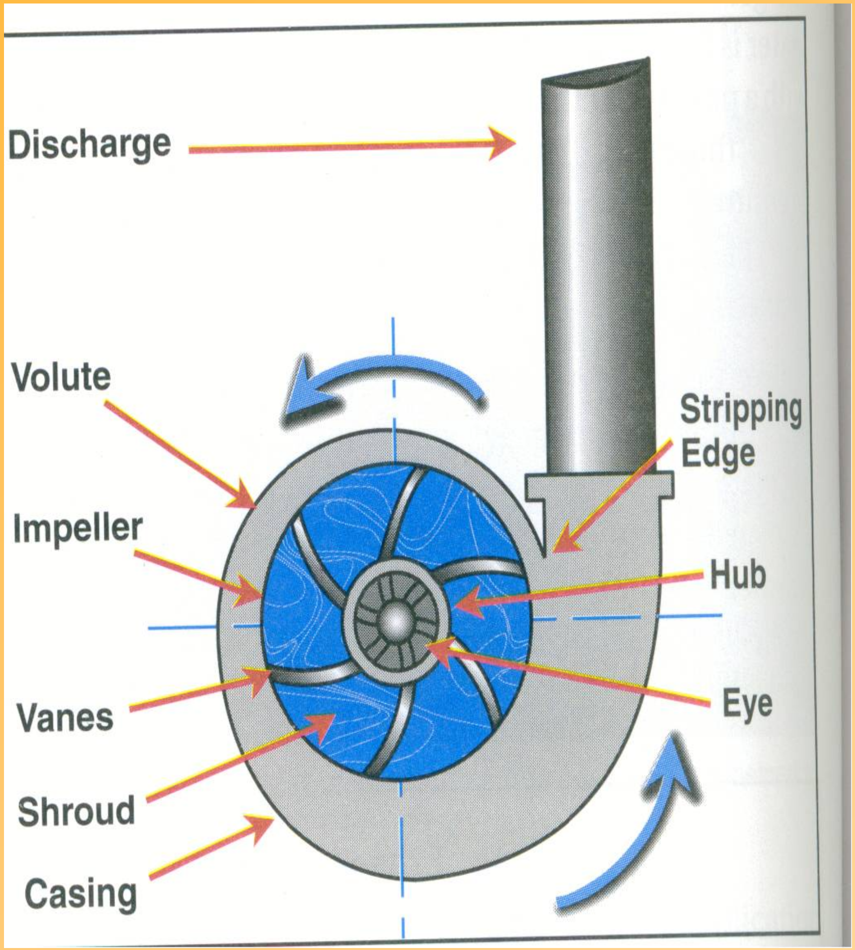
This illustration gives us some interesting insight to the eye and the vanes of the impeller. Note the direction of rotation and the direction which the vanes curve. The vanes curving in the opposite direction is what gives the impeller the ability to sling water and help create the velocity.



Pump Theory

Centrifugal pumps

May I suggest you study this illustration. You may see it again!!



Pump Theory

Centrifugal pumps

Did you note the volute and how it changes in size in the previous slide?

The volute increases in size because the amount of water passing through it increases as it moves toward the discharge. The gradually increasing size of the waterway allows the water to slow down which in turn causes it to “back up”. This is what enables the pump to build pressure.

Pump Theory

Centrifugal pumps

There are three factors that effect a centrifugal fire pump's discharge pressure.

- Amount of water being discharged
- Speed at which the impeller is turning
- Pressure of the water coming into the intake from a pressurized water source.

Lets begin with our flow amount.

Pump Theory

Centrifugal pumps

If a discharge is too large, the pump will only build a very small amount of pressure. On the other hand, if a discharge is closed, this will result in a very high pressure. Typically, the amount of discharge pressure a pump is capable of creating is directly related to the volume of water the pump is trying to flow.

Note to self:

Why then does the pressure decrease rather than increase on a discharge gauge when a discharge valve is partially closed? It's restricting flow which creates more pressure back towards the pump.

Right?

Pump Theory

Centrifugal pumps

Don't over think the situation.

