

Basic Pump Operations

Presented by
The Alabama Fire College

This course is a sixteen (16) hour non-certification course intended to give firefighting personnel the basic understanding of fire department pump operations. The material referenced can be found in **IFSTA *Pumping Apparatus Driver/Operator Handbook, 2nd Edition*** and while the textbook is not required, students are encouraged to utilize the text, and instructors should have it on hand for reference. During the course, instructors should take adequate time to ensure understanding of the basic pumping skills and at the completion, should ensure each student completes the skills listed on the **Basic Pump Skills Competency** form.

Basic Pump Operations

Instructor's Manual

Water and Pressure

Lesson 1

PRESENTATION OUTLINE**VISUALS/NOTES****Characteristics of Water**

- A. Water is a compound (molecule) of hydrogen and oxygen formed when two hydrogen atoms (H_2) combine with one oxygen atom (O).
- B. Between 32°F and 212°F (0°C and 100°C), water exists in a liquid state.
- C. Below 32°F (0°C) (the freezing point of water), water converts to a solid state of matter called ice.
- D. Above 212°F (100°C) (the boiling point of water), water converts into a gas called water vapor or steam; it cannot be seen in this vapor form.

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Characteristics of Water

- E. Water is considered to be incompressible, and its weight varies at different temperatures.

Note: Water is measured in pounds per cubic foot (kg/L)

- 1. Water is heaviest close to its freezing point — approximately 62.4 lb/ft³ (1 kg/L)
- 2. Water is lightest close to its boiling point — approximately 60 lb/ft³ (0.96 kg/L)
- 3. For fire protection purposes, ordinary fresh water is generally considered to weigh 62.5 lb/ft³ or 8.33 lb/gal (1 kg/L)

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Characteristics of Water

Surface Area of Water

- A. The speed with which water absorbs heat increases in proportion to the water surface exposed to the heat.
- B. Water expands when converted to steam. At 212°F (100 °C), water expands approximately 1,700 times its original volume.
- C. Steam expansion is rapid inside a burning building. The use of a fog stream in a direct or combination fire attack requires that adequate ventilation be provided ahead of the hoseline.

Slides 5 – 9
Surface Area of Water

Advantages of water

- 1. Water has a greater heat-absorbing capacity than other common extinguishing agents.
- 2. A relatively large amount of heat is required to change water into steam. This means that more heat is absorbed from the fire.
- 3. The greater the surface area of water exposed, the more rapidly heat is absorbed. The exposed surface area of water can be expanded by using fog streams or deflecting solid streams off objects.
- 4. Water converted into steam occupies 1,700 times its original volume.
- 5. Water is plentiful, relatively inexpensive, and readily available in most jurisdictions.

Slide 8
Advantages of Water as an Extinguishing Agent

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Advantages of Water as an Extinguishing Agent

Disadvantages of water

- 1. Water has a high surface tension and does not readily soak into dense materials. However, when wetting agents are mixed with water, the water's surface tension is reduced and its penetrating ability is increased.
- 2. Water may be reactive with certain fuels such as combustible metals.
- 3. Water has low levels of opacity and reflectivity that allow radiant heat to easily pass through it.
- 4. Water freezes at 32°F (0°C), which is a problem in jurisdictions that frequently experience freezing atmospheric conditions. Freezing water poses a hazard to firefighters by coating equipment, roofs, ladders, and other surfaces. In addition, ice forming in and on equipment may cause it to malfunction.
- 5. Water readily conducts electricity, which can be hazardous to firefighters working around energized electrical equipment.

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Disadvantages of Water as an Extinguishing Agent

Principles of Fluid Pressure

- A. Pressure — Force per unit area; may be expressed in pounds per square foot (psf), pounds per square inch (psi), or kilopascals (kPa).
- B. Force — A simple measure of weight; is usually expressed in pounds or kilograms
 - 1. Determining force (customary system)
 - a. The weight of 1 cubic foot of water is approximately 62.5 pounds.
 - b. Because 1 square foot contains 144 square inches, the weight of water in a 1-square-inch column of water 1 foot high equals 62.5 pounds divided by 144 square inches, or 0.434 pounds.
 - c. A 1-square-inch column of water 1 foot high therefore exerts a pressure at its base of 0.434 psi.
 - d. The height required for a 1-square-inch column of water to produce 1 psi at its base equals 1 foot divided by 0.434 psi/ft; therefore, 2.304 feet of water column exerts a pressure of 1 psi at its base.

Principles of Fluid Pressure

- A. First Principle — Fluid pressure is perpendicular to any surface on which it acts.
- B. Second Principle — Fluid pressure at a point in a fluid at rest is the same intensity in all directions.
- C. Third Principle — Pressure applied to a confined fluid from without is transmitted equally in all directions.
- D. Fourth Principle — The pressure of a liquid in an open vessel is proportional to its depth.
- E. Fifth Principle — The pressure of a liquid in an open vessel is proportional to the density of the liquid.
- F. Sixth Principle — The pressure of a liquid on the bottom of a vessel is independent of the shape of the vessel.

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Principles of Fluid Pressure

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Principles of Fluid Pressure

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Principles of Fluid Pressure

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Principles of Fluid Pressure

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Principles of Fluid Pressure

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Principles of Fluid Pressure

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Principles of Fluid Pressure

Terms Associated with Pressure

- A. Atmospheric pressure — Pressure exerted by the atmosphere at sea level (14.7 psi [101 kPa])
- B. psig — Pounds per square inch gauge; actual atmospheric pressure = gauge reading
- C. psia — Pounds per square inch absolute; the psi above a perfect vacuum, absolute zero
- D. Vacuum — Any pressure less than atmospheric pressure
- E. Perfect vacuum — Absolute zero pressure
- F. Negative pressure — Gauge readings of less than 0 psi or kPa
Note: The term negative pressure is technically a misnomer.
- G. Head— The height of a water supply above the discharge orifice
- H. Head pressure — The result of dividing the number of feet that the water supply is above the discharge orifice by 2.304.
- I. Static pressure — Stored potential energy available to force water through pipe, fittings, fire hose, and adapters
- J. Static — At rest or without motion
- K. Normal operating pressure — That pressure found in a water distribution system during normal consumption demands
- L. Residual pressure — That part of the total available pressure not used to overcome friction loss or gravity while forcing water through pipe, fittings, fire hose, and adapters
- M. Residual — A remainder or that which is left
- N. Flow pressure (velocity pressure) — That forward velocity pressure at a discharge opening while water is flowing
- O. Elevation — The center line of the pump or the bottom of a static water supply source above or below ground level

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Terms Associated with
Pressure

- P. Altitude — The position of an object above or below sea level
- Q. Pressure loss — What occurs when a nozzle is above the pump
- R. Pressure gain — What occurs when a nozzle is below the pump
- S. Elevation pressure — Another term for both pressure loss and pressure gain
- T. Friction loss — That part of the total pressure lost while forcing water through pipe, fittings, fire hose, and adapters

Causes of friction loss in fire hose

- A. Movement of water molecules against each other
- B. Linings in fire hose
- C. Couplings
- D. Sharp bends
- E. Change in hose size or orifice by adapters
- F. Improper gasket size

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Causes of Friction
Loss in Fire Hose**

Causes of friction loss in piping systems

- A. Movement of water molecules against each other
- B. Inside surface of the piping
 - 1. The rougher the inner surface of the pipe, the more friction loss that occurs
- C. Pipe fittings
- D. Bends
- E. Control valves

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Causes of Friction
Loss in Piping System**

Principles of friction loss

- A. First Principle — If all other conditions are the same, friction loss varies directly with the length of the hose or pipe.
- B. Second Principle — When hoses are the same size, friction loss varies approximately with the square of the increase in the velocity of the flow.
- C. Third Principle — For the same discharge, friction loss varies inversely as the fifth power of the diameter of the hose.
- D. Fourth Principle — For a given flow velocity, friction loss is approximately the same, regardless of the pressure on the water.

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Principles of Friction Loss

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Principles of Friction Loss

Slide 32
Principles of Friction Loss

Factors affecting friction loss

- A. Water is practically incompressible (a pressure of 30,000 psi [210 000 kPa] is required to reduce its volume one percent). The same volume of water supplied into a fire hose under pressure at one end will be discharged at the other end.
- B. Friction loss in a system increases as the length of hose or piping increases.
- C. Flow pressure will always be greatest near the supply source and lowest at the farthest point in the system.
- D. When the valve on the nozzle end of a hose is opened, water flows moderately at a low pressure. If the opening is made directly at the hydrant, the flow will be much greater at a higher pressure.
- E. Decreasing the amount of water flowing through a hose reduces the speed of the water in the hose; consequently, there is less friction loss.
- F. If velocity is increased beyond practical limits, the friction becomes so great that resistance agitates the entire stream, creating critical velocity. Beyond this point, it becomes necessary to parallel or siamese hoselines to increase the flow and reduce friction.

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Other Factors Affecting Friction Loss

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Other Factors Affecting Friction Loss

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Other Factors Affecting Friction Loss

Ways to reduce friction loss

- A. Minimize sharp bends or kinks in the hose by using proper hose handling techniques.
- B. Reduce the length of the hose or increase its diameter.

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Ways to Reduce Friction Loss

Facts about water hammer

- A. Suddenly stopping water moving through a hose or pipe results in an energy surge being transmitted in the opposite direction, often at many times the original pressure. This surge is referred to as water hammer.
- B. Where large volumes of water are involved, such as in large diameter hose layouts, water hammer is especially critical and can damage the pump, appliances, hose, or the municipal water system itself.
- C. Whenever water is flowing, always close nozzles, hydrants, valves, and hose clamps slowly to prevent water hammer.
- D. Equip apparatus inlets and remote outlets with pressure relief devices to prevent damage to equipment.
- E. High-volume systems should be protected with dump valves.

