TOPIC: Pump Theory - Types of Pumps

TIME FRAME: 2 Hours

LEVEL OF INSTRUCTION:

BEHAVIORAL OBJECTIVE:

Condition: A written quiz

Behavior: The student will be able to describe: the types of fire pumps used by CDF, their characteristics, operating principles, and common uses.

Standard: With a minimum of 70% accuracy

MATERIALS NEEDED:

- Chalkboard and chalk
- Student information sheets
- Appropriate visual aids
- Pump cut-aways
- Slides
- Audio visual equipment

REFERENCES:

- IFSTA, Fire Department Pumping Apparatus, 7th Edition, Chapter 5

PREPARATION: In order to effectively operate or trouble shoot fire pumps on CDF engines you must first be able to identify the different types of pumps used and understand their basic operating principles.

PRESENTATION	APPLICATION

I. TYPES OF PUMPS

A. Positive Displacement

1. Piston
2. Rotary gear
3. Rotary vane

B. Centrifugal

1. Single stage
2. Multiple stage

II. POSITIVE DISPLACEMENT PUMPS

A. Characteristics

1. Will pump air or water
   a. Used as a primer on centrifugal pumps
2. Constant volume of air or water pumped on each complete cycle
   a. Maximum slippage is 10%
   b. Slippage is the ability of water or air to escape by slipping through the pumps inner-workings
3. Must have very tight part tolerances, therefore, high maintenance requirements
4. Requires a relief valve
   a. Since the pump creates a constant volume of water each cycle, shutting off a discharge could damage the pump. Relief valves shunt water back to the suction side of the pump

PRESENTATION	APPLICATION
B. Types of Positive Displacement Pumps	
	Information sheet #1
1. Piston pump	
a. A piston moves back and forth through the length of a cylinder	
	Example: CDF backpump
(1) On the rearward stroke as the size of the chamber capable of holding air or water expands the pressure in that chamber decreases. The external air or water being at a higher atmospheric pressure forces the suction or inlet valve open and air or water enters the chamber.	
(2) When the piston is at its fullest rearward extension the air and water fill the chamber and equalize pressures on the inside and outside.	
(3) The intake or suction valve then closes on the forward stroke, the size of the chamber diminishes applying pressure to the air or water. Since this pressure is greater than the outside pressure, the discharge valve opens allowing the air or water to escape.	

PRESENTATION	APPLICATION
(4) At the piston's full forward extension, pressure inside the cylinder equals pressure outside and no exchange of air or water occur as the discharge valve closes.	
2. Rotary gear	
	Information sheet #2
	Not in common use with CDF apparatus
a. A minimum of two gears within the pump casing turn in opposite directions	
b. Each gear is in contact with:	
(1) The inside wall of the pump casing	
(2) The partner gear	
(a) As the teeth on the gears contact the pump casing wall, they force the air or water trapped in the pocket formed by two adjacent teeth and the casing wall toward the discharge.	
(b) As additional teeth contact the pump casing wall and displace the air or water, it increases the pressure within the casing. The air or water then flows outward from the discharge valve in order to equalize pressure inside and outside the pump.	

PRESENTATION	APPLICATION
(c) Concurrently the area between the gears and the suction or inlet valve becomes a low pressure area allowing water or air to enter that portion of the casing.	
3. Rotary vane	Commonly used on CDF apparatus as a primer pump
a. Consists of a circular disk upon which equally spaced vanes are mounted	
b. The disk is positioned off center within the pump casing	
c. As the disk rotates rapidly, the vanes which are either spring mounted or free sliding, extend outward via spring tension or centrifugal force, toward the inside wall of the pump casing	
(1) The distance from the spinning disk and the inside wall of the pump casing decreases as the disk rotates from the suction or intake port to the discharge port.	
(2) As a result, air or water trapped between the extended vane and the casing wall is compressed into a progressively smaller area until it reaches the discharge port and is discharged under pressure.	