Answer:

The pressure sending unit for that discharge gauge is down stream from the valve you are operating. When a valve is "gated back", it reduces the pressure to the hose line connected to that discharge thus keeping nozzle pressure and reaction within normal limits.

Pump Theory

Centrifugal pumps

The speed at which the impeller spins will also determine the pressure developed. Greater the speed, greater the pressure development. The pump will turn two times faster than the engine. This creates a 2:1 gear ratio. If the Engine RPM is 1000 then the Pump RPM is 2000.

Pump Theory

Centrifugal pumps

A similar principle applies to pump rpm and discharge pressure.

If we increase the pumps rpm by one time, this will increase the discharge pressure by two times.

Lets say our engine is at idle (700 rpm). This would mean our pump is turning at 1400 rpm and has a discharge pressure of 50 psi. If we increase our engine rpm to 1400 rpm, then our pump rpm would be 2800 rpm, and our discharge pressure would now be

200 psi.

FYI

Many times the only difference between a 1250 gpm pump and a 1500 gpm pump is….

The gear ratio! Not impeller size

<u>Pump Theory</u>

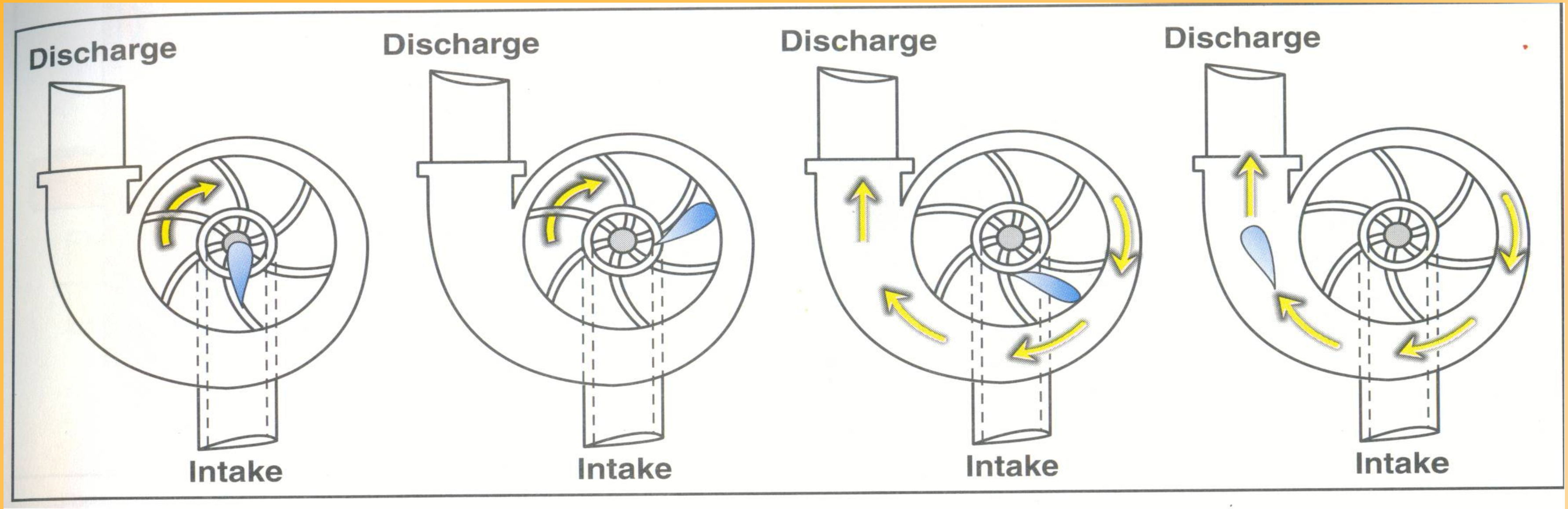
Centrifugal pumps

The third factor that influences the pumps ability to create discharge pressure is the pressure being introduced at the pumps intake. One of the most beneficial attributes of a centrifugal pump is that there is no positive blockage between the intake and the discharge outlet. What this means to the engineer is….any pressure received at the intake of our pumps can be added to the pressure the pump is developing to help reach our desired PDP. Refer to the following slide for an example. This slide was presented earlier in the program.