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Water Hammer

Primary components of a municipal water system

- A. Four primary components of a municipal water system
 - 1. Source of water supply
 - 2. Means of moving water
 - 3. Water processing or treatment facilities
 - 4. Water distribution system, including storage
- B. Source of water supply
 - 1. The primary water supply can be obtained from either surface water or groundwater.
 - 2. Although most water systems are supplied from only one source, there are instances where both sources are used.
- C. Means of moving water
 - 1. Direct pumping system
 - a. Uses one or more pumps that take water from the primary source and discharge it through the filtration and treatment processes

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Primary Components of
Municipal Water Systems

Slide 41
Source of Water Supply

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Means of Moving Water

- b. Includes a series of pumps that then forces the water into the distribution system
- 2. Gravity system
 - a. Uses a primary water source located at a higher elevation than the distribution system
 - b. Works best when the primary water source is located at least several hundred feet (meters) higher than the highest point in the water distribution system
- 3. Combination system
 - a. Is a combination of a direct pumping system and a gravity system
 - b. Includes elevated storage tanks to supply the gravity flow

A. Water distribution system, including storage

- 1. The distribution system is the part that receives the water from the pumping station and delivers it throughout the area served.
- 2. The ability of a water system to deliver an adequate quantity of water relies upon the carrying capacity of the systems network of pipes.
- 3. When water flows through pipes, its movement causes friction that results in a reduction of pressure. There is much less pressure loss in a water distribution system when fire hydrants are supplied from two or more directions.
 - a. A fire hydrant that receives water from only one direction is known as a dead-end hydrant.
 - b. A fire hydrant that receives water from two or more directions is called a circulating feed or a looped line.
- 4. A distribution system that provides circulating feed from several mains constitutes a grid system, consisting of the following components:
 - a. Primary feeders — Large pipes, (mains) with relatively widespread spacing, that convey large quantities of water to various points of the system for local distribution to the smaller mains
 - b. Secondary feeders — Network of intermediate-sized pipes that reinforce the grid within the various loops of the primary feeder system and aid the concentration of the required fire flow at any point
 - c. Distributors — Grid arrangement of smaller mains serving individual fire hydrants and blocks of consumers
- 5. To ensure sufficient water, two or more primary feeders

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Water Distribution System,
Including Storage

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Water Distribution System,
Including Storage

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Water Distribution System,
Including Storage

Slides 48 – 52
Water Distribution System,
Including Storage

should run from the source of supply to the high-risk and industrial districts of the community by separate routes.

6. In residential areas, the recommended size for fire hydrant supply mains is at least 6 inches (150 mm) in diameter. These should be closely gridded by 8-inch (200 mm) cross-connecting mains at intervals of not more than 600 feet (180 m).
7. In the business and industrial districts, the minimum recommended size is an 8-inch (200 mm) main with cross-connecting mains every 600 feet (180 m)
8. Twelve-inch (300 mm) mains may be used on principal streets and in long mains not cross-connected at frequent intervals.

Private water supply systems

- A. Private water supply systems are most commonly found on large commercial, industrial, or institutional properties, but may also be found in some residential developments.
- B. Private water supply systems may service one large building or a series of buildings on the complex.
- C. Purposes
 1. To provide water strictly for fire protection purposes
 2. To provide water for sanitary and fire protection purposes
 3. To provide for fire protection and manufacturing processes
- D. The design of private water supply systems is typically similar to that of municipal systems.
- E. Most private water supply systems separate piping for fire protection and domestic/industrial services. This has a number of advantages:
 1. The property owner has control over the water supply source.
 2. Either of the systems are unaffected by service interruptions to the other system.

Slide 53 Private Water Supply Systems

Summary

- A. All pumping apparatus driver/operators should understand the properties of water as a fire extinguishing agent, know the factors that influence its delivery during a pumping operation, and be thoroughly familiar with the operation of the apparatus to which they are assigned.
- B. Fire department personnel must also be familiar with the design and reliability of both public and private water supply systems in their jurisdiction.
- C. Large, well-maintained systems may provide a reliable source of water for fire protection purposes. Small capacity, poorly maintained, or otherwise unreliable private water supply systems should not be relied upon to provide all the water necessary for adequate fire fighting operations.

**Slide 54
Summary**

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Summary**

**Slide 56
Summary**

Basic Pump Operations

Instructor's Manual

Fire Hose, Nozzles, and Flow Rates

Lesson 2

PRESENTATION OUTLINE

VISUALS/NOTES

Fire streams

- A. A fire stream is a stream of water or other extinguishing agent after it leaves a nozzle until it reaches the desired point.
- B. During the time the stream of water or extinguishing agent passes through space, it is influenced by:
 - 1. Velocity
 - 2. Gravity
 - 3. Wind
 - 4. Friction with the air
 - 5. Operating pressures
 - 6. Nozzle design
 - 7. Nozzle adjustment
 - 8. Condition of the nozzle orifice
- C. The type of fire stream that is applied to a fire depends on the type of nozzle being used. Each type of nozzle has its own optimum flow rate and discharge pressure, which affects the hydraulic calculations that must be performed by the driver/operator. Driver/Operators must understand the capabilities of each type of nozzle in order to provide the appropriate pressure and volume of water.

Slide 2
Fire Stream

Slide 3
Fire Stream

Solid stream nozzles

- A. Are designed to produce a stream as compact as possible with little shower or spray
- B. Have the ability to reach areas that other streams might not reach
- C. May be used on handlines, portable or apparatus-mounted master streams, or elevated master streams
- D. Are designed so that the shape of the water in the nozzle is gradually reduced until it reaches a point a short distance from the outlet; at this point, the nozzle becomes a cylindrical bore whose length is from one to one and one-half times its diameter
- E. Have a smooth-finish waterway that contributes to both the shape and reach of the stream
Note: Alteration or damage to the nozzle can significantly alter stream shape and performance
- F. Nozzle pressure and the size of the discharge opening determine the flow and stream reach.
- G. Should be operated at 50 psi (350 kPa) on handlines
- H. Should be operated at 80 psi (560 kPa) on master stream devices

**Slide 4
Solid Stream Nozzles****Slide 5
Solid Stream Nozzles****Equation for determining the flow from a solid stream nozzle.**

- A. Customary
$$\text{GPM} = 29.7 \times d^2 \times \sqrt{\text{NP}}$$

GPM = Discharge in gallons per minute
29.7 = A constant
d = Diameter of the orifice in inches
NP = Nozzle pressure in psi

**Slide 6
Determining Flow from a Solid
Stream Nozzle**

Fog stream nozzles

A. Fog stream terms

1. Periphery — The line bounding a rounded surface; the outward boundary of an object distinguished from its internal regions
2. Deflection — A turning or state of being turned; a turning from a straight line or given course; a bending; a deviation
3. Impinge — To strike or dash about or against; clashing with a sharp collision; to come together with force

Slide 7 Fog Streams

B. A fog stream may be produced by deflection at the periphery or by impinging jets of water or by a combination of these.

1. Periphery-deflected streams
 - a. Are produced by deflecting water from the periphery of an inside circular stem in a periphery-deflected fog nozzle. This water is again deflected by the exterior barrel.
 - c. Shape is determined by the relative positions of the deflecting stem and the exterior barrel.
2. Impinging stream nozzle
 - a. Drives several jets of water together at a set angle to break the water into finely divided particles
 - b. Usually produces a wide-angle fog pattern, but a narrow pattern is possible.

C. The reach of a fog stream is directly dependent on

1. The width of the stream
2. The size of the water droplets
3. Wind
4. The amount of water flowing

Slide 8 Reach of a Fog Stream

D. When water is discharged at angles to the direct line of discharge, the reaction forces largely balance each other, thus reducing nozzle reaction. This balancing of forces is the reason why fog patterns are easier to handle than solid or stream patterns.

E. Types

1. Constant flow nozzles
 - a. Are designed to flow a specific amount of water at a specific nozzle discharge pressure on all stream patterns
 - b. Utilize a periphery-deflected stream

Slide 9 Constant Flow Nozzles

- c. Discharge the same volume of water regardless of the pattern setting
 - d. Are intended to be operated at a nozzle pressure of 100 psi (700 kPa)
 - e. Some may operate at 50 to 75 psi (350 kPa to 525 kPa) for special applications such as high-rise fire fighting
2. Manually adjustable nozzles
- a. Have a number of constant flow settings, enabling the firefighter to select a flow rate that best suits the existing conditions
 - b. Supply the selected flow at the rated nozzle discharge pressure; actual flow will differ if proper pressure cannot be supplied
 - c. Are designed to supply the gallonage marked on each setting at a nozzle pressure of 100 psi (700 kPa)

CAUTION! Take care when adjusting flow settings. Nozzles that are set on a low flow may not provide the volume of water needed to sufficiently cool a burning fuel. The minimum flow setting for interior structural firefighting is 95 to 100 gpm (380 L/min to 400 L/min)

3. Automatic nozzles
- a. Are the most common variable flow nozzles in use today
 - b. Are also referred to as constant pressure nozzles or multipurpose nozzles
 - c. Are basically variable flow nozzles with pattern-change capabilities and the ability to maintain the same nozzle pressure
 - d. Maintain approximately the same nozzle pressure and pattern if the gallonage supplied to the nozzle changes
 - e. Can have a stream that appears adequate, but may not be supplying sufficient water for extinguishment or protection; it should be the goal of the driver/operator to provide an acceptable flow of water at the discharge pressure for which the nozzle is designed
 - f. Most are designed for a 100 psi (700 kPa) discharge pressure; some may be designed for lower pressures such as 50 to 75 psi (350 kPa to 525 kPa)

CAUTION! Make sure that adequate pump discharge pressures are used to supply hoselines equipped with automatic nozzles. Nozzles receiving inadequate pressures may not provide the volume of water needed to sufficiently cool a burning fuel even though the stream appears adequate.

