Massachusetts Firefighting Academy
Student Manual

Advanced Fire Skills

Pumps & Hydraulics

09/18

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Pumps and Hydraulics

Slide 2

Inspection,
Maintenance, and
Testing

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Objective

At the conclusion of this module, the student should have the student an understanding of daily, weekly and annual testing and inspection of apparatus

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Maintenance involves the apparatus and all equipment carried on the piece.

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Maintenance

- Improves reliability
- Reduces problems
  - Repair costs
  - Downtime for repairs

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Documentation

- Details the history of the apparatus
  - Identifies problems
  - Shows the need for repair or replacement
  - Tracks the cost of maintenance
- Inventory of equipment
- Records are required by ISO for rating purposes

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Daily Inspection

Engine Oil Level	Fuel Level
Radiator Coolant	Water Tank Level
Batteries	Tires
All Lights	Air System Pressure
Horn and Siren	Equipment

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Weekly Inspection

Transmission Oil Level	Check for Loose Nuts, Pins etc.
Power Steering Fluid	Start and Run Motor Driven Equipment
Hydraulic Brake System	Check Operation of Pump
Air Brake System	Equipment on Apparatus
Check All Engine Belts	Ladders
Battery Terminals / Cables	Tools
Operate Valves in Cooling System	SCBA
Check Drains and Hose Connections	Salvage Equipment

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Pump Theory

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Functions of a Fire Department Pumper

- Provides water for Firefighting
- Controls water
  - To overcome friction loss
- Source of water to supply pumpers at the proper pressure

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Provides Water for Firefighting

- Handlines
- Master stream appliances
- Supplement sprinkler system
- Supplement standpipe system
- Relay pumping to other apparatus

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Controls Water

- Friction loss
- Back pressure
- Forward pressure
- Excessive line pressure when other lines shut down
- Increase pressure

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Water Sources

- Tank Supply
- Pressure Source
- Hydrants
- Dry Hydrants
- Static Sources

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Types of Pumps

- Rotary Vane
- Centrifugal

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Rotary Vane Pump

- Used as a priming device
- In a cycle, the rotor turns, and the vanes advance outward
- Space between the rotor and housing is filled with water
- Vanes then force air out the discharge

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Rotary Vane Pump

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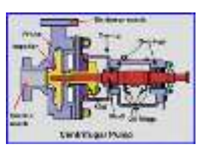
Centrifugal Pump

- Spinning action creates outward force
- An impeller is used
  - Water enters the eye and is thrown outward



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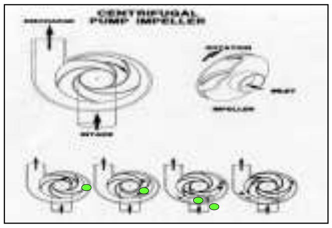

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Single Stage Pump

- Has one impeller
  - Total flow and pressure depend on engine speed
- May have a single or double eye in the impeller
- Greatest efficiency is at or near capacity
- More common and simpler to operate, purchase, and maintain

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Two Stage Pump

- Also known as series/parallel or pressure/volume
- Has two impellers on a single shaft
- Two modes of operation

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Series/Pressure or Parallel

- Water flows through each impeller in series/pressure
- Pressure is increased by each impeller
- Results in higher pressure and lower volume
- Pressure setting is used for flows up to 50% to 70% of pump capacity

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Parallel or Volume

- Both impellers are working, but not in series
- Water passes through either impeller, but not both
- Results in greater volume and lower pressure
- Used for flows greater than 50% of pump capacity

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Class Ratings

- Have a capacity of 750 to 2500 gpm
- Tested to pump:
  - 100% of capacity @ 150 psi net capacity
  - 70% of capacity @ 200 psi net capacity
  - 50% of capacity @ 250 psi net capacity
- Must be capable of pumping at capacity up to 2000 feet of elevation

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Powering Pumps

- Front Mounts
- Power Take Off
- Mid-ship
- Separate Engine
- Rear Mount

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Front Mount

- Pump is driven through a reduction gear with a clutch on the front of the motor
- Pump is independent of transmission – pump and roll capability
- Location of pump makes it susceptible to freezing and collision damage
- Pump is engaged by a clutch lever most often found at the pump itself

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Power Take Off (PTO)

- PTO pumps are smaller (250 – 1500 gpm)
- Driven by gears within the transmission case (shaft)
- Pump is engaged by a PTO control
- Apparatus is normally stopped, but may be moved in a lower gear

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Mid-ship

- Split-drive, shaft driven through a transfer case from the road transmission
- Transfer case allows selection of road or pump capability
  – Usually no pump and roll capability
- Allows for full power from engine to the pump
- Pump is engaged by shifting the transfer case lever from road to pump

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Rear Mount

- Split-drive, shaft driven through a transfer case from the road transmission
- Transfer case allows selection of road or pump capability
  – Usually no pump and roll capability
- Allows for full power from engine to the pump
- Pump is engaged by shifting the transfer case lever from road to pump

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Separate Engine

- Power is independent of the apparatus
- Examples:
  - Skid-mounted
  - Trailer mounted
  - Built into the apparatus
  - Crash truck

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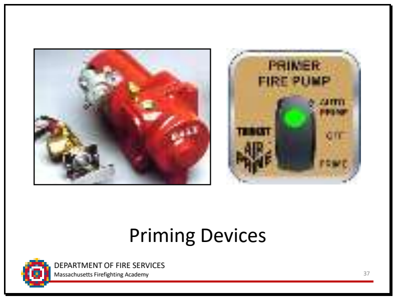

Two Types of Priming Devices: Electric & Air primers

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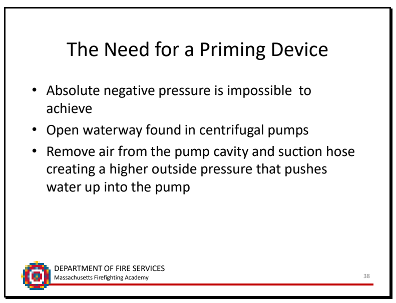

Atmospheric Pressure 14.7 pounds per square inch at sea level

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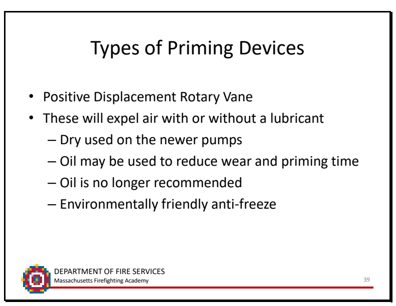