Pump Theory

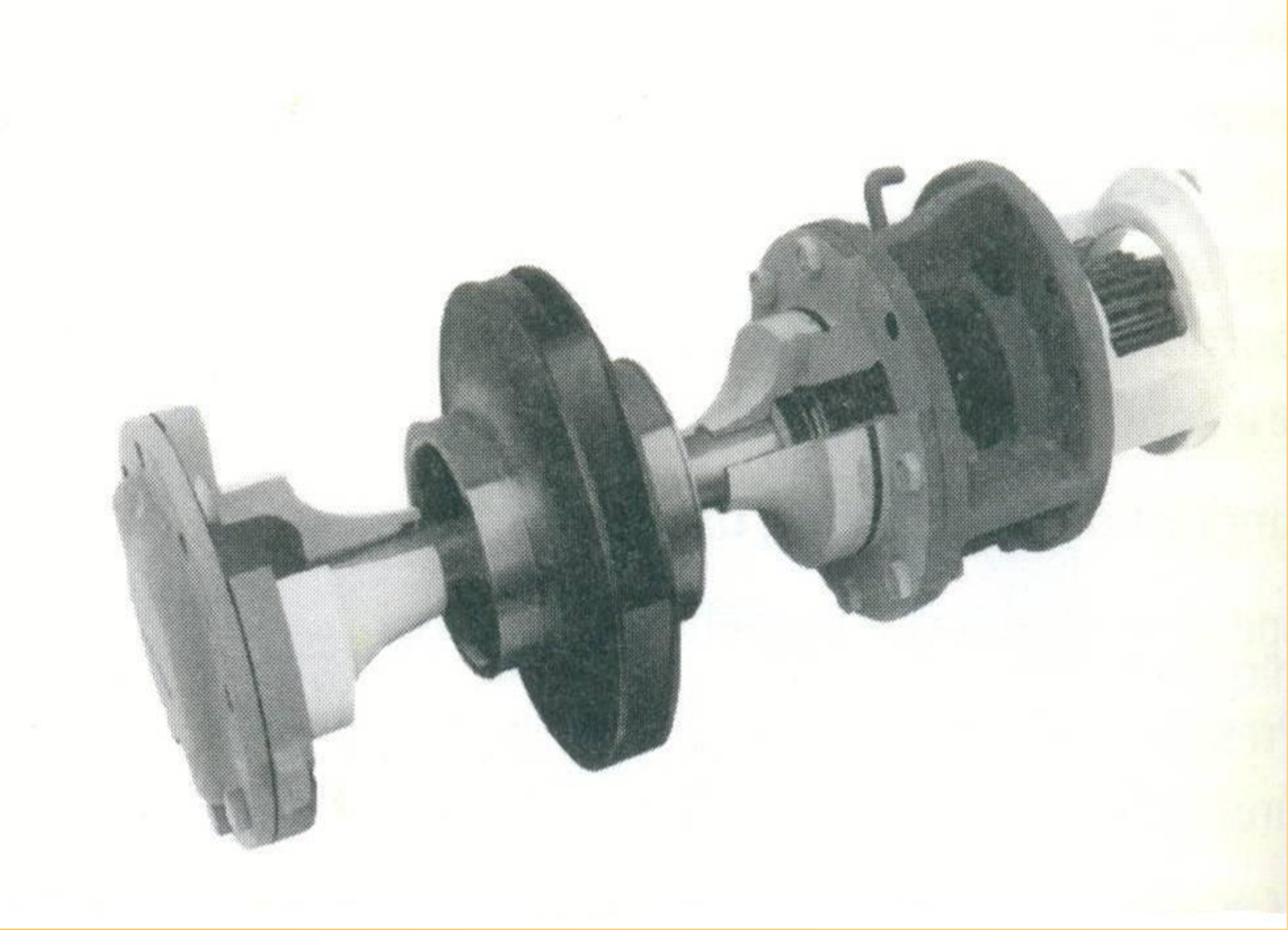
Centrifugal pumps

Here is a simple illustration of the path water takes from intake to discharge.