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Constant Flow Nozzles

Slide 11
Manually Adjustable Nozzles

Slides 12
Automatic Nozzles

Slide 13
Automatic Nozzles

Slide 14
Automatic Nozzles

Slide 15
Automatic Nozzles

- g. Serve as a pressure regulator for the pumper as lines are added or shut down, ensuring that all available water may be used continuously
- h. Maintain a constant nozzle pressure of approximately 100 psi (700 kPa), no matter how much the pump discharge pressure is above this figure
- i. Enlarge opening size automatically as pump discharge pressure is increased

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Automatic Nozzles

Handline nozzles

- A. Are designed to be placed on attack lines that can be easily maneuvered by firefighters
- B. May be of the solid, fog, impinging, or broken stream type
- C. Range in size from small booster line nozzles for ¾-inch (19 mm) booster line to large fog or solid stream nozzles that are designed to be placed on the end of a 3-inch (77 mm) hoseline
- D. Can flow a maximum of 350 gpm (1 400 L/min) safely; flows greater than 350 gpm (1 400 L/min) produce nozzle reactions that make the hoselines difficult and dangerous for firefighters to handle

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Handline Nozzles

Slide 18
Handline Nozzles

Master stream nozzles and the four basic categories.

Master stream nozzles

- A. Include any fire stream that is too large to be controlled without mechanical aid
- B. Are powerful and generate a considerable amount of nozzle reaction force; it is extremely important that firefighters take proper safety precautions
- C. May be either solid or fog streams; both utilize a nozzle of sufficient size to deliver the higher flows
- D. Are the "big gun" of the fire department
- E. Are usually operated at 80 psi (560 kPa) (smoothbore) and 100 psi (700 kPa) (fog)

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Master Stream Nozzles

Slide 20
Master Stream Nozzles

F. Flow 350 gpm (1 400 L/min) or greater

G. Are used when:

1. Handlines would be ineffective
2. Conditions are unsafe
3. Manpower is limited

H. Are used from fixed positions, so most have some means for moving the stream in either a vertical or horizontal plane, or both

1. To permit such adjustments, the water must pass through one or more sharp bends
2. On some larger master stream devices, there are two bends that form a loop in the shape of a ram's horns.
3. Some other master stream devices have a single bent-pipe waterway.

I. Friction loss varies from device to device – each department must determine the friction loss in the devices it has available, either by flow test or manufacturer's documentation

Note: Refer to Appendix C for the procedure for determining friction loss in master stream devices.

J. Monitors

1. Are often incorrectly referred to as deluge sets, but they differ in one important way: with a monitor, the stream direction and angle can be changed while water is being discharged
2. Types
 - a. Fixed (sometimes called a deck gun or turret) — Is permanently mounted on the apparatus
 - b. Combination — Is mounted on the apparatus, but can be used there as a turret or removed and used as a portable monitor
 - c. Portable — Can be carried to the location where it is needed

K. Turret pipe

1. Is mounted on a fire apparatus deck and is connected directly to the pump by permanent piping
2. Is also sometimes called a deck gun or deck pipe
3. Is supplied by permanent piping from the pump

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Master Stream Nozzles

Slide 22
Monitors

Slide 23
Monitors

Slides 24
Turret Pipe

L. Deluge set

1. Consists of a short length of large diameter hose with a large nozzle or large playpipe supported at the discharge end by a tripod
2. Has a siamese connection at the supply end
3. Cannot have direction and angle of the stream changed while discharging water

**Slides 25
Deluge Set**

M. Elevated master streams

1. Are large-capacity nozzles that are designed to be placed on the end of an aerial device
2. May be permanently attached to elevating platforms and preplumbed aerial ladders or may be detachable
3. Ladder pipes
 - a. Are a master stream device used in conjunction with aerial ladders
 - b. Are attached to the rungs of an aerial ladder and are supplied by fire hose (usually 3-inch [77 mm] hose)
 - c. Can be operated manually by a firefighter at the tip of the ladder or by using a rope from the ground, although some departments choose to control them only from the ground to avoid putting a firefighter in jeopardy on the ladder
CAUTION! Ladder pipes should be controlled from the ground to avoid putting a firefighter in jeopardy on the ladder.
 - d. Movement is limited to vertical up-and-down motions; horizontal movement of the nozzle would place dangerous stress on the aerial ladder. If the nozzle direction needs to be changed horizontally, the entire ladder must be redirected.
4. Have preplumbed waterways instead of hose, as do some aerial ladders and all aerial platforms. These preplumbed waterways:
 - a. Generally have the ladder pipe attached to the end of the waterway, which is on the underside of the ladder
 - b. May be operated from the top either manually or by a power control switch located there
 - c. Can usually be operated from the turntable or pump panel area by remote power controls
 - d. May be operated by electric, hydraulic, or pneumatic power system
5. May be used with elevating platforms
 - a. Are basically similar to those with preplumbed aerial

**Slide 26
Elevated Master Streams**

**Slide 27
Ladder Pipes**

ladders

- b. Are different from preplumbed aerial ladders in that they are located on the aerial platform and can be more easily maneuvered by firefighters at the tip of the aerial device
- c. Some are equipped with two master streams on one platform, giving added flexibility during large-scale fire operations

Special purpose nozzles

A. Most special purpose nozzles are broken stream nozzles.

- 1. These differ from fog stream nozzles in that fog streams use deflection or impinging streams to create a fog pattern, while broken streams are created when water is forced through a series of small holes on the discharge end of the nozzle.
- 2. In general, broken streams produce larger droplets of water than do fog streams, giving broken streams better reach and penetrating power

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Special Purpose Nozzles

B. Cellar nozzles

- 1. Are also called distributors
- 2. Are often used on basement fires
- 3. Can be lowered through holes cut in the floor or through some other suitable opening
- 4. May or may not be equipped with shutoffs; if not, an in-line shutoff valve should be placed at a convenient location back from the nozzle
- 5. May also be used to attack attic fires – the nozzle is pushed through a hole in the ceiling to attack the fire above

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Cellar Nozzles

C. Water curtain nozzles

- 1. Are decreasing in use
- 2. Produce a fan-shaped stream intended to protect combustible materials from the heat of an adjacent fire
- 3. May be used to protect firefighters from heat
- 4. Must cover a wide area and be reasonably heavy to be effective
- 5. Are only effective in absorbing convected heat from a fire; radiant heat penetrates the water curtain

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Water Curtain Nozzles

Slide 32
Water Curtain Nozzles

Note: A water curtain between the fire and combustible

material is not as effective as the same amount of water flowing over the surface of the combustible material. It is better to direct fire streams onto exposed surfaces. This may be accomplished by allowing the water to rain down on the exposure being protected.

D. Piercing nozzles

1. Are also called penetrating nozzles
2. Are commonly used in aircraft fire fighting and to apply water to areas that are otherwise inaccessible to water streams, such as voids or attics below lightweight roof systems
3. May be used to deliver aqueous film forming foam (AFFF) to a confined area
4. Are generally a 3- to 6-foot (1 m to 2 m) hollow steel rod 1½-inches (38 mm) in diameter
5. Have a discharge end that is a hardened steel point suitable for driving through concrete block or other types of wall or partition assemblies; built into that point is an impinging jet nozzle capable of delivering about 100 gpm (400 L/min) of water at standard operating pressure
6. Have a driving end opposite the pointed end; this end is driven with a sledgehammer to force the point through an obstruction

Slide 33 **Piercing Nozzles**

Slide 34 **Piercing Nozzles**

E. Chimney nozzles

1. Have been developed to attack chimney flue fires
2. Are designed to be placed on the end of a booster hose
3. Are a solid piece of brass or steel with numerous, very small impinging holes
4. Generally produce only 1.5 to 3 gpm (6 L/min to 12 L/min) at a nozzle pressure of 100 psi (700 kPa)
5. Produce water in a very fine, misty fog cone
6. Process
 - a. Hose and nozzle are lowered down the entire length of the chimney and then quickly pulled out.
 - b. The mist from the nozzle immediately turns to steam and chokes the flue fire as well as loosens the soot on the inside of the chimney.
 - c. The process may damage booster hose, so it is better to use an old section of hose on the end of the regular section of hose.