Positive Displacement

- Rotary vane
- Small in size
- Operate with high speed rotation
- May be driven
  - Electrically
  - Power take-off
  - From pump transmission

Dry type is now being used on all new pumpers
These primers will expel air with or without a lubricant
Oil is no longer recommended due to pollutants
Environmentally friendly antifreeze may be used in place of oil

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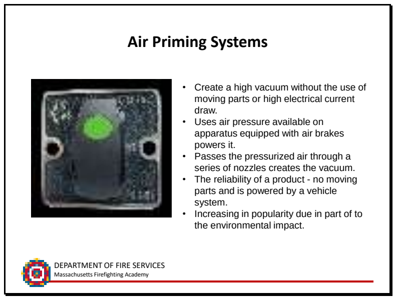

Source – Article – Fire Apparatus & Emergency Equipment, 5/1/2013, “Automatic Fire Pump Priming”, W. Parker Browne https://www.fireapparatusmagazine.com/articles/print/volume-18/issue-5/features/automatic-fire-pump-priming.html

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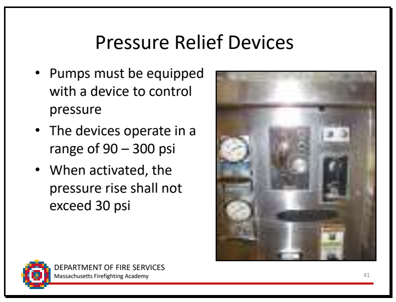

Operated on differential pressure – NFPA 1901, Section 16.10.13

To set this device, water must be flowing

This is a Waterous relief.
It has an on/off switch and an egg shaped handle

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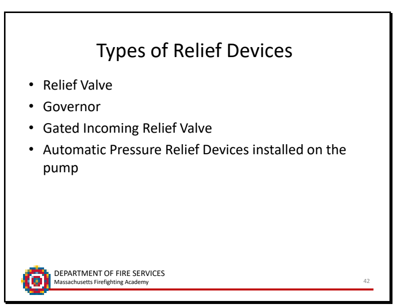

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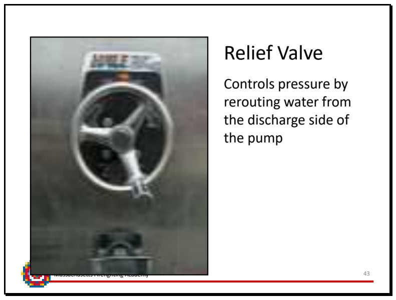

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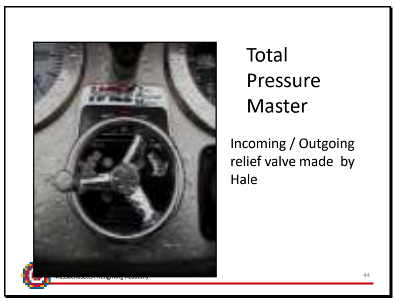

Meets NFPA 1901 standard for pressure control systems

Will not interfere with priming

Single panel-mounted pressure control valve
- Sets both external (dump) and internal relief valves

Provides protection from excess inlet pressure during relay and hydrant operations

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Very common in most apparatus being manufactured these days.
Mention about “PRESET” button. When activated all discharges are raised to preset PSI, generally somewhere between 100 and 130 psi, but again, know what your department preset is set.
If preset is activated and you need lower/higher pressures than preset is set to then you have a choice to “manually” lower or raise by pushing the “INC” or “DEC” buttons.
In PSI Mode pump operator will set and let the “brain” do all the rpm and flow adjustments for you. As bails are closed/opened the PSI Mode adjusts engine speed automatically.
PSI Mode – used for the attack pump
RPM Mode – used for drafting as well as pumping LDH. Steady flow of water up the street.

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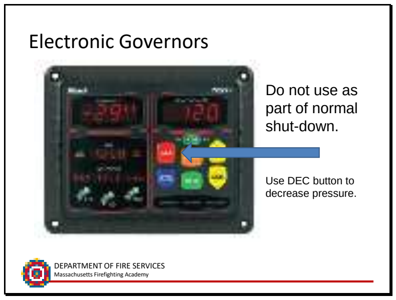

DO NOT PUSH THE IDLE BUTTON AS A PART OF NORMAL SHUT-DOWN OF LINES. This is for a true emergency and not to be used as part of standard operation Use the INC/DEC buttons

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Manufacturer's Built-In Relief is usually factory set but can be reset in the field. NOT generally adjusted by the FD. Located inside the pump panel area.

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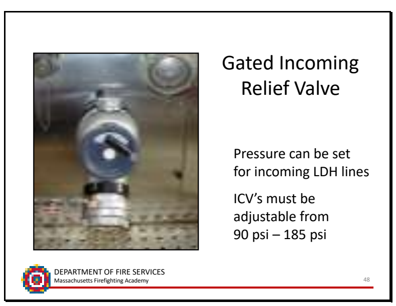

NOTE – There's an air relief usually found on top of the valve. MUST be opened as LDH is being charged. Don't close until air is bled from line.

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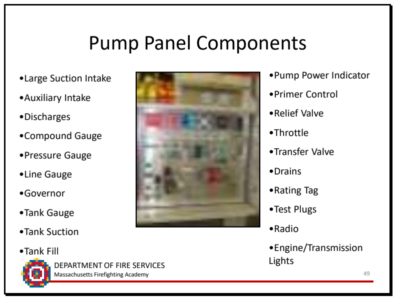

Every pump panel is different is different and built to the specifications of the local FD. Know and understand the layout of your pump panel.

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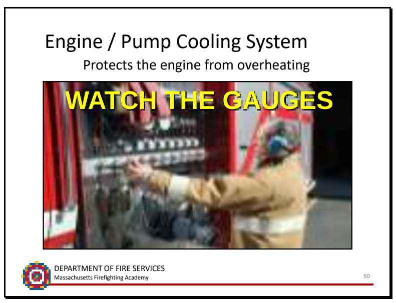

WATCH THE GAUGES! Winter/summer, makes no difference, water must be circulated around the pump. Modern fire pumps are built with a lot of plastic and rubber parts. Overheating will warp and damage these parts.
HINT – tell students to feel the discharge ports to feel the warmth. It happens quickly.

