Fire Protection Hydraulics and Water Supply Analysis

FPST 2483 Chapter 9
Introduction to fire pumps

1

Module objective

- Upon completing this module, the student should be able to:
  - Identify basic fire pumps
  - Understand the principles of pump operation
  - Know some pump components
- Reading material: chapter 9

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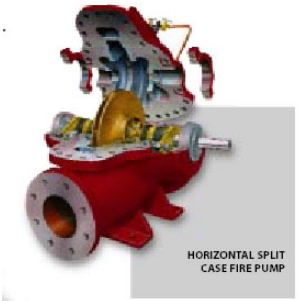
FIRE PUMPS

- A stationary pump that provides pressure boost to ensure an adequate water volume is provided at a sufficient pressure.



HORIZONTAL SPLIT CASE FIRE PUMP

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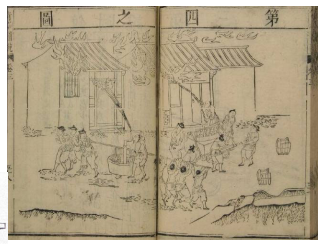
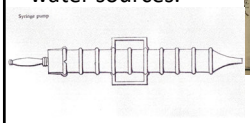
Why Apparatus Need Fire Pumps

- Most water systems don't have enough pressure to supply attack lines from onboard and static water sources.





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Early Fire Pumps

- Date to late 1700s
- Were operated by hand
- Had positive displacement piston and rotary gear pumps

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Modern Apparatus Fire Pumps

- Are driven by the apparatus or a separate engine
- Are of centrifugal design
  - End-suction pumps
  - In-line pumps
  - Horizontal split-case pumps
  - Vertically mounted split-case pumps
  - Vertical-shaft turbine pumps

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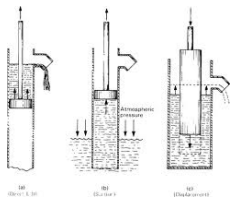
Positive Displacement Pumps

- Specific amount of air or water forced through the pump by each action of a piston or gear
- No longer used as the primary fire pump on apparatus
- Used as priming pumps on all modern apparatus



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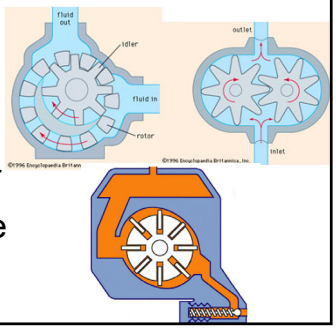
Two Types Of Positive Displacement Pumps

- Piston type
- Rotary type
  - Rotary gear
  - Rotary vane



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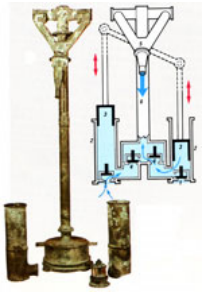
Piston Pump Operation

1. A piston moves back and forth inside a cylinder.
2. The action compresses and expels air in the pump.
3. Atmospheric pressure forces water into pump.
4. Once pump is primed, each discharge of water draws an equal amount into the pump.

- Piston Pump Capacity Factors

1. Size of cylinder (diameter and depth)
2. Number of strokes per minute



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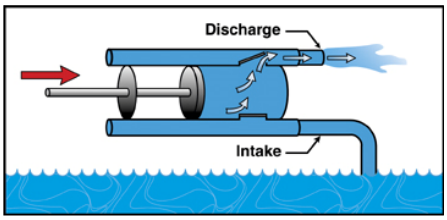
Piston Pump Operation

- Single-acting piston pump: water discharge at one end of piston stroke



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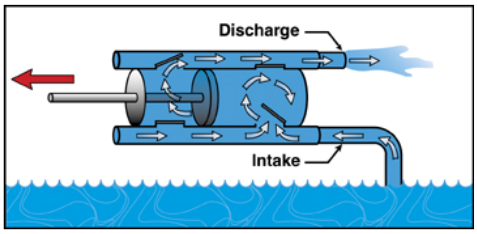
Piston Pump Operation