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Slide 36 **Chimney Nozzles**

Nozzle reaction

A. Nozzle reaction

1. Is the force pushing back on firefighters as water is discharged from a nozzle at a given pressure?
2. Illustrates Newton's Third Law of Motion – For every action, there is an equal and opposite reaction
3. Forces firefighters to limit the amount of nozzle pressure that can be supplied to an attack line
4. Can cause serious injury to firefighters due to nozzles violently whipping around from excess nozzle reaction

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Nozzle Reaction

B. Practical working limits for velocity of fire streams

1. Are within 60 to 120 feet per second (18.3 m to 36.6 m per second)
2. Are produced by nozzle pressures that range from 25 to 100 psi (175 kPa to 700 kPa)
3. Fog nozzles
 - a. Are designed to operate at a nozzle pressure of 100 psi (700 kPa)
 - b. Become difficult to handle above this pressure
4. Solid stream handlines
 - a. Are usually designed to operate at 50 psi (350 kPa) when equipped with up to 1½-inch (38 mm) nozzles
 - b. May be raised to 65 psi (455 kPa) without becoming unmanageable; above this point, become increasingly difficult to handle
5. Portable master stream devices — Should not be operated above the recommended nozzle pressure unless approved by the manufacturer of the device
6. Fixed master stream devices with solid stream nozzles — May be operated at higher pressures (80 to 100 psi [560 kPa to 700 kPa]) as required
7. Solid stream nozzles used on aerial devices — Should be limited to a nozzle pressure of 80 psi (560 kPa)
8. Fog nozzles used on aerial devices — Should be limited to a nozzle pressure of 100 psi (700 kPa)

Slide 38
Practical Working Limits for Velocity of Fire Streams

Slide 39
Practical Working Limits for Velocity of Fire Streams

Slide 40
Practical Working Limits for Velocity of Fire Streams

Slide 41
Practical Working Limits for Velocity of Fire Streams

C. Determining nozzle reaction

1. Is not done at the fire scene
2. Can prove useful in other situations, such as determining hose and nozzle configurations for preconnected attack lines that will be placed on the apparatus
3. Solid stream nozzles

Slide 42
Determining Nozzle Reaction

- a. Customary

$$NR = 1.57 \times d^2 \times NP$$

NR = Nozzle reaction in pounds

1.57 = A constant

d = Nozzle diameter in inches

NP = Nozzle pressure in psi

4. Fog stream nozzles

- a. Customary

$$NR = 0.0505 \times Q \times \sqrt{NP}$$

NR = Nozzle reaction in pounds

0.0505 = A constant

Q = Total flow through the nozzle in gpm

NP = Nozzle pressure in psi

Slide 43

**Determining Nozzle Reaction
on Solid Stream Nozzles**

Slide 44

**Determining Nozzle Reaction
on Fog Stream Nozzles**

Summary

- A. Pumping apparatus driver/operators must be familiar with the different types of nozzles carried on their apparatus.
- B. Each type of nozzle has its own optimum flow rate and discharge pressure.
- C. The particular type of nozzle being used affects the hydraulic calculations that driver/operators must perform.
- D. Even though driver/operators are usually not responsible for selecting an appropriate nozzle to perform a particular evolution, they must understand the capabilities of each nozzle in order to properly support it.

**Slide 45
Summary**

**Slide 46
Summary**

Basic Pump Operations

Instructor's Manual

Theoretical Pressure Calculations

Lesson 3

PRESENTATION OUTLINE

VISUALS/NOTES

Friction loss, elevation pressure, and total pressure loss (TPL)

- A. To produce effective fire streams, it is necessary to know the amount of friction loss in the fire hose and any pressure loss or gain due to elevation.
- B. Friction loss can be caused by:
 - 1. Hose condition
 - 2. Coupling condition
 - 3. Kinks
 - 4. Volume of water flowing per minute
- C. The calculation of friction loss must take into account the length and diameter of the hoseline and any major hose appliances attached to the line. Because the amount of hose used between an engine and the nozzle is not always the same, driver/operators must be capable of determining friction loss in any given length of hose.
- D. Elevation differences, such as hills, gullies, aerial devices, or multistoried buildings, create a pressure loss or gain known as elevation pressure. The development of elevation pressure occurs anytime there is a change in elevation between the nozzle and the pump.
- E. Together, friction loss and elevation pressure loss are referred to as total pressure loss (TPL).

Slide 1
Friction Loss and
Elevation Pressure

Slide 2
Friction Loss and
Elevation Pressure

Slide 3
Friction Loss and
Elevation Pressure

Equation for determining friction loss**A. Equation A**

$$FL = CQ^2L$$

FL = Friction loss in psi

C = Friction loss coefficient (from Table 8.3)

Q = Flow rate in hundreds of gpm (flow/100)

L = Hose length in hundreds of feet (length/100)

B. Steps

1. Obtain from Table 8.3 the friction loss coefficient for the hose being used.
2. Determine the number of hundreds of gallons of water per minute flowing (Q) through the hose by using the equation $Q = \text{gpm}/100$.
3. Determine the number of hundreds of feet of hose (L) by using the equation $L = \text{feet}/100$.
4. Plug the numbers from Steps 1, 2, and 3 into Equation A to determine the total friction loss.

Slide 4**Determining Friction Loss****Slide 5****Determining Friction Loss****Slide 6****Determining Friction Loss****Determining your own friction loss coefficients**

- A. If you wish to calculate more accurate results for the fire hose that is carried on your apparatus, rather than use the results from the standard friction loss coefficients, it is recommended that you test your hose to determine the actual coefficients.
- B. In order to get results indicative of averages that can be expected on the fireground, it is necessary to use the same hose that would be used on the fireground.
- C. Departments should conduct tests on hose that is in service, not on hose that has been in storage or hose that has never been put into service (unless new hose is about to be placed into service).
- D. Departments should test only one hose type at a time.

Slide 7**Determining Your Own Friction Loss Coefficients****Appliance pressure loss**

- A. Appliances used on the fireground include reducers, increasers, gates, wyes, manifolds, aerial apparatus, and standpipe systems.

Slide 8**Appliance Pressure Loss**

- B. Appliance friction loss is insignificant in cases where the total flow through these appliances is less than 350 gpm.
- C. Above 350 gpm, friction loss varies with the size of the device and the flow.
- D. For this lesson, assume a 0 psi loss for flows less than 350 gpm and a 10 psi loss for each appliance (other than master stream devices) in a hose assembly when flowing 350 gpm or more.
- E. Friction loss caused by handline nozzles is not considered in the calculations in this lesson, as it is generally insignificant in the overall pressure loss in a hose assembly.
- F. For this lesson, assume a friction loss of 25 psi in all master stream appliances, regardless of the flow.

Slide 9
Appliance Pressure Loss

Slide 10
Appliance Pressure Loss

Elevation pressure

- A. Elevation pressure is created by elevation differences between the nozzle and the pump.
- B. Water exerts a pressure of 0.434 psi per foot of elevation. When a nozzle is operating at an elevation higher than the apparatus, this pressure is exerted back against the pump. To compensate for this pressure "loss," elevation pressure must be added to friction loss to determine total pressure loss.
- C. Operating a nozzle lower than the pump results in pressure pushing against the nozzle. This "gain" in pressure is compensated for by subtracting the elevation pressure from the total friction loss.
- D. Equation B
EP = 0.5H
EP = Elevation pressure in psi
0.5 = A constant
H = Height in feet

Slide 11
Elevation Pressure

Slides 12
Elevation Pressure

Slides 13
Elevation Pressure

Slide 14
Determining Elevation Pressure

Slides 15-17
Determining Elevation Pressure

E. It is generally easier to determine elevation pressure in a multistoried building by another method. By counting the number of stories of elevation, equation C may be used.

F. Equation C

$$\text{EP} = 5 \text{ psi} \times (\text{number of stories} - 1)$$

Hose layouts

A. The combination of friction loss and elevation pressure is referred to as total pressure loss (TPL). Pressure changes are possible due to hose friction loss, appliance friction loss (when flows exceed 350 gpm), and any pressure loss or gain due to elevation. By adding all the affecting pressure losses, the total pressure loss can be determined for any hose lay.

**Slide 18
Hose Layouts**

B. Simple hose layouts

1. Single hoseline
 - a. Is the most commonly used hose lay
2. Multiple hoselines (equal length)
3. Wyed hoselines (equal length)
4. Siamesed hoselines (equal length)

**Slide 19
Simple Hose Layouts**

D. Complex hose layouts

1. Standpipe operations
 - a. In most cases, fire departments have predetermined pressures that driver/operators are expected to pump into the fire department connection (FDC) of a standpipe system.
 - b. These pressures are contained in the department's SOPs, in the pre-incident plan for that particular property, or on a faceplate adjacent to the FDC.
 - c. In order to be able to determine the required pressure for the standpipe system, it is necessary to determine the total pressure loss. Treat the FDC like any other hose appliance.
2. Multiple hoselines (unequal length) — When unequal length hoselines are used, the amount of friction loss varies in each line. For this reason, friction loss must be calculated in each hoseline.
3. Wyed hoselines (unequal length)

**Slide 20
Standpipe**

**Slide 21
Standpipe**

**Slide 22
Standpipe**

**Slide 23
Standpipe**

4. Master streams

- a. Remember to add a 25 psi pressure loss to all calculations involving master stream devices.
- b. Determining friction loss for master streams is essentially the same as those used for other fire streams, unless unequal length or diameter hoselines are used to supply a master stream appliance.
- c. In this situation, use an average of the hose lengths for ease of calculation.
- d. Aerial devices with piped waterways are treated in the same manner as master stream appliances: using a friction loss of 25 psi to include the intake, internal piping and nozzle.

Slide 24
Master Stream

Slide 25
Master Stream

Slide 26
Master Stream

Determining pump discharge pressure

- A. In order to deliver the necessary water flow to the fire location, the pump discharge pressure at the apparatus must be enough to overcome the sum of all pressure losses.

Slide 27
Determining Pump
Discharge Pressure

B. Equation D

$$\text{PDP} = \text{NP} + \text{TPL}$$

PDP = Pump discharge pressure in psi

NP = Nozzle pressure in psi

TPL = Total pressure loss in psi (appliance, friction, and elevation losses)

Slide 28
Determining Pump
Discharge Pressure

- C. In many situations it is important that attack lines be supplied with water at somewhere near the required nozzle pressure until the driver/operator has time to calculate the correct pump discharge pressure. It is SOP in many departments for the driver/operator to initially charge attack lines with fog nozzles at 100 psi and those equipped with solid stream nozzles at 50 psi pump discharge pressure while setting up for the pump operation.