Pump Theory

Centrifugal pumps



Pump Theory

Centrifugal pumps

The single stage pump is the workhorse used within the fire service. They are not widely used in areas with many high rises because they are only capable of pumping 50% of their capacity at 250psi for just a limited amount of time. We do have a few things to cover concerning these pumps.

They both have to do with physics and will require us to revisit our high school science class.

Pump Theory

Centrifugal pumps

We must look back to
Sir Isaac Newton.

Newton's law (a law of physics) says…for every action there is an equal and opposite reaction.

Armed with this information let's examine the "why" to having an eye on each side of the impeller.

Pump Theory

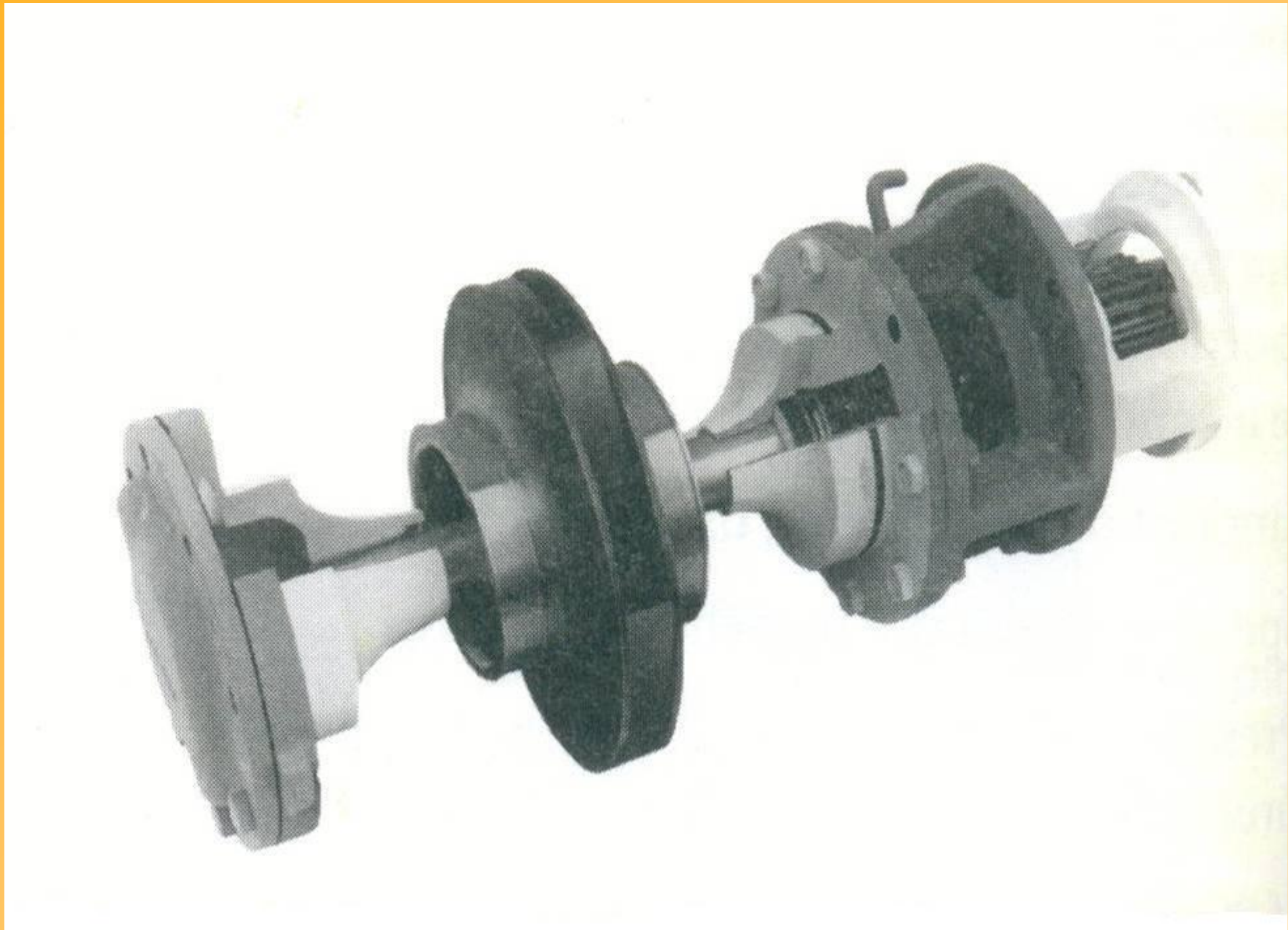
Centrifugal pumps

As water enters and moves through the pump, it creates stress on the pump, its bearings, other moving parts, and the casing which is mounted to the truck frame. The stress placed on these different locations is the equal and opposite reaction….Newton's law in action. This movement of water entering the pump causes a lateral thrust to be placed against one side of the impeller. So ask yourself, what could be done to help minimize this law of physics?

Pump Theory

Centrifugal pumps

Note that this impeller has an eye (intakes) on both sides.



Pump Theory

Centrifugal pumps

The answer: *Double suction impeller*