- Double-acting piston pump: water discharge at both ends of stroke



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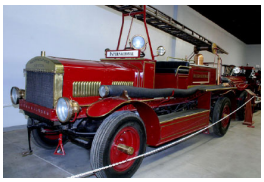
Fire Service Piston Pumps As Primary Pumps

- Primarily used on Ahrens-Fox apparatus
- Phased out of construction in the 1940s
- Were double-acting, multi-cylinder pumps



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Fire Service Piston Pumps As High-pressure Pumps

- Manufactured by John Bean in 1960s and 1970s
- High-pressure, low-volume pumps
- Capable of 1,000 psi at 15 gpm

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Rotary Pumps

- Simplest design of all fire service pumps
- Few ever used for primary fire pumps
- Rotary primer pumps on almost all modern apparatus
- Two types: rotary gear and rotary vane

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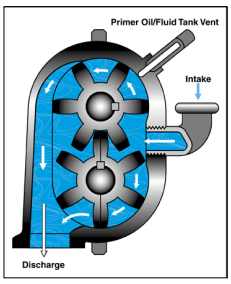
Rotary Gear Pumps



- Rotary gear pumps consist of two tightly meshed gears that rotate inside a watertight case.
- Teeth contact each other and come in close proximity to the case.
- Gears form watertight and airtight pockets within the case as they rotate away from the intake and toward the outlet.

Rotary Gear Pump Capacity Factors

1. Size of pocket
2. Speed that gears are turning

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Rotary Gear Pump Limitations

- Gears susceptible to wear from sand and debris
- Made of soft metals to reduce damage to pump casing
- Gear may have to be replaced when worn

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Rotary Vane Pumps

- A rotor is mounted off-center inside the pump casing.
- The distance between the rotor and the casing is much greater at the intake area than at the discharge area.
- The rotor is equipped with a series of vanes that are free to move within the slot where they are mounted.

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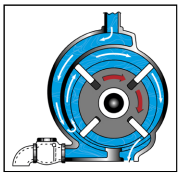
Rotary Vane Pumps



Rotary Vane Pump

1. As the rotor turns, centrifugal force forces the vanes outward against the casing.
2. Air is trapped between the rotor and the casing in the pockets between adjacent vanes.
3. As the vanes turn, these pockets become smaller, which compresses the air and builds pressure.
4. Pressure is maximized at pump discharge.
5. Close spacing of the rotor at the discharge prevents the air or water from returning to the intake side.
6. Capacity depends on pocket size between the rotors and rotor speed.
7. Once air is removed from pump a partial vacuum is created.
8. Atmospheric pressure forces water into pump.

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Centrifugal Fire Pumps

- The primary fire pump on all modern fire apparatus
- Considered a nonpositive displacement pump
- Imparts velocity to the water and then converts that velocity to pressure within the pump casing

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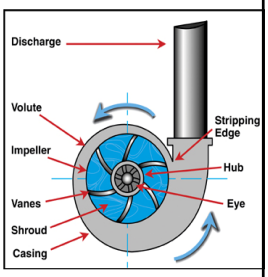
Construction And Operation Of Centrifugal Pumps

1. Inside the pump casing are one or more disks called impellers.
2. Water enters the pump at the center of the casing and through the impeller eye.
3. Rapidly revolving impellers throw the water toward the outer edge of the impeller.
4. The faster the impeller turns, the more velocity it imparts to the water.
5. The pump casing confines the water, converting its velocity to pressure.



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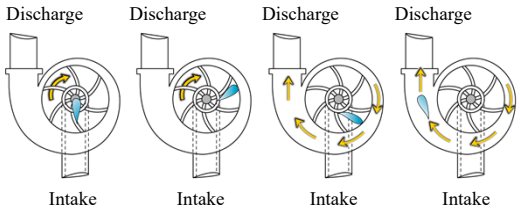
Centrifugal Pump Configuration



The route of water through a centrifugal pump.

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Factors Affecting The Capacity Of A Centrifugal Pump

- The speed of the impeller impacts the amount of pressure developed (the faster it spins, the more pressure is developed).
- The volume is impacted by the size of the eye of the impeller (the larger the eye, the greater the volume).