Slide 29
Determining Pump
Discharge Pressure

Equation for determining net pump discharge pressure (NPDP)

- A. Virtually all fire pumps in use today are centrifugal pumps. These pumps are able to take advantage of incoming water pressure into the pump. Thus, if a pumper is required to discharge 150 psi, and it has an intake pressure of 50 psi coming into the pump, the pump only needs to add 100 psi more to meet the demand. This concept is called net pump discharge pressure (NPDP).
- B. NPDP takes into account all factors that contribute to the amount of work the pump must do to produce a fire stream.
- C. When a pumper is being supplied by a hydrant or a supply line from another pumper, the NPDP is the difference between the pump discharge pressure and the incoming pressure from the hydrant.

D. Equation E

$$\text{NPDP}_{\text{PPS}} = \text{PDP} - \text{Intake reading}$$

NPDP_{PPS} = Net pump discharge pressure from a positive pressure source

PDP = Pump discharge pressure

Note: This equation does not apply to situations where the pumper is operating at a draft.

Slide 30
Determining Pump Discharge Pressure

Slide 31
Determining Net Pump Discharge Pressure

Slide 32
Determining Net Pump Discharge Pressure

Summary

- A. To fulfill the primary fireground function of supplying attack crews with an adequate volume of water at pressures that are both safe and effective, driver/operators must be able to make certain hydraulic calculations in the field.
- B. To do this, they must know how to factor in losses in pressure due to friction, as well as pressure losses or gains because of elevation differences.
- C. In addition, driver/operators must be able to calculate the pump pressure required to supply multiple hoselines of varying diameters, lengths, and configurations.

Slide 33
Summary

Slide 34
Summary

Basic Pump Operations

Instructor's Manual

Fire-Ground Hydraulic Calculations

Lesson 4

PRESENTATION OUTLINE

VISUALS/NOTES

Methods for determining pressure loss and required pump discharge pressure on the fireground

Slide 1
**Methods for Determining
Pressure Loss and Required
Pump Discharge Pressure**

- A. On the fireground, the driver/operator commonly relies on one or more of the following methods for determining pressure loss and required pump discharge pressure:
1. Flowmeters
 2. Hydraulic calculators
 3. Pump charts
 4. Hand method
 5. Condensed "Q" formula
 6. GPM flowing method

Flowmeters

- A. Provide the water flow in gallons per minute (liters per minute); the number displayed on the flowmeter requires no further calculation because it reflects how much water is moving through the discharge valve and consequently the nozzle
- B. Are particularly advantageous when supplying hoselines or master stream devices equipped with automatic nozzles
- C. Can make it possible for driver/operators to pump (within the limits of the pump) the correct volume of water to nozzles without having to know the length of hoseline, the amount of friction loss, or whether the nozzles are above or below the pump
- D. Are allowed (per NFPA 1901, *Standard for Automotive Fire Apparatus*) to be used instead of pressure gauges on all discharges 1½ to 3 inches (38 mm to 77 mm) in diameter
- E. Can be used on discharges that are 3½ inches or larger, but

Slide 2
Flowmeters

Slide 3
Flowmeters

Slide 4
Flowmeters

must also have an accompanying pressure gauge

F. Must provide a readout in increments no larger than 10 gpm (38 L/min)

G. Types

1. Paddlewheel

- a. Was the first type of flowmeter used on fire apparatus
- b. Is mounted in the top of a straight section of pipe in such a manner that very little of the device extends into the waterway, reducing the problems of impeded flow and damage by debris
- c. Decreases sediment deposit because the paddlewheel is located at the top of the pipe
- d. Works by measuring the speed at which the paddlewheel is spinning and translates that information into a flow measurement

**Slide 5 – 6
Flowmeters**

2. Spring probe

- a. Is gaining increasing use in the fire service
- b. Uses a stainless steel spring probe to sense water movement in the discharge piping; the greater the flow of water through the piping, the more the spring probe is forced to bend
- c. Has only one moving part (the spring probe itself), so relatively maintenance free

**Slide 7 – 8
Flowmeters**

H. Should be accurate to a tolerance of +/- 3 percent, when properly calibrated and in good working condition; the readout should not be more than 3 gallons (12 L) high or low for every 100 gpm (400 L/min) flowing

Flowmeter applications

**Slide 9
Flowmeter Applications**

A. Diagnosing waterflow problems

1. The flowmeter can be used as a diagnostic tool to identify waterflow problems.
2. If the flow does not increase when the driver/operator increases pressure, several problems are likely – kinks, a valve closed, etc.
3. If a firefighter communicates that water volume at the nozzle has suddenly diminished but there is no reduction in the flowmeter reading, it can be assumed that a hose has

**Slide 10
Diagnosing Waterflow
Problems**

burst.

B. Relay pumping

1. Use of a flowmeter during relay pumping makes it possible to feed a supply line without having to know the number of gallons (liters) flowing from the pumper receiving the water.

C. Standpipe operations

1. When pumping to standpipes, it is difficult to determine where hoselines and nozzles are being placed in a multistory building.
2. Using a flowmeter can solve this problem by determining the number and type of nozzles connected to the standpipe, adding the maximum rated flow for each nozzle flowing, and then pumping the volume of water that matches this figure.

Hydraulic calculators

- A. Enable the driver/operator to determine the pump discharge pressure required to supply a hose layout without having to perform tedious mental hydraulic calculations

Slide 11
Hydraulic Calculators

B. Types

1. Manual or mechanical — Operate by moving a slide or dial in which the water flow, size of hose, and length of the hose lay are indicated
2. Electronic
 - a. Allow the driver/operator to input the known information: the water flow, size of hose, length of hose lay, and any elevation changes
 - b. Computes the required pump discharge pressure using preprogrammed formulas from the factory or other available software
 - c. May be portable or mounted near the pump panel
 - d. Inexpensive electronic programmable calculators can be preprogrammed for fireground calculations and carried on apparatus

Slide 12
Hydraulic Calculators

Slide 13
Hydraulic Calculators

Pump charts

- A. Are used by some fire departments to reduce the need for calculations on the emergency scene

Slide 14
Pump Charts

- B. Contain the required pump discharge pressures for various

hose lays and assemblies used within that jurisdiction

C. May be placed on laminated sheets carried on the apparatus or on plates that are affixed to the pump panel

**Slide 15
Pump Charts**

D. May be developed by fire departments or supplied by fire hose or nozzle manufacturers

E. Columns

1. Nozzle column — Should include only those nozzles and devices used by the department developing the chart; also includes applications such as sprinkler system support or relay pumping operations
2. GPM (L/min) column — Indicates the flow being provided to that nozzle or layout
3. NP column — Indicates the nozzle pressure being produced
4. 100, 200, etc. (30, 60, etc.) columns — Indicate the number of feet (meters) of hose being used to supply a given nozzle or layout

**Slide 16
Pump Chart Columns**

**Slide 17
Pump Chart Columns**

Hand method

A. The hand method is used for determining friction loss in 1¾-inch and 2½-inch hose.

B. For 2½-inch hose

1. Starting with the thumb of the left hand, each finger is numbered at the base in terms of hundreds of gallons per minute.
2. Returning to the thumb, and again moving from left to right, the tip of each finger is given a successive even number, beginning with two.
3. Because nozzle capacities vary in gpm, the nearest half-hundred can be used with slight variations. The numbers 3, 5, 7, and 9 can be used for flows of 150, 250, 350, and 450 gpm, respectively. These half-hundred figures can be assigned to the spaces between the fingers.
4. The friction loss for 100 feet of 2½-inch hose at a desired flow is determined by selecting the finger to which the desired flow has been assigned, and multiplying the number at the tip of the finger by the first digit at the base of the finger.
5. The answers provided by this method give a reasonable estimate of the friction loss that can be expected in that

**Slide 18
Hand Method for
2½-Inch Hose**

**Slide 19
Hand Method for
2½-Inch Hose**

**Slide 20
Hand Method for
2½-Inch Hose**

**Slide 21
Hand Method for
2½-Inch Hose**

**Slide 22
Hand Method for**

hoseline. If more accurate figures are required, one of the other methods previously discussed in this curriculum needs to be employed.

2½-Inch Hose

C. For 1¾-inch hose

1. Calculate the friction loss in 100 feet of 1¾-inch hose by going to the finger that corresponds to the flow you are using and multiplying the number at the tip of the finger by the number at the base of the same finger.

**Slide 23
Hand Method for
1¾-Inch Hose**

Note: This method has no conversion for the metric system of measurement.

The Condensed "Q" formula

- A. Has been developed for fireground operations in which friction loss can be determined for 2 ½-, 3-, 4-, and 5-inch hose.

- B. Equation F (3-inch hose) — Can be used for 3-inch hose with either 2½-inch or 3-inch couplings

$$\text{FL per 100 feet} = Q^2$$

FL = Friction loss in 100 feet of 3-inch hose

Q = Number of hundreds of gpm

Note: The amount of friction loss calculated using this formula will be 20 percent greater than if the same situation is calculated using $FL = CQ^2L$.

**Slide 24
Determining Friction Loss
Using the Condensed "Q"
Formula**

- C. Equation G (4-inch hose)

$$\text{FL per 100 feet} = \frac{Q^2}{5}$$

FL = Friction loss in 100 feet of 4-inch hose

Q = Number of hundreds of gpm

**Slide 25
Determining Friction Loss
Using the Condensed "Q"
Formula**

- D. Equation H (5-inch hose)

$$\text{FL per 100 feet} = \frac{Q^2}{15}$$

FL = Friction loss in 100 feet of 5-inch hose

Q = Number of hundreds of gpm

**Slide 26
Determining Friction Loss
Using the Condensed "Q"
Formula**

Note: This method does not work for the metric system of measurement.