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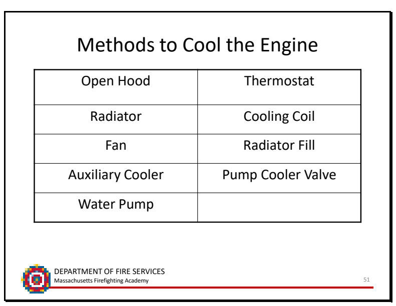

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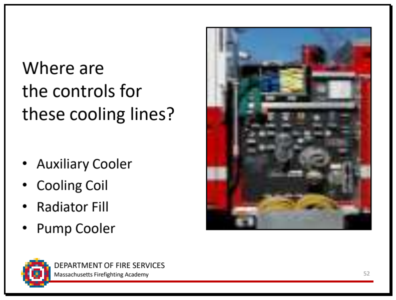

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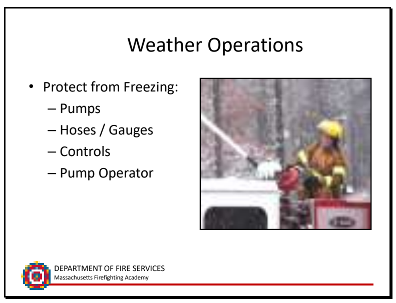

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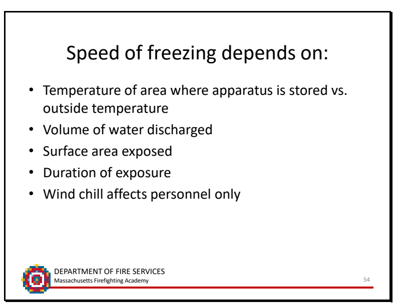

The small plastic lines to gauges will freeze VERY quickly.

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Freezing Prevention

- Do not shut down lines completely
- Moving water does not freeze as quickly
- Drain booster lines, monitors etc.
- Valves should be closed when no hose-lines are connected
- Check antifreeze levels
- Circulate water
- All pumps leak – watch for icing

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Freezing Prevention

- Take time to dress properly <u>prior</u> to leaving the station
- Dress in multiple layers
- Move around – standing still slows the body down
- Drink warm fluids
- Use the pull-out platform step

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Drafting Procedure

- Spot the truck
- Connect the hard suction
  - 12" off the bottom and from the surface
- Close all drains and discharges
- Prime until a steady discharge or constant pressure reading
- If no prime, check drains, discharges and suction hose
- When primed, increase throttle and open discharges slowly

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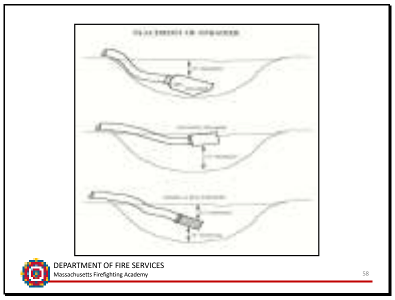

Some FD's carry a beach ball help in avoid a swirling vortex from occurring. Sucking air into the strainer will cause loss of prime.

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System Check When Pump Will Not Draft

- Primer Operation
- All Suction Connections
- All Discharge Connections
- Is Gate Open for Suction

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NOTE – newer drafting hose will often times suck air when drafting hose is positioned with a sharp drop-off from suction connection. Try to "soften" the sharp angle by placing something between the intake and the sharp angle. Another useful solution is to have a wet towel placed around the coupling area where air is leaking in.
Air leaks are often seen as small air bubbles emanating from where the air leak occurs. Another useful hint when having issues drafting is to open up a discharge and allow water to flow out of the discharge as the draft is being pulled. "Sometimes" this is just enough to overcome the air leak problem. Note that these are helpful hints that could assist the pump operator in overcoming the common problems at the moment and are by no means acceptable means by which to overcome pump problems created by greater issues that should be looked into by certified technicians.

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Water Distribution Systems

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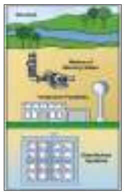
Water Distribution Systems

- Quality
- Quantity
- Reliability
- Economy



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Water Distribution Systems

- Supply Sources
  - Reservoirs, tanks, in-ground wells
- Treatment Facility
  - Softens water, fluoride, cleans, removes bacteria and minerals
- Delivery System
  - Gravity
  - Pump
  - Combination

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Mains

- Primary
  - ❑ 24" – 36"
- Secondary
  - – 12" – 16"
- Distributors
  - – 6" minimum for hydrants with 20 psi minimum pressure to prevent backup of contaminants into the system

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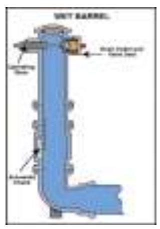

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Distance Between Hydrants

500' – High Value

800' – Residential

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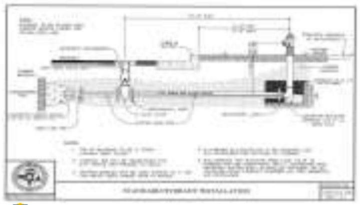
Standard Hydrant Installation



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Proper opening of the hydrant requires 18 – 22 turns of the operating nut

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NOTE – gate both sides of hydrant

HYDRANT GATES & HAV – REMINDER, open and close the gates/valves slowly to avoid water hammer somewhere in the water system.

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NFPA Hydrant Color Code

Caps and Bonnet Color Code	
0 – 499 GPM	Red
500 – 999 GPM	Orange
1000 – 1499 GPM	Green
1500 and up	Light Blue

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Markings

- Weather
- Time of Day
- Ease of Locating
  - Flags
  - Pole Markings
- Carrying Capacity Varies
  - Diameter
  - Pressure
  - Friction Loss
  - Age of Water System

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Interconnecting Feed Distribution

- Helps Reduce:
  - Friction Loss
  - Sedimentation
  - Incrustation
- Higher Output Pressure
  - Residual

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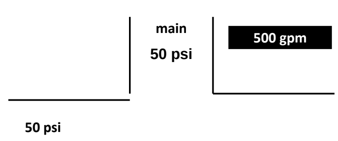

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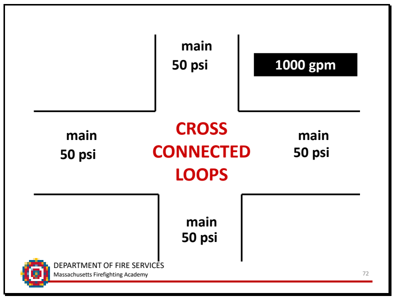