If water is allowed to enter from both sides of the impeller, the stress placed on the impeller and all related parts is virtually eliminated. The energy of the water entering from both sides of the impeller are equal and opposite. This minimizes this law of physics and provides a larger waterway for water to move through the impeller.

Pump Theory

Centrifugal pumps

Radial thrust is also developed as water is delivered to the discharge due to the impeller spinning at such high rates of speed. The stripping edges in the opposed discharge volutes divert the water 180 degrees apart. The water moving in opposite directions causes the radial thrust to be canceled. These designs provide a hydraulically balanced pump!

Pump Theory

Centrifugal pumps
Two-stage pumps
In a nut shell

- Two impellers
- Mounted on a single shaft
- Impellers have the same capacity
- Able to operate in pressure or volume
- Have a transfer valve

Pump Theory

Two-stage pumps

Pump manufacturers have recommendations for when to changeover from pressure mode to volume mode according to the amount of water being flowed. The old rule of thumb used to be ½ the rated capacity of the pump. Now with the newer designed pumps, the rule of thumb is becoming 2/3 (two-thirds) the rated capacity.

If there is any doubt as to a particular pump, contact the pump manufacturer for the specs. It is common practice to keep a pump in pressure mode until this flow is met. The pump is kept in pressure mode because many bread and butter pumping operations can be accomplished without reaching two thirds capacity.