GPM flowing method

- A. Permits friction loss to be calculated from the gpm flow
- B. Is applicable to both solid and fog streams
- C. Can be used for hose sizes other than 2½-inch
- D. Method (2½-inch hose)
 - 1. Find the flow in gpm from a nozzle at a specified pressure.
 - 2. Subtract 10 from the first two numbers of the gpm flow in order to derive a sufficiently accurate friction loss figure per 100 feet of 2½-inch hose.
- E. Method (1½-inch hose)
 - 1. Find the flow in gpm from a nozzle at a specified pressure.
 - 2. Multiply the flow times four.
 - 3. Subtract 10 from the first two numbers of the gpm flow in order to derive a sufficiently accurate friction loss figure per 100 feet of 1½-inch hose.
- F. Refer to Tables 9.3 and 9.4 for more information.

Note: This method does not work for the metric system of measurement.

Summary

- A. Fireground situations are often loud and somewhat chaotic scenes that make performing complex mental calculations difficult for driver/operators.
- B. Many departments train their driver/operators to use flowmeters, hydraulic calculators, pump charts, and simplified methods of determining pressure loss and required pump discharge pressure during fire incidents.

Slide 27
GPM Flowing Method

Slide 28
GPM Flowing Method for
2½-Inch Hose

Slide 29
GPM Flowing Method for
1½-Inch Hose

Slide 30
Summary

Basic Pump Operations

Instructor's Manual

Fire Pump Theory

Lesson 5

PRESENTATION OUTLINE

VISUALS/NOTES

Positive displacement pumps

- A. Have been largely replaced by the centrifugal pump for use as the main fire pump on modern fire apparatus
- B. Are still a necessary part of the overall pumping system on modern fire apparatus because they can pump air
- C. Are used as priming devices to get water into centrifugal pumps during drafting operations; by removing the air trapped in the centrifugal pump, water is forced into the pump casing by atmospheric pressure
- F. Rotary pumps
 - 1. Are the simplest of all fire apparatus pumps in design
 - 2. Were used extensively as the major pump on older fire apparatus
 - 3. Are now used as small capacity booster-type pumps, low-volume high pressure pumps, and priming pumps
 - 4. Rotary gear pumps
 - a. The rotary gear pump consists of two gears that rotate in a tightly meshed pattern inside a watertight case. The gears are constructed so that they contact each other and are in close proximity to the case.
 - b. With this arrangement, the gears within the case form watertight and airtight pockets as they turn from the intake to the outlet.
 - c. As each gear tooth reaches the discharge chamber, the air or water contained in that pocket is forced out of the pump.
 - d. As the tooth returns to the intake side of the pump, the gears are meshed tightly enough to prevent the water or air that has been discharged from returning to the intake.
 - e. Produce amount of water dependent upon the size of

Slide 1

Positive Displacement Pumps

Slide 2

Rotary Pumps

- the pockets in the gears and the speed of rotation
- f. Are very susceptible to damage from normal wear, sand, and other debris; can be prevented with bronze or soft metal gears
- 5. Rotary vane pumps
 - a. Are constructed with movable elements that automatically compensate for wear and maintain a tighter fit with closer clearances as the pump is used
 - b. Are one of the most common types of pumps used to prime centrifugal pumps
 - c. The rotor is mounted off-center inside the housing. The distance between the rotor and the housing is much greater at the intake than it is at the discharge. The vanes are free to move within the slot where they are mounted.
 - d. As the rotor turns, the vanes are forced against the housing by centrifugal force.
 - e. When the surface of the vane that is in contact with the casing becomes worn, centrifugal force causes it to extend further, thus automatically maintaining a tight fit.
 - f. As the rotor turns, air is trapped between the rotor and the casing in the pockets formed by adjacent vanes.
 - g. As the vanes turn, this pocket becomes smaller, which compresses the air and causes pressure to build up. This pocket becomes even smaller as the vanes progress toward the discharge opening.
 - h. At this point, the pressure reaches its maximum level, forcing the trapped air out of the pump. The air or water is prevented from returning to the intake by the close spacing of the rotor at that point.
 - i. As in the rotary gear pump, the air being evacuated from the intake side causes a reduced pressure (similar to a vacuum), and water is forced into the pump by atmospheric pressure until the pump fills with water.
 - j. At this point, the pump is primed and forces water out of the discharge in the same manner as air was forced out.
 - k. Are more efficient at pumping air than a standard rotary gear pump because the pump is self-adjusting

Slide 3
Rotary Vane Pump
Characteristics

Slide 4
Operation of Rotary
Vane Pumps

Centrifugal pumps

- A. Centrifugal pumps are utilized by nearly all modern fire apparatus.

Slide 5
Centrifugal Pumps

- B. The centrifugal pump is classified as a nonpositive displacement pump because it does not pump a definite amount of water with each revolution. Rather, it imparts velocity to the water and converts it to pressure within the pump itself. This gives the pump a flexibility and versatility that has made it popular with the fire service.
- C. The centrifugal pump has virtually eliminated the positive displacement pump as a major fire pump in the fire apparatus.
- D. The centrifugal pump consists of:
1. Impeller — Transmits energy in the form of velocity to the water
 2. Casing — Collects the water and confines it in order to convert the velocity to pressure
 3. Volute — Is a water passage that gradually increases in cross-sectional area as it nears the pump discharge outlet
- E. The impeller in a centrifugal pump rotates very rapidly within the casing, generally from 2,000 to 4,000 rpm.
- F. The volume capacity of the pump is dependent on the size of the eye of the impeller. The greater the eye, the greater the flow capacity.
- G. The three main factors that influence a centrifugal fire pump's discharge pressure:
1. Amount of water being discharged
 2. Speed at which the impeller is turning
 3. Pressure of water when it enters the pump from a pressurized source (hydrant, relay, etc.)

Slide 6
Centrifugal Pumps

Slides 7
Centrifugal Pumps

Slide 8
Centrifugal Pumps

Slide 9
Centrifugal Pumps

Pump mounting and drive arrangements

- A. Auxiliary engine-driven pumps
1. Are powered by a gasoline or diesel engine independent of an engine used to drive the vehicle
 2. Some are powered by special fuels, such as jet fuel
 3. Are used on:
 - a. Airport rescue and fire fighting (ARFF) vehicles
 - b. Wildland fire apparatus

Slide 10
Auxiliary Engine-Driven Pumps

Slide 11
Auxiliary Engine-Driven Pumps

- c. Mobile water supply apparatus
- d. Trailer-mounted fire pumps
- e. Portable fire pumps
4. Offer the maximum amount of flexibility; can be mounted anywhere on the apparatus
5. Are ideal for pump-and-roll operations (pumping water while the apparatus is in motion)
6. Have pumping capacity of 500 gpm (2 000 L/min) or less for wildland or mobile water supply apparatus
7. Have pumping capacity of 4,00 gpm (16 000 L/min) or more for ARFF apparatus and trailer-mounted applications

Slide 13
Auxiliary Engine-Driven Pumps

B. Power take-off driven fire pumps

1. Are driven by a driveshaft that is connected to the power take-off (PTO) on the chassis transmission
2. Are used on initial attack, wildland, and mobile water supply apparatus
3. Have become popular on structural pumpers
4. Must be mounted correctly for dependable and smooth operation; the pump gear must be mounted in a location that allows for a minimum of angles in the driveshaft
5. Are powered by an idler gear in the truck transmission and are under the control of the clutch; permits pump-and-roll operation, but isn't as effective as the separate engine unit
6. Change pressure when the driver changes the vehicle speed
7. Most limit the pump capacity to about 500 gpm (2 000 L/min) because of the strain on the engine's horsepower
8. Some "full torque" units permit the installation of pumps as large as 1,250 gpm (5 000 L/min)

Slide 14
Power Take-Off Driven Fire Pumps

Slide 15
Power Take-Off Driven Fire Pumps

C. Front-mount pumps

1. Are mounted between the front bumper and the grill
2. Are driven through a gear box and a clutch connected by a universal joint shaft to the front of the crankshaft
3. Are set to turn the impeller of the pump faster than the engine; the ratio is usually between 1½:1 and 2½:1
4. Have pump capacities as high as 1,250 gpm (5 000 L/min)
5. Are more susceptible to freezing in cold climates; can be overcome through the use of external lines that circulate radiator coolant through the pump body
6. Can obstruct the air flow through the vehicle's radiator and contribute to engine overheating

Slide 16
Front-Mount Pumps

Slide 17
Front-Mount Pumps

7. Are in a vulnerable position in the event of a collision
8. Can be used for pump-and-roll operations
9. Most are engaged and controlled from the pump location itself, putting the driver/operator in a vulnerable spot at the front of the vehicle; a lock must be provided to prevent the road transmission from being engaged while the pump is operating
10. Engages a warning light inside the cab when in use; vehicle should not be driven while the pump is turning and no water is being discharged or damage to the pump results

Slide 18
Front-Mount Pumps

Slide 19
Front-Mount Pumps

D. Midship pumps

1. Are mounted laterally across the frame behind the engine and transmission
2. Are supplied power through the use of a split-shaft gear case located in the drive line between the transmission and the rear axle
3. Have power diverted from the rear axle by shifting of a gear and collar arrangement inside the gear box
4. Are driven by a series of gears or a drive chain
5. Are arranged so that the impeller turns faster than the engine, usually 1½ to 2½ times as fast
6. Have a transfer case inside the cab
7. Should be engaged inside the cab and the road transmission put in the proper gear