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Water Flow Problems

- Water Hammer
- Nozzle Reaction
- Cavitation
- Dead End Mains
- Incrustation
- Sedimentation

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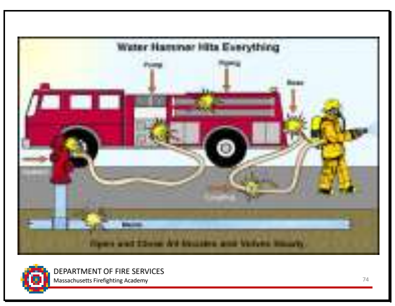

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DANGERS OF WATER HAMMERS

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Water Hammers Can Damage and Destroy

1. Water systems in the ground
2. Water systems in buildings
3. Hose lines
4. Appliances
5. Damage or destroy fire pumps
6. Most important: cause severe injury to firefighters working inside a fire building

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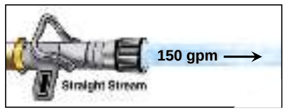
Nozzle Reaction is equal to half the flow

←75 psi



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Cavitation of a Pump

(“the pump running away from the water”)

- Water is discharged from the pump faster than it is coming in
- Air cavities are created in the pump and move from the point of highest vacuum into the pressurized section and collapse
- High velocity causes severe shock to the pump – usually resulting in damage

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Dead End Mains

- Water mains that are not cross connected with other mains – low water flow
- Know your water distribution system

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Incrustation

- Increases resistance for water flow by lining of pipe interior
- Caused by:
  - Tubercular corrosion of rust (iron pipe)
  - Chemicals in the water
  - Growth of biological or living organisms
- Water mains flushed each year reduces incrustation
- Flow test should be done to determine obstructions

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Sedimentation

- Materials that settle to the bottom of a liquid
  - Mud, clay, leaves etc.
- Strainers in pump intakes
- Flushed water mains
- Flush hydrant prior to charging supply lines if possible

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Basic Hand-line Hydraulics

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Hose

- Quality and Age
  - Rougher:
    - more resistance
- Diameter
  - Larger hose:
    - less friction loss for the same gpm

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Efficient Carrying Capacity of Hose

1"	12-30 gpm
1-1/2"	100 gpm
1-3/4"	150 gpm
2"	200 gpm
2-1/2"	300 gpm
3"	500 gpm
4"	1000 gpm
5"	2000 gpm

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Friction loss is part of the total pressure that is lost while forcing water through pipes, fittings, fire hose, nozzles and adapters.

Friction loss is lost energy!!

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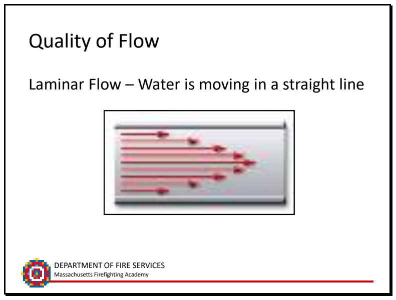

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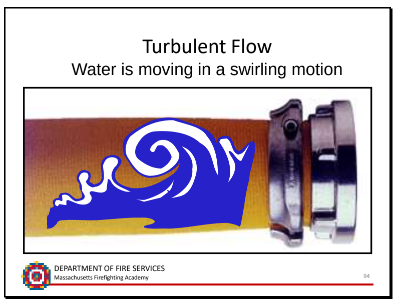

Turbulent Flow - the flow of a fluid past an object such that the velocity at any fixed point the liquid varies irregularly

Factors that influence friction loss:

- Quality and age of hose
  - Older hose is more rough and therefore creates more friction
- Diameter of hose
  - The larger the hose, the less friction loss for the same gallons flowing per minute
- Length of hose
- Appliances in hoseline
- Quantity of water being pumped
- Elevation
- Nozzle and flow

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Appliances

- Varies with type and amount of flow
- Rule of Thumb add:
  - 10 psi for master streams and ladder pipes
  - 5 psi for wyes, siameses etc.
  - 25 psi for standpipes

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GPM's Delivered

- Varies with type of nozzle
- Combination (fog)
  - Varies with nozzle pressure
- Solid Stream
  - Varies with tip size

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TIP SIZE	Solid Stream Master Streams 80 psi	Solid Stream Hand-lines 50 psi
	1-1/4" = 400	¾" = 100
	1-3/8" = 500	7/8" = 150
	1-1/2" = 600	15/16" = 175
	1-3/4" = 800	1" = 200
	2" = 1000	1-1/8" = 250
		1-1/4" = 300

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Types of Pressure

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Static Pressure:

Stored energy that is available to move water through pipes, hoses and appliances.

- Shown on compound gauge with no water flowing
- Static pressure remains the same at any point in the closed system if elevation is the same

No matter what size hose or piping

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Slide 100

Residual Pressure:

Kinetic energy that is available perform work. Water pressure that was not used to overcome back pressure due to elevation or friction loss.

- Incoming pressure shown on compound gauge with water flowing
- Residual pressure is different at various points in the system due to friction loss and elevation

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Slide 101

Negative Pressure:

Any pressure created in the fire pump or hard suction hose which is less than atmospheric.

– Atmospheric pressure is 14.7 psi at sea level

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Normal Operating Pressure:

Pressure through water distribution system during normal consumption demands.

– Fluctuates during day and night and also according to time of year

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Line Pressure:

Pressure needed to provide proper nozzle pressure with a given layout.

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Discharge Pressure:

In situations requiring multiple lines, the pump develops pressure for the highest line (greatest pressure).

– Gate back for all others to get the proper line pressure

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Nozzle Pressure:

The pressure required at the nozzle to develop a proper fire stream from a nozzle.

– Nozzle pressure and the tip size determine flow capability
– Standard nozzle pressures;
  - Combination nozzle: 100 – 75 – 50
  - Solid Stream nozzle (hand-line): 50
  - Solid Stream nozzle (master stream): 80

Slide 106

Net Pump Pressure:

Combined total pressure (psi) developed by the fire pump.

Net pump pressure = PSIG pressure + PSIG vacuum (inches of Hg.)

Slide 107

Flow Pressure:

Forward velocity pressure at a discharge opening measured with a Pitot Gauge.