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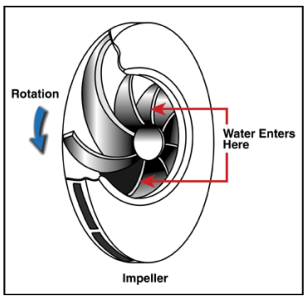
Factors Affecting The Capacity Of A Centrifugal Pump



The impeller is mounted off-center in the casing. The water passage (the volute) gradually increases in cross-sectional area as it nears the pump's discharge outlet.
The gradually increasing size of the waterway enables the pressure to build proportionately.

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Three factors on Discharge Pressure

- Amount of water being discharged
- Speed at which the impeller is turning
- Pressure on water when it enters the pump from a pressurized source (hydrant, relay, etc.)

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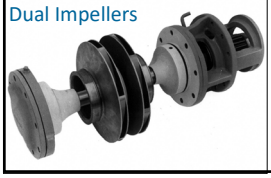
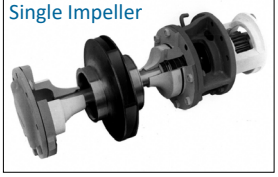
Centrifugal Fire Pump Limitations

- Will not pump air (not self-priming)
- Requires a separate priming pump to remove air before it will pump from a static source

Dual Impellers



Single Impeller



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Factors Affecting Pump Mounting/Drive Arrangement

- Cost
- Appearance
- Space required
- Ease of maintenance
- Tradition

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Fire Pumps Outlet

GPM RATING	OUTLET DIAMETER (INCHES)
• 500	• 3, 4, and 5
• 750	• 4 and 5
• 1000	• 5 and 6
• 1500	• 5, 6, and 8
• 2000	• 6 and 8

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Fire Pumps

- Types of Fire Pumps
  - Horizontal Split-Case Pump
  - Vertically Mounted Split-Case Pump
  - Vertical-Shaft Turbine Pump
- Types of Drivers
  - Electric Motors
  - Diesel Engines
  - Steam Turbine

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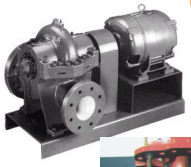
Horizontal Split-case pumps



- Centrifugal pump
- Casing can be split
- Water can be supplied under pressure
- Usually 500 gpm or larger
- Common sizes
  - 500, 750, 1000, 1500 gpm
- Pressure ratings 40 psi to 290 psi
- Same parts as fire apparatus pump
- Power supply can vary
  - electric, diesel, steam, etc.

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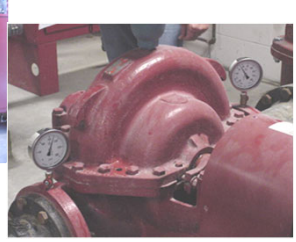
Horizontal Split Case



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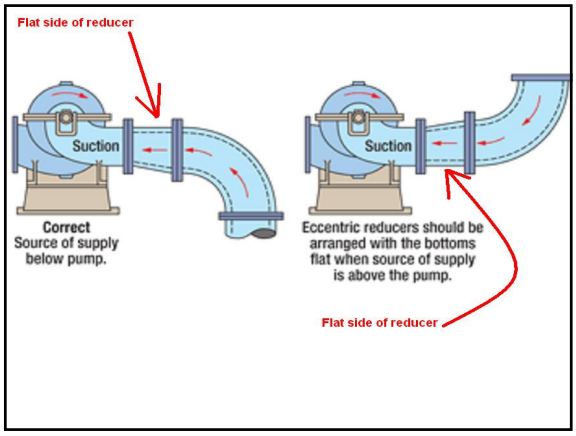

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Diesel Drive - Horizontal Split Case Fire Pump

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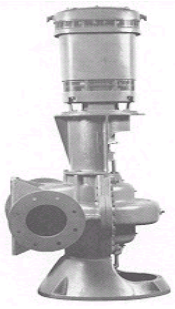
Vertically Mounted Splitcase pump