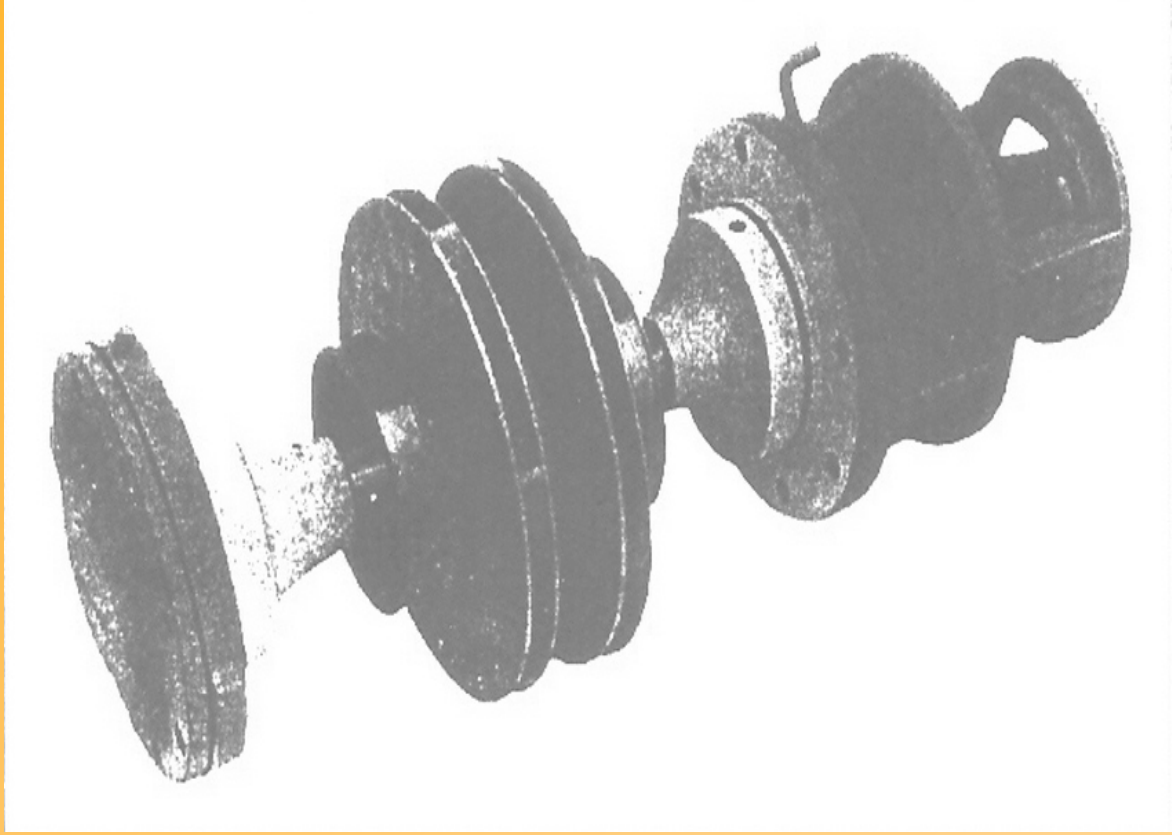
When the pump is operating in pressure mode, it does not require much increase in engine rpm/pump rpm to reach the desired PDP thus decreasing the wear and tear on both the engine and pump.

Pump Theory

Centrifugal pumps

Two stage pump picture

note each impeller only has one eye.



Pump Theory

Pumping in volume mode

When operating a two stage pump in the volume position, both impellers receive water from the source and deliver it to the discharge. Each impeller is capable of delivering 50% of the total capacity of the pump. If we have a pump rated to 1500 gpm, then each impeller is capable of flowing 750 gpm at 150 psi. The streams of the two impellers are combined at the discharge manifold to equal 1500 gpm.

Pump Theory

Centrifugal pumps

Changing from Volume to Pressure mode

The engineer should anticipate fire flow requirements as the firefighting operation progresses. As the engineer, it will be your responsibility to make sure the pump is in the proper position. If you have any question as to which position the pump should be in, then you should operate it in **volume**. Though volume mode could make it difficult to achieve high pump pressures, it will allow you to flow 100% of the pumps capacity.

Refresher…..what type of pumping could be utilized if your pump discharge pressure needs to be greater than the pumps capabilities?

TANDEM PUMPING

Pump Theory

Centrifugal pumps

Changing from Volume to Pressure mode

The process of switching between pressure and volume mode is often referred to as ***changeover***. Operating the transfer valve changes the direction of the water and doubles the previous discharge pressure. If the transfer valve is operated at too high of a pressure, damage could occur to the pump and hoses. In most cases it is recommended not to operate the transfer valve above 75psi.

Pump Theory

Centrifugal pumps

A separate third stage pump is commonly found in cities with many tall buildings. These pumps are mounted outboard on two stage pumps and have a separate drive system. These types of engines must carry hose that is rated and tested for very high pressures.

Pump Theory

Summary

"Knowledge and Understanding Is Power"

Truly understanding pump theory and its different subjects is what separates good engineers from the best engineers. This online presentation is an excellent start but must be followed by regular practical application of your knowledge and skills. The Fire Engineer Training Simulator is second to none for providing real world practical training. If your not sure you believe me….just wait till the hands on training day. I assure you that this will be the most fun and practical learning experience you have ever had in a pump operations course.