Slide 108

Forward Pressure:

Pressure gained by water flowing, when the nozzle is lower than the pump.

- Figured at 0.5 psi per foot.
  - 5 psi per floor below ground level

Slide 109

Back Pressure:

Pressure that is must be overcome when the nozzle is above the pump.

- Figured at 0.5 psi per foot
  - 5 psi per floor above ground level

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Nozzles and Appliances

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Nozzles

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Solid Stream

- Fixed orifice, smooth bore nozzle which produces an unbroken stream
- Produces a stream that is compact and has little shower or spray
- Has good reach
- Made to operate in a range of 40 – 60 psi with 50 psi being the accepted standard

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Solid Stream Nozzle

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Solid Stream

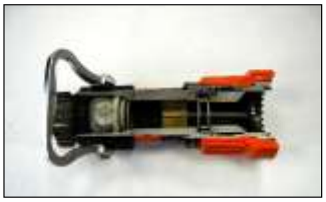
- Advantages
  - Greater reach
  - Greater penetration
  - Less likely to disturb normal thermal layering of heat and gases during interior attack
- Disadvantages
  - Set stream pattern
  - May not be used for foam application
  - Less heat absorption per gallon delivered
  - Must be fully opened to get full gpm/psi delivered

Slide 115

Combination Nozzle

- Produces a fog stream of fine water droplets
- Can be adjusted to different patterns
- The fog pattern is good for heat absorption
- Made to operate in a range of 50 – 100 psi, 100 psi being the accepted standard
- Fixed or Adjustable gallons
- Automatic

Slide 116



Combination Nozzle

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Combination Nozzle

- Advantages
  - Discharge pattern may be adjusted
  - Gallonage may be adjusted
- Disadvantages
  - Does not have the reach or penetration power of solid streams
  - Fog stream is more susceptible to wind current
  - When improperly used during interior attack, can cause the spread of fire, create heat inversion and cause steam burns
  - Need to operate fully open to get full gpm/psi

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Automatic Nozzles

- Combination nozzle with a sensing device that maintains a constant 100 psi
- May use slide valve or ball valve
- Automatic adjustable gallonage
- Requires minimum contact with pump operator
- Able to control nozzle reaction at the nozzle
- Handlines: 1-1/2" – 3" hose
  - 50 – 350 gpm (full range)
  - 60 – 200 gpm (mid range)

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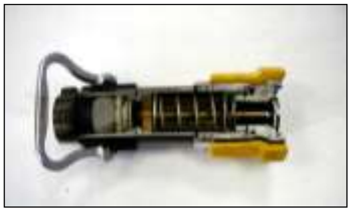

Automatic Nozzle

Slide 120

Automatic Nozzle

- Advantages
  - Nozzle operator has flow control
  - Consistent hard-hitting streams
  - Maintains optimum nozzle pressure at all times
  - Will adjust to the flow available
    - If flow is increased, the gpm's will automatically increase pressure
  - Will maintain maximum reach for available flow

Slide 121

Broken Stream Nozzle

- Produces coarsely divided drops of water
- Good heat absorption
- Examples:
  - Piercing Nozzle
  - Water Curtain Nozzle
  - Bresnan Nozzle
  - Cellar Nozzle
  - Chimney Nozzle
  - Navy / Rockwood Nozzle

Slide 122

Master Stream Appliances

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Master Stream Appliances

- Master streams are discharged from appliances using tips larger than 1-1/4"
- May be either solid stream or fog
- Solid tip master streams should be operated in a range of 60 – 80 psi
- Combination tip master streams are operated at 50 –100 psi
- Friction loss in master stream appliances starts at 10 psi
- The age of the appliance may require more psi with high flows at the tip

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Ladder Pipe

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Slide 128

Ball Distributor Valve

- Used with Large Diameter Hose
- Also called portable hydrant or manifold
- Principle is same as a wye appliance
- Generally have a 4" or 5" inlet with 2 or more smaller
- May also be an outlet that is same size as the inlet

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Hydrant Assist Valve

- Makes pumping the LDH line accessible and does not require the shutdown of the hydrant in order to set the pump
- With these valves there is no stoppage of water flow

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Wyes and Siamese Valves

- Wye
  - Divides one or more lines
  - Has one female and two or more lines
  - Used to divide a larger line into smaller or same size lines
- Siamese
  - Combines two or more lines into one line
  - Has one male and two or more female connections / Storz connections
  - Used to combine several lines into one larger one to supply a ladder pipe or ground gun

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LDH Siamese

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2-1/2” Siamese

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Gated Incoming Relief Valves

- Designed to release all air coming into the pump from LDH
  - Must be opened manually
- Should be left open when the pumper is put back in service
- Newer type are self-closing
  - Paddle wheel closes the bleeder valve
- Female end comes in 4”, 4-1/2”, 5” or 6”
- Storz side comes in 4”, 5”, or 6”
- Older type pressure relief is on the pump side, not the hose side

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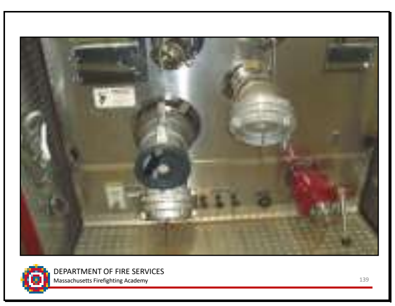
Slide 139



Slide 140

Relay Valves

- Z-Valve
- LDH inlet and outlet with 2 gated LDH valves and 1 clapper valve
- Used to increase the pressure in a long LDH relay
- Adapter to convert a Harrington hydrant assist valve into a relay valve

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Adapters

NPT TO NST / or size	2-1/2" NST to 3"
2-1/2" NST to 4" Storz	1-1/2" Double Male
4" x 5" Stortz	2-1/2" NST to 5" Storz
4-1/2" NST Female x 4" Storz	4-1/2" NST Female x 5" Storz
2-1/2" NST Female x 1-1/2" Male	2-1/2" Double Male
2-1/2" Plug Cap	2-1/2" Cap
Suction Caps	Reducer Caps