- Same principles as horizontal
- Saves floor space



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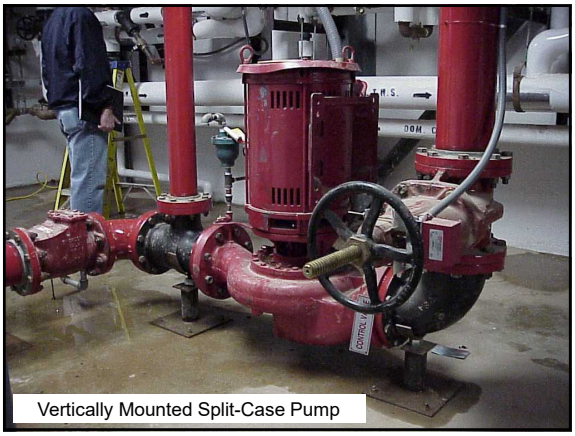
Vertically Mounted Split-Case Pump

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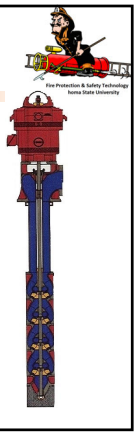
Vertical-shaft turbine pump

- Designed to pump water from wells
- Water is from non-pressurized source
- Don't require priming due to placement of impellers in water
- Increase pressure by adding impellers



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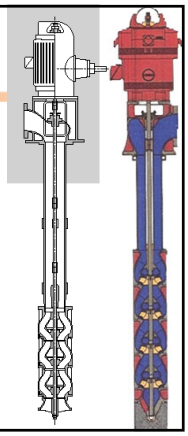
Vertical-shaft turbine pump

- Driven by:
  - –Electric, steam, Diesel
- Sizes:
  - –250 to 5,000 gpm
- Pressures:
  - –40 psi to 500 psi



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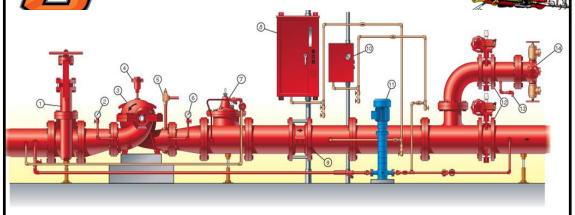
Electric-driven pump



1. Isolation Gate Valve (suction)
2. Compound Suction Gauge
3. Horizontal Split Case Fire Pump, Electric Motor Driven
4. Automatic Air Release Valve
5. Casing Relief Valve
6. Discharge Pressure Gauge
7. Low Suction Pressure Shutoff Valve
8. FIRE PUMP CONTROLLER
9. SYSTEM CHECK VALVE
10. JOCKEY PUMP CONTROLLER
11. JOCKEY PUMP
12. ISOLATION VALVES
13. Ball Drip Valve
14. Test Valve Manifold with Hose Valves, Caps & Chains

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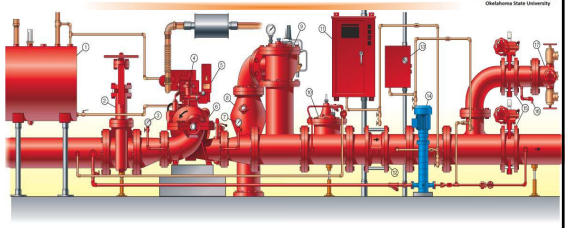
Diesel-driven pump



1. Fuel Tank, Diesel Engine
2. Isolation Gate Valve (suction)
3. Compound Suction Gauge
4. Automatic Air Release Valve
5. Diesel Engine Drive
6. Horizontal Split Case Fire Pump
7. Discharge Pressure Gauge
8. Enclosed Waste Cone with Sight Glasses
9. Main Relief Valve
10. Low Suction Pressure Shutoff Valve
11. Fire Pump Controller
12. System Check Valve
13. Jockey Pump Controller
14. Jockey Pump
15. Isolation Valves
16. Ball Drip Valve
17. Test Valve Manifold with Hose Valves, Caps & Chains

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Summary

- The earliest fire service pumps were manually operated, positive displacement pumps.
- Next came mechanically operated positive displacement pumps of the piston or rotary gear/vane design.
- Modern fire service pumps are of the centrifugal design.
- Modern pumps require a wide variety of other equipment including primers, pressure control devices, gauges, valves, and other devices.

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