Slide 20
Midship Pumps

Slide 21
Midship Pumps

Slide 22
Midship Pumps

- Note: To be sure that the transmission is in the correct gear, observe the speedometer reading after the pump is engaged. With the engine idling and the pump engaged, most speedometers read between 10 and 15 mph (16 km/h to 24 km/h). Some newer apparatus may be designed so that the speedometer does not go above 0 mph (km/h) when the pump is engaged.
8. Require that the clutch be disengaged and the road transmission be placed in neutral to prevent damage to the gears
 9. Do not have the ability to pump-and-roll
 10. Must have a lock on the transmission or shift lever to hold the automatic transmission gear selector in the proper gear for pumping
 11. May include a green light on the dash that, when lit, indicates that it is safe to begin the pumping operation
 12. Hydrostatic pumps
 - a. Are driven by a shaft from the front of the vehicle's engine, which turns a pump that drives a midship-

Slide 23
Midship Pumps

Slide 24
Midship Pumps

Slide 25
Midship Pumps

- mounted or rear-mounted centrifugal water pump
- b. Have up to 1,000 gpm (4 000 L/min capacity)
- c. Can be used for both stationary and pump-and-roll operations
- d. Do not output according to speed of the engine
- e. Can significantly reduce the power available for driving the vehicle
- f. Can sometimes take all of the engine output to produce maximum flow

Slide 26
Hydrostatic Pumps

E. Rear-mount pumps

1. Have become increasingly popular in recent years
2. Advantages
 - a. Provide more even weight distribution on the apparatus chassis
 - b. Allow the apparatus to have more compartment space for tools and equipment
3. Disadvantage — May expose driver/operator to oncoming traffic
4. May be powered by split-shaft transmission or PTO
5. Are connected to the transmission by a driveshaft

Slide 27
Hydrostatic Pumps

Intake and discharge piping

A. Piping systems

1. Components
 - a. Intake piping
 - b. Discharge piping
 - c. Pump drains
 - d. Valves
2. Must be of a corrosion-resistant material; most are constructed of cast iron, brass, stainless steel, or galvanized steel

Slide 28
Piping Systems

Valves

A. Valves

1. Control most of the intake and discharge lines from the pump
2. Must be airtight
3. May require repair as they age and are subjected to frequent use

Slide 29
Valves

Automatic pressure control devices**A. Automatic pressure control devices**

1. When a pump is supplying multiple attack lines, any sudden flow change in one line can cause a pressure surge on the other.
2. Some type of automatic pressure regulation is essential to ensure the safety of personnel operating the hoselines.
3. NPFA 1901 requires some type of pressure control device to be part of any fire apparatus pumping system.
4. The device must operate within 3 to 10 seconds after the discharge pressure rises and must not allow the pressure to exceed 30 psi above the set level.

Slide 30
Automatic Pressure
Control Devices

Slide 31
Automatic Pressure
Control Devices

B. Relief valves

1. Are of two types (or concepts)
 - a. Those that relieve excess pressure on the discharge side of the pump
 - b. Those that relieve excess pressure on the intake side of the pump

Slide 32
Relief Valves

C. Pressure governor

1. Regulates pressure on centrifugal pumps
2. Regulates the power output of the engine to match pump discharge requirements
3. Relieves excessive pressure that is generally caused by shutting down one or more operating hoselines
4. Varies with each manufacturer's designs; may be attached to either a regular or an auxiliary throttle
5. Can be used in connection with a throttle control, engine throttle, and/or pump discharge
6. Piston assembly governor — Fits onto the carburetor (gasoline engines) or throttle link (diesel engines) and reduces or increases the engine speed under the control of a rod connected to a piston in a water chamber
7. Electronic governor — Uses a pressure-sensing element connected to the discharge manifold to control the action of an electronic pump amplifier that compares pump pressure to an electrical reference point

Slide 33
Pressure Governor

Slides 34
Pressure Governor

Slide 35
Pressure Governor

Pump primers**A. Positive displacement primers**

1. Are the most common choice of manufacturers and fire departments
2. May be rotary vane or rotary gear type
3. May be driven off the transfer case of the transmission
 - a. Are not as common as electric-driven
 - b. Should operate with an engine rpm around 1,000 to 2,000
4. May be electric-driven — Can be operated effectively, regardless of engine speed
5. Have an inlet connected to a primer control valve that is in turn connected to the fire pump
6. Use an oil supply or some other type of fluid to seal the gaps between the gears and the case and to act as a preservative and minimize deterioration

C. Exhaust primers

1. Are still found on many small skid-mounted pumps and some older pieces of apparatus
2. Operate on the same principle as a foam eductor
3. Require high engine rpm to operate
4. Are not very efficient
5. Require a great deal of maintenance
6. Require that any air leaks in the pump be kept to an absolute minimum and that the suction hose and gaskets be kept in good condition

D. Vacuum primers

1. Are the simplest type of primer
2. Were common on older, gasoline-powered fire apparatus
3. Prime the pump by connecting a line from the intake manifold of the engine to the intake of the fire pump with a valve connected in the line to control it
4. Can draw water through the pump and into the intake manifold, causing damage to the engine; can be prevented with a check valve
5. Work best at low engine rpm

Slide 36**Positive Placement Primers****Slide 37****Exhaust Primers****Slide 38****Exhaust Primers****Slide 39****Exhaust Primers****Slide 40****Vacuum Primers**

Summary

- A. While some water systems supply sufficient pressure to operate nozzles and other fire fighting equipment without the pressure being increased, most fire situations require the fire department to increase the available water pressure.
- B. In most cases, added pressure is provided by a fire pump built into a piece of fire apparatus – a conventional or specialized fire department pumper.
- C. To do their jobs properly, driver/operators must know the operating theory as well as the operational capabilities and limitations of the pumping apparatus within their departments.

**Slide 41
Summary**

**Slide 42
Summary**

Basic Pump Operations

Instructor's Manual

Operating Fire Pumps

Lesson 6

PRESENTATION OUTLINE

VISUALS/NOTES

Making the pump operational

- A. The process of making the fire pump operational is also referred to as "putting the pump into gear."
- B. The process for making the fire pump operational begins after the apparatus has been properly positioned and the parking brake has been set. Proper position is determined by a variety of factors, such as tactical use and the water supply that will be used.
- C. After properly positioning the apparatus and setting the parking brake, on the majority of apparatus, the remainder of the procedure for making the fire pump operational takes place before the driver/operator exits the cab.
- D. Once the driver/operator exits the cab, the next step, in all cases except when the apparatus is used for pump-and-roll operations, should be to chock the apparatus wheels.
Note: IFSTA recommends that the apparatus wheels be chocked every time the apparatus is stopped with the engine running and the driver/operator exits the cab.

Operating from the water tank

- A. Of the three possible types of water supply for the fire pump, most driver/operators operate solely from the onboard water tank at the vast majority of incidents. The need to use an external pressurized or static water supply source occurs much less frequently.
- B. In some circumstances, the fire attack begins with water in the tank and then, if the fire progresses, it becomes necessary to make the transition to an external supply source.

Slide 1
Making the Fire Pump
Operational

Slide 2
Making the Fire Pump
Operational

Slide 3
Making the Fire Pump
Operational

Slide 4
Operating from the
Water Tank

- C. The pump operator must be able to make the transition from the apparatus tank to an incoming water supply smoothly, with no disruption of the fireground operation.

Operating from a pressurized water supply source

- A. Two basic pressurized water supply sources used to supply a fire pump
 1. Hydrant
 2. A supply hose from another fire pump
- B. Negative pump pressure (vacuum)
 1. Water enters the pump under pressure from the source.
 2. As the discharge pressure or volume from the fire pump increases, the incoming pressure from the supply source may drop due to friction loss in the water system.
 3. If the discharge pressure (and the resulting flow volume) is increased too much, the intake pressure from the supply source may be reduced below 0 psi (0 kPa).
- C. Dangers of operating at negative pressure (vacuum) from a pressurized water source
 1. From a fire hydrant
 - a. Increases the possibility of damage to the fire pump due to cavitation
 - b. Can cause damage to the pump and water system due to water hammer if the flow is stopped suddenly
 - c. May damage water heaters or other domestic appliances on a municipal water supply system
 2. From another pumper
 - a. Can cause supply hose to collapse, resulting in interruption of water supply
 - b. Can damage the pump through cavitation

Choosing a hydrant.

- A. In order to select the best hydrant, a thorough knowledge of the water system is required.
- B. The best hydrants are located on large water mains that are interconnected in a grid pattern so that they can receive water from several directions at the same time.

Slide 5 Operating from the Water Tank

Slide 6 Operating from a Pressurized Water Supply Source

Slide 7 Negative Pump Pressure (Vacuum)

Slide 8 Dangers of Operating at Negative Pressure from a Fire Hydrant

Slide 9 Choosing a Hydrant

- C. The worst hydrants typically are those located on "dead-end mains."

Preliminary checks that should be made after making hydrant connections but before opening the hydrant

- A. Certain preliminary checks should be performed before opening the hydrant.
1. The tank-to-pump valve must be closed if the intake is not equipped with a shutoff valve.
 2. A dry barrel hydrant must be opened all the way.
- B. After the pump is full of water and the pressure in the system has stabilized with no water flowing, a reading of the pressure on the master intake gauge indicates the static pressure in the water supply system.
- C. It may be desirable for the pump operator to record or remember the static pressure before the operation begins. Some departments use a grease pencil to mark the static pressure on the intake gauge.