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Changeover Procedures

Step 1	Position the apparatus in a safe position, and immobilize it by setting the parking brake and blocking the wheels.
Step 2	Engage the pump and select the proper gear in the road transmission. Lock the gear into place.
Step 3	Open the tank-to-pump valve.
Step 4	Set the transfer valve to the SERIES (PRESSURE) position if necessary.
Step 5	Increase the throttle setting to obtain the desired pressure, priming if necessary.
Step 6	Set the relief valve or pressure governor.
Step 7	Open the circulator valve or partially open the tank fill valve.
Step 8	When an external water supply becomes available, reduce the discharge pressure by 50 psi. Open the intake valve while closing the tank-to-pump valve. Check the discharge pressure and adjust as needed. Readjust the pressure relief device. (If equipped with an electronic governor, the reduction of 50 psi will be approximately the needed discharge pressure when the incoming water source valve is opened completely and the bleeder valve closed) Remember the tank fill valve was opened in Step 7. Adjust the flow of the tank fill as needed. Readjust the throttle and check the setting of the relief device.
Step 9	Check to make sure the tank to pump valve is closed completely. The older pumpers may not be equipped with a check valve in the tank-to-pump line, causing the tank to back fill.

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Worksheets

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Types of Pressure

- Static
- Residual
- Normal operating
- Nozzle
- Friction loss
- Back
- Forward
- Line
- Engine pressure

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Explanations to follow in the next slides.

These pressure types are those which concern us in the fire service.

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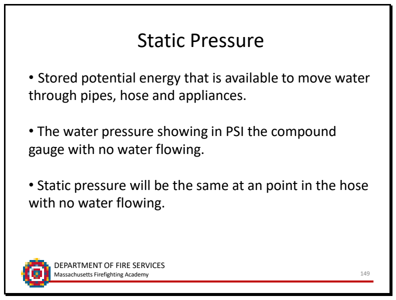
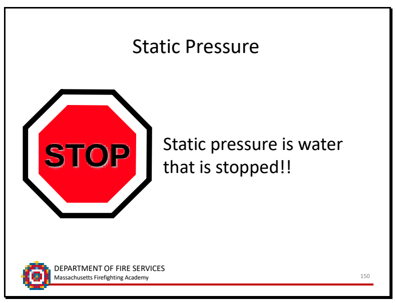


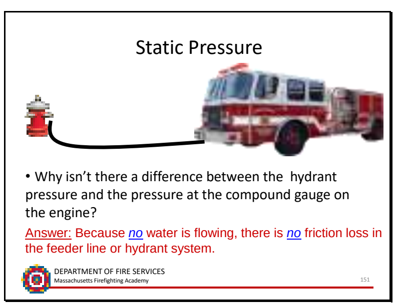
PSI is pounds per square inch.
Gauges may show a difference in static pressure due to elevation. A compound gauge AKA intake gauge displays positive and negative pressure.

Slide 150



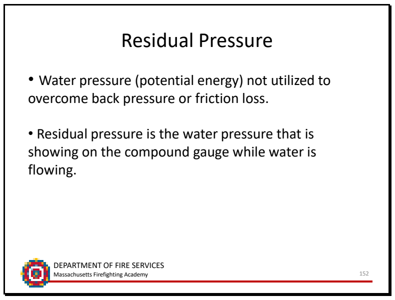
Pressure is created by the municipal or private property pressure source. This is pressure reflected on the intake/compound gauge with no water flowing. If you had hose laid out and not flowing with a gauge behind the nozzle, the same PSI would be reflected at the gauge as will be the intake /compound gauge. No water flowing.

Slide 151



The same PSI is exerted throughout the pump, and out any attack line or a supply line to another engine with no water flowing. The exception is when the nozzle is below the level of the pump.

Slide 152

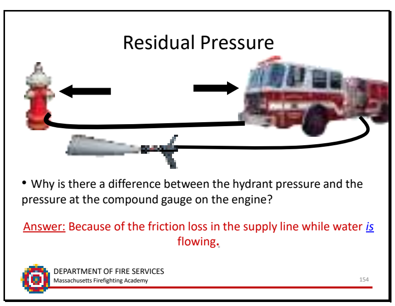


Residual pressure is the pressure left over and indicated on the intake gauge. Once water is flowing and the MPO looks back to the intake gauge, what we see now is residual pressure. The pressure which is still potentially usable, coupled with at this point an unknown water supply/GPM.

Slide 153

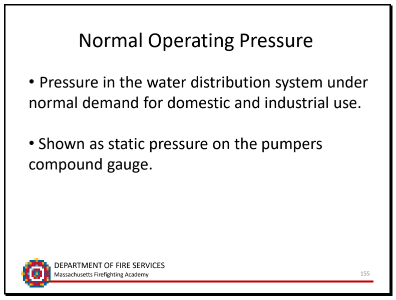
This pressure is with water flowing. PSI will be varied at any given point in the hose due to friction loss and changes in elevation.

Slide 154



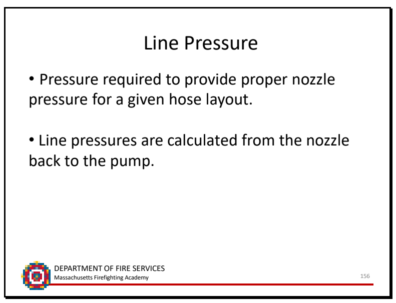
Once water is flowing there will be friction loss in the intake hose (and hydrant system) resulting in a lower residual pressure.
This will correspond to the amount of water flowing through the intake, more water, lower residual.
Don't let it go below 20PSI. (rule of thumb)
How can we help this situation out? Larger intake hose, add another intake hose and/or a shorter intake hose. Less required GPM. If that doesn't help what does this mean? Maxed out the water supply. Remember that each time we flow more water, the supply pressure and GPM decreases.

Slide 155



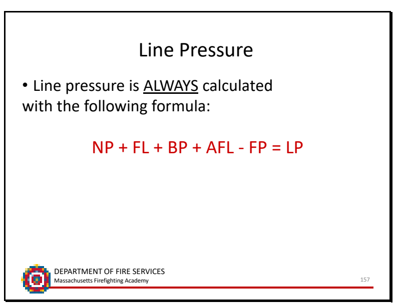
Usually consistent, know your area. This also includes the required fire flow for firefighting purposes in order to confine a major fire to the buildings within a block or complex.