PRESENTATION	APPLICATION
(3) As the air or water is discharged, the pressure within the pump casing decreases and air or water under higher atmospheric pressure outside the pump casing flows inward through the suction or intake ports.	
III. CENTRIFUGAL PUMPS	
A. Characteristics	
1. Will not pump air therefore needs a primer (positive displacement pump).	
2. All water within the pump casing is not discharged with each impeller rotation.	
3. Has 100% slippage which allows water to circulate among inner workings within the pump casing.	
a. Relatively loose tolerances reduce amount of wear and maintenance costs.	
b. Lack of friction between parts minimizes power loss between motor and pump.	
4. Does not require a relief valve	
B. Parts of A Centrifugal Pump	
	Information sheets #3 and #4
1. Pump casing - the exterior housing of a centrifugal pump which contains all pump components.	
2. Impeller shaft - the shaft which extends from the pump motor through the pump casing and upon which the impeller is attached.	

PRESENTATION	APPLICATION
3. Impeller - a round hollow metal object attached to the pump shaft which rotates at varying speeds to impart velocity to the water within the pump.	
4. Impeller vanes - walls within the interior of the impeller which compartmentalize the water so the water can be directed toward the discharge and given velocity. Vanes extend from the center of the circular impeller to the outer edge in a non-concentric arc.	
5. Suction inlet or eye - an area around the impeller shaft which allows water within the pump casing to enter the interior portion of the impeller.	
6. Volute - the area between the outer edge of the impeller and the pump casing.	
7. Discharge - the area through which the water exits the pump under pressure.	
C. Operating Principles	
1. Centrifugal force - as an object rotates around a center point it tends to travel outward in a straight line from that center point. The greater the speed of the rotation the greater the outward speed with which the object travels from that center point.	
	Information sheet #5 Examples/ Demonstration 1. Tie nut or washer on string and rotate or 2. Rotate bucket of water

PRESENTATION	APPLICATION

2. Centrifugal pump

   a. As the impeller rotates on the drive shaft it throws the water which was introduced into the impeller at the suction inlet outward to the volute.

      (1) The greater the speed with which the shaft and impeller rotate the greater the speed or velocity with which the water is thrown outward.

      (2) The larger the impeller's circumference the greater the speed or velocity with which the water is thrown outward.

   b. Since water is thrown outward by the impeller around its entire circumference the volume of water increases as it approaches the discharge port.

      (1) The volute increases in size as it approaches the discharge to accommodate this greater volume of water.

      (2) The volute is also designed to confine the area into which the water can travel in order to maintain the velocity or pressure which has been created within the pump.

D. Types of Centrifugal Pumps

1. Single stage

   a. A centrifugal pump with a single impeller attached to the impeller shaft.

   b. Designed for volume pumping operations

PRESENTATION	APPLICATION
2. Multiple stage	
a. A centrifugal pump with two or more impellers attached to the impeller shaft. Usually a common shaft	
b. Impellers can be configured, via a transfer valve	
(1) Pressure - series mode	
(2) Volume - parallel mode	
c. Interconnecting waterway	
E. Advantages Over Single Stage	
1. Delivers higher pump pressures without requiring increased engine and pump speed.	
F. Transfer Valve Controls Water Flow	
	Information sheet #6
1. Two-position valve	
2. Usually hand operated	
3. Transfers (changes over) pump from parallel (volume) to series (pressure) or vice versa.	
4. Series (Pressure) With transfer valve in this position a volume of water is directed into the first stage impeller and is discharged under pressure to the second stage impeller. The pressure/velocity of the water coming to the second stage impeller is then increased (supercharged) and discharged from the second stage of the pump at twice the pressure/velocity of the first stage.	
a. Same volume of water passes through both stages	

PRESENTATION	APPLICATION

b. Water pressure/velocity upon discharge is doubled.

5. Parallel (volume) - In this position water enters both pump impellers at the same time from a common suction inlet, and leaves through a common discharge creating more pump volume while maintaining the same pump pressure.

a. Equal volume of water enters each impeller

b. Water discharged without being supercharged

G. Summary - Parallel vs. Series

1. Series impellers - greater pressure, equal volume

2. Parallel impellers - greater volume, equal pressure

IV. CAUTION

A. Do not switch transfer valve while pumping operations are occurring and engine pressure exceeds 50 P.S.I.

1. Damage equipment

2. Injure personnel

SUMMARY:

Every engine operator should be thoroughly familiar with the operating principles relating to positive displacement and centrifugal pumps. Failure to distinguish between the two accurately will potentially hamper fireground operations and will delay the trouble shooting process when mechanical problems arise.

EVALUATION:

A written quiz.

ASSIGNMENT:

To be determined by instructor(s).