Putting the pump in service

- A. Do not engage the pump drive system before leaving the cab if there will be an extended period of time where water is introduced into the pump.
- B. If operating a two-stage pump, set the transfer valve to the proper position before increasing the throttle to build discharge pressure.
- C. Open discharge valves slowly, particularly when using large diameter hose.
- D. Keep the pump from overheating by ensuring a continued minimum flow. Some methods for preventing overheating:
1. Pull some of the booster line off the reel and securely tie off the nozzle to a solid object. Open the valve that supplies the booster reel, and discharge water in a direction that will not harm people or damage property.
 2. Open a discharge drain valve.
 - a. These should be designed to discharge the water in a manner that will not harm people or damage property.
 - b. Some are equipped with threaded outlets that allow a

Slide 10
After Making Hydrant Connections but Before Opening the Hydrant

Slide 11
After Making Hydrant Connections but Before Opening the Hydrant

Slide 12
Putting the Pump in Service

Slide 13
Preventing Pump Overheating

- hose to be connected and then routed away from the apparatus to a safe discharge point.
- c. In this case, it is better to discharge water away from the apparatus so that it does not become stuck in the mud (or frozen in ice) that could be created by discharging water directly beneath it.
 3. Partially open the tank fill valve or pump-to-tank line.
 - a. Even if the water tank becomes full and overflows through the tank vent, this cooling action is better than allowing the pump to overheat.
 4. Use a bypass or circulator valve if the apparatus is so equipped.

Shutting down the hydrant operation.

- A. Gradually slow the engine rpm to idle to reduce the discharge pressure.
- B. Take the pressure control device out of service if in use.
- C. Slowly and smoothly close the discharge valves.
- D. Place the drive transmission into neutral, and disengage the pump control device.

Slide 14 Shutting Down the Hydrant Operation

Operating from a static water supply source

- A. In most cases, pumpers will be pumping water from a static water supply that will be located at a lower level than the fire pump. Because one drop of water will not stick to another, it is not possible to pull water into the pump from a lower level.
- B. In order to pump from a lower level, a pressure differential (partial vacuum) must be created by evacuating some of the air inside the fire pump. In order to accomplish this, an airtight, noncollapsible waterway (hard intake hose) is needed between the fire pump and the body of water to be used.
- C. The amount of friction loss in the hard intake hose is dependent upon the diameter and length of the hose. The smaller the diameter of the hose, and the greater its length, the higher the friction loss. To allow for this, the size of the intake hose is increased for larger capacity pumps.

Slide 15 Operating from a Static Water Supply Source

Slide 16 Operating from a Static Water Supply Source

- D. The total pressure available to overcome all these pressure losses is limited to the atmospheric pressure at sea level (14.7 psi or 100 kPa).
- E. Atmospheric pressure decreases 0.5 psi (3.5 kPa) for each 1,000 feet (305 m) of elevation gain. Because the same amount of atmospheric pressure must overcome elevation pressure as well as friction loss, increasing the height of the lift also decreases total pump capacity.
- F. While the pump is moving water, the vacuum reading on the master intake gauge provides an indication of the remaining pump capacity. The maximum amount of vacuum that most pumps develop is approximately 22 inches (560 mm) of mercury. A reading anywhere close to this figure is a warning to the pump operator that the pump is getting close to the limit of its ability.
- G. If an attempt is made to increase the discharge from the pump beyond the point of maximum vacuum on the intake, cavitation results. Cavitation is the condition where water is being discharged from the pump faster than it is coming in. Damage to the pump can occur.
- H. Indications that the pump is cavitating:
 - 1. Hose streams will pulsate, and the pressure gauge on the pump will fluctuate
 - 2. A popping or sputtering may be heard as the water leaves the nozzle
 - 3. The pump will be noisy, sounding like gravel is passing through it
 - 4. A lack of reaction on the pressure gauge to changes in the setting of the throttle
- I. You can discharge only the amount of water that has been taken in on the intake side of the pump.

Slide 17
Operating from a Static Water Supply Source

Slide 18
Cavitation

Slide 19
Indications of Cavitation

Selecting the drafting site

- A. If the purpose of the operation is to supply water to a fireground directly or through a relay, there may not be much choice as to where to set up. If the draft is being established to supply water tenders (tankers) for a shuttle operation, there may be several choices. The choice is dictated by the following factors:

Slide 20
Selecting a Drafting Site

1. Amount of water
2. Type of water
3. Accessibility of water

B. Amount of water available

1. The most important factor in the choice of the draft site is the amount of water available.
2. In order for a pumper to approach its rated capacity using a traditional strainer, there should be a minimum of 2 feet (0.6 m) of water over the strainer. It is also desirable to have 2 feet (0.6 m) of water all around the strainer.
3. If there are not 2 feet (0.6 m) above the strainer, floating debris can clog the strainer or the rapid movement of the water into the intake strainer can cause a whirlpool to form. A wooden board, capped plastic bottle, or beach ball may be placed above the strainer to prevent a whirlpool effect.

C. Accessibility

1. A maximum atmospheric pressure of 14.7 psi (100 kPa) is available when drafting. This 14.7 psi (100 kPa) has to overcome elevation pressure and friction loss in the intake hose. As the amount of lift increases:
 - a. Elevation pressure increases
 - b. Less friction loss can be overcome
 - c. Capacity of the pump is decreased
2. All fire pumps meeting NFPA and UL requirements are rated to pump their capacity at 10 feet (3 m) of lift. If the lift is less, the capacity is higher; if the lift is greater, the capacity decreases.
3. When selecting a drafting site, it is important to keep the lift as low as possible.
4. Other considerations include the stability of the ground, the time of the year, the convenience of connecting hoselines, and the safety of the operator.

Slide 21**Amount of Water Available****Slide 22****Amount of Water Available****Slide 23****Accessibility of Water****Priming the pump and beginning operation.****A. Priming the pump starts the draft operation.****B. If operating a two-stage pump, the transfer valve should be in the PARALLEL (VOLUME) position during priming.****C. Before priming, make sure that all drains and valves are closed and that all unused intake and discharge openings are****Slide 24****Priming the Pump and Beginning Operation**

capped to make the pump as airtight as possible.

- D. If the primer is a positive displacement pump that is driven by the transfer case, the engine rpm should be set according to the manufacturer's instructions. Most priming pumps are intended to work best when the engine is set between 1,000 and 1,200 rpm.
- E. Once the pump is airtight and the engine rpm set, operate the primer control. The vacuum reading on the master intake gauge should read 1 inch (25 mm) for each 1 foot (0.3 m) of lift.
- F. The priming action should not be stopped until all the air has been removed and the primer is discharging a steady stream of water.
- G. The entire priming action typically requires 10 to 15 seconds from start to finish, but when using no more than 20 feet (6 m) of hard intake hose lifting a maximum of 10 vertical feet (3 m), it should not take more than 30 seconds (45 seconds in pumps larger than 1,250 gpm [5 000 L/min]).
- H. If a prime has not been achieved in 30 seconds, stop priming and find out what the problem is. Causes of inability to prime:
 - 1. An air leak that prevents the primer from developing enough vacuum to successfully draft water
 - 2. Insufficient fluid in the priming reservoir
 - 3. Engine speed (rpm) is too low
 - 4. Lift is too high
 - 5. A high point in the hard intake hose is creating an air pocket
- I. After the pump has been successfully primed, slowly increase the setting of the throttle before attempting to open any of the discharges. The pressure needs to be between 50 and 100 psi (350 kPa and 700 kPa).
- J. Open the desired discharge valve slowly while observing the discharge pressure. If the pressure falls below 50 psi (350 kPa), pause for a moment to allow it to stabilize before opening the valve further. If the pressure continues to drop, momentarily operating the primer may eliminate the air still trapped in the pump and restore the pressure to the original value.

Slide 25
Priming the Pump and
Beginning Operation

Slide 26
Priming the Pump and
Beginning Operation

Slide 27
Priming the Pump and
Beginning Operation

Slide 28
Priming the Pump and
Beginning Operation

- K. Constant movement of water through the pump is necessary to prevent overheating, and to maintain a vacuum.

Problems that can occur while operating from draft.

A. Operating the pump from draft

1. Operating from draft is the most demanding type of pump operation. It demands a careful monitoring of the gauges associated with the engine as well as those associated with the pump. Any deviation from the normal engine temperature is a signal that another pumper should be used for drafting.
2. Problems that can occur while operating from draft fall into one of three categories:
 - a. Air leak on the intake side of the pump
 - b. Whirlpool allowing air to enter the pump
 - c. Air leakage due to defective packing in the pump
3. Blockage may occur after the pump has been operating satisfactorily for some time at a high rate of discharge, which creates a maximum velocity of the water that is entering the strainer. Try to clear the blockage and restore the operation to normal.

Slide 29 Operating the Pump from Draft

B. Shutting down the operation

1. Slowly decrease the engine speed to idle, take the pump out of gear, and allow the pump to drain.
2. After the pump is drained and the connections have been removed, operate the mechanical primer for a few seconds until primer oil or fluid comes out of the discharge from the priming pump.

Slide 30 Shutting Down the Operation

Summary

- A. Driver/Operators must know how to operate fire pumps under a variety of conditions.

Slide 31 Summary

- B. On the fireground, driver/operators must be able to engage the pump, to make it operational, and troubleshoot any problems that may develop.

- C. Driver/Operators must also choose the best available water source – onboard water tank, pressurized source, or static source – and provide this water to the pump.

Slide 32 Summary

- D. Finally, driver/operators must operate the pump to safely and effectively supply water to attack lines and support automatic sprinkler systems and standpipes in buildings so equipped.



Basic Pumping Operations Skills Competency

Each student should successfully complete each skill listed below

Student Name:		Safely performed the following steps	
1. Properly engages fire pump			
2. Secures apparatus with parking brake and wheel chocks			
3. Pumps to desired hose from water tank			
4. Pumps to desired hose from pressurized source			
5. Displays knowledge of friction loss			
6. Transitions from tank to pressurized source smooth and without loss of flow			
7. Properly shut down operation			
8. Did not allow pump to overheat			
9. Did not allow pump to cavitate			
10. Properly disengages pump			
Evaluator Notes			
Evaluator Print Name & Signature:	Date	Overall Skill Sheet Score	
		Pass ____	Fail ____