Slide 156



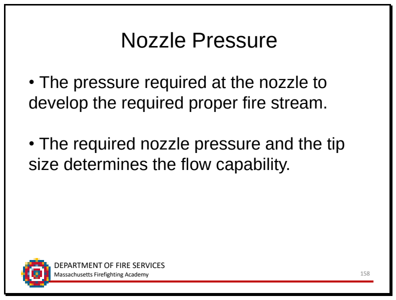
In the case of pre-connected lines the Line Pressures may be calculated in advance. With proper NP's the correct GPM will be delivered. The LP gives the most accurate number as it is directly linked to the discharge port. With only one line operating the EP and the LP will reflect almost the same pressure.

Slide 157



Nozzle Pressure + Friction Loss + Back Pressure – Forward Pressure = Line Pressure
We will NOT be getting into very much Appliance Loss today.
LP is usually calculated from the nozzle back to the pump – adding up are the types of loss to figure an accurate LP or EP or both if only 1 line is operating. In some cases there may be more than one LP.

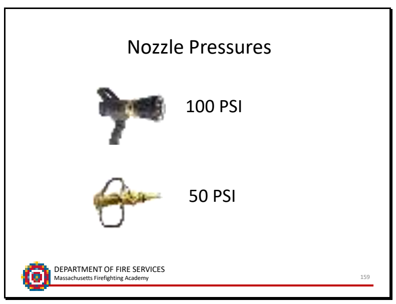
Slide 158



Ask the recruits if water will come out of the nozzle if we pump either toO low or too high of a nozzle pressure. The answer should be yes, however the reach, pattern and GPM will be affected. The proper nozzle pressure has been predetermined and allows the nozzle to operate at its most efficient levels.

If a nozzle is over pressurized the water droplets are atomized (made smaller). If the nozzle is under pressurized the water droplets are bigger. In either case the conversion takes longer if at all, more water is used more fire damage and we take a longer beating.

Slide 159

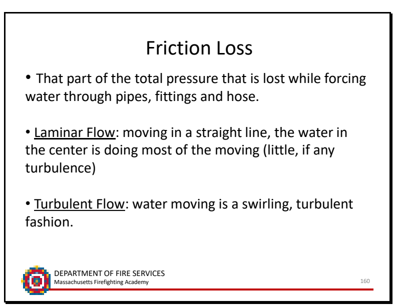


Newer combination nozzles may require a lesser nozzle pressure, break away and other low pressure nozzles will be covered later. Unless told otherwise, all combination nozzles will be 100 PSI. This does not reflect low pressure (75 PSI) nozzles or master stream solid stream nozzles.(later lecture)

Master stream SS nozzles are 80 PSI, follow up on this in the MS lecture.

Nozzle reaction is not a reaction of NP. Nozzle reaction is a reaction of the GPM flowing.

Slide 160



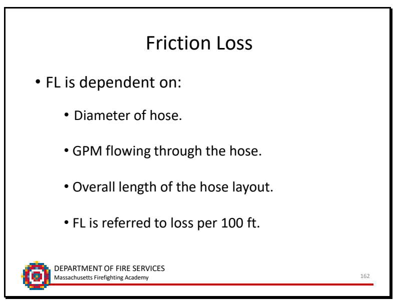
Draw a cross section of laminar flow and one of turbulent flow.

FL is a cost to us in reaching the required EP (LP). The longer the hose the more FL. The higher the GPM is over ECC the more FL is etc.

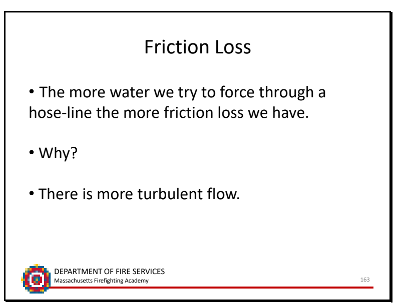
Slide 161

Turbulence = FL
The more turbulence, the more FL and less laminence. Once the FL is surpassed the turbulence increases drastically.

Slide 162



Slide 163



Friction loss increases proportionally as length increases, 200’ twice that of 100’.
Friction loss increases disproportionately as flow increases, 400 GPM 4x that of 200 GPM. (3” @ 200 GPM = 4 PSI per 100’, @ 400 GPM = 16 PSI per 100’ or 4 times.)
Very important to use the proper size line for the GPM required.
Friction loss effected by quality, age, and diameter of hose.
Also effected by sharp bends, partially open gates and valves.

Slide 164

Back Pressure

- Pressure exerted on a column of water due to gravity.
- Fire ground = 1 ft. of water = .5 PSI.
  .5 PSI raises water 1 ft.
- # of floors, minus 1, x 5 PSI.

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Rule of thumb is each floor is roughly 10', to raise water 10' it would take 5 PSI. So we can assume by rule of thumb that it takes 5 PSI to overcome each floor of elevation. REMEMBER that when we are on the first floor the nozzle is at or near 0' of elevation, it is not until we go to the second floor that we are now 10' up. This reflects that the pumper is also at this level.

Example: A water tank 100' high will expert what pressure at the base if it had a gauge attached to it? Actually 43.29 PSI, for fire ground hydraulics it will be 50 PSI, as referred to the fire ground hydraulics .5 PSI/1 foot of height.

Slide 165

Back Pressure

- How much back pressure if we are up 30'?
  15 PSI
- How much back pressure if we are at the 3rd floor?
  10 PSI

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If the height is given divide by 2 when a floor is given, disregard the 1st floor if and only if the pumper is on the same level, and then add 5 PSI/floor.

Slide 166

Forward Pressure

- Opposite of back pressure.
- Pressure gained due to the effects of gravity.
- Formulas are the same as back pressure except they work in our favor and subtract that PSI from the EP.

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Example: if the nozzle is 40' below the pressure source, ie: the pump, again divide by 2, 40/2 = 20 or 5 PSI per 10". This 20 PSI helps the pump or hydrant, or other sources of water pressure, when the discharge point (nozzle) is below the level of the pressure source, hydrant, and pump.

Slide 167

Appliance Friction Loss

•Appliance is a device that water flows through.

• Example: Gated wye.

• If the flow is less than 350 GPM there is no AFL calculated.

• Over 350 GPM it will be 10 PSI.

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Slide 168

Engine Pressure

• The highest pressure required by the engine to supply all the hose line options in use at the time will show on the master discharge gauge.

• It will be the same as the highest required line pressure.

• When only one line is in use the LP and the EP will be the same.

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The highest LP should be the same as the EP, however most line gauges are plumbed in at the farthest point and the main gauges are plumbed directly from the pump housing. The friction loss in the piping can cause a difference between gauges ie, if the line pressure is 160 PSI on one line and 145 PSI on another the EP should be 160 PSI, in reality the main gauge may read 170 PSI indicating the friction loss in the piping.

Slide 169

Pressure Source Evaluation
“Static/Residual Rule”

• This procedure allows the pump operator to determine water flow availability by comparing the static pressure to the residual pressure.

• Calculations are estimates only and will be determined by the pump operator.

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This is an important piece of information for the MPO – always try to maximize use of the discharge ports & intakes.

Crews might pull lines when no water is available, or the chief might call for extra lines if the operator doesn’t understand this rule, it can be lethal to operating attack lines a building.

Slide 170

"Pressure/Residual Rule"

- Begin with determining the static pressure.
- Observe the residual pressure after water is flowing.
- Calculate the % drop based on the static pressure.
- Determine the available GPM.

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NOTE! If asked how we figure this when water is already flowing or unsure of original static pressure – say it is operator judgment and experience, based on the PSI drop when the second line is charged. This can be difficult to do. Try to know what PSI or GPM's are in your district.

100 S PSI
90 R PSI
10 used PSI

Slide 171

Pressure Source Evaluation

- 0 – 10 % drop = 3 more lines of the same GPM
- 11 – 15 % drop = 2 more lines of the same GPM
- 16 – 25 % drop = 1 more line of the same GPM
- Over 25 % drop = no more lines of the same GPM, (maybe more GPM but less than the original)

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Finding 10% is easy, add half back to that number for 15%, add the original number to that for 25%.

10% - take original PSI, move decimal point once to the left (ex. 80 PSI = 8 PSI)
15% - do above and add ½ of that answer to the above answer (ex. 8 PSI plus ½ of 8 PSI (or 4 PSI), = 12 PSI)
25% - add original answer to the above answer (ex. 12 PSI plus 8 PSI = 20 PSI)

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Example

- The static pressure was 100 PSI and the residual pressure is 85 PSI.
- How many PSI drop was it ? 15 PSI
- What was the percentage ? 15 %

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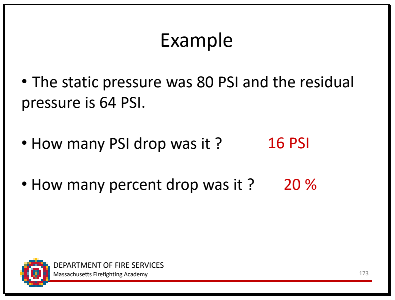
Finding 10% is easy, add ½ back to that number for 15%, add the original number to that for 25%.

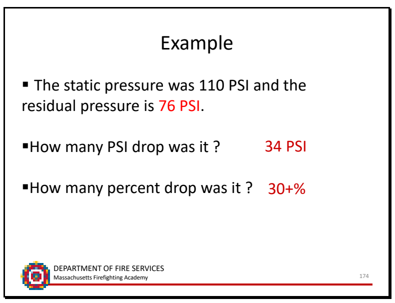
What category is this
0-10%
11-15%
16-25%
25+%

Slide 173



Note: whatever the PSI drop, is what it took to deliver the GPM that is flowing.

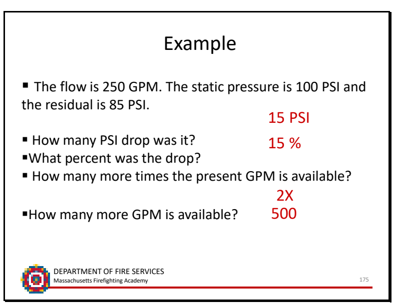
Slide 174



Note: For classroom work, if a RFF wants to accurately compute the % loss. Divide the PSI drop by the original hydrant static PSI

34.0 divided by 110 = .30909

Slide 175



Note for Instructor: If necessary take a few minutes and do this out long hand on the easel board.

0-10% = 3 more equal GPM’s
11-15% = 2 more equal GPM’s
16-25% = 1 more equal GPM
25%+ = 0 more

This hydrant used 15 PSI to deliver 250 GPM. There are 500 GPM’s more to use and a total GPM of 750 gallons per minute.

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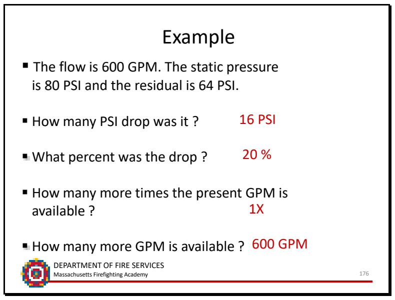
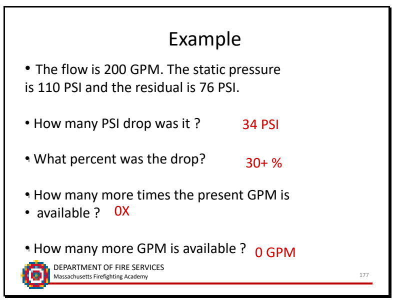


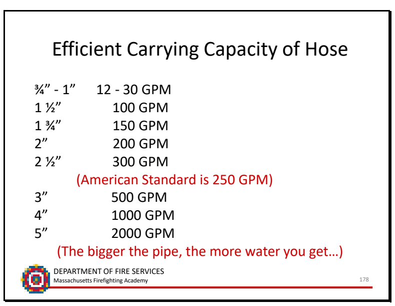
0-10% = 3 more equal GPM’s
11-15% = 2 more equal GPM’s
16-25% = 1 more equal GPM
80 S PSI
<u>64 R PSI</u>
16 PSI used to deliver the original 600 GPM.
20% of 80 = 16. These numbers match.
Only 1 more equal GPM is available for a total of the original 600 GPM & 600 GPM more = 1200 GPM.

Slide 177



This hydrant depicts a high static PSI but every low GPM.
Pre-fire planning is extremely important.
Knowing every bit of information as possible in your district or town is very important as to the outcome of a fire, etc.

Slide 178



Hose can deliver more GPM than listed but friction loss goes up fast making long lays inefficient, causing excessive EP’s/LP’s.

Slide 179

1 ½” and 1 ¾” Friction Loss

Flow	1 ½”/ 100’	1 ¾”/ 100’
50	10	5
80	20	10
100	30	15
125	50	25
150	----	30
200	----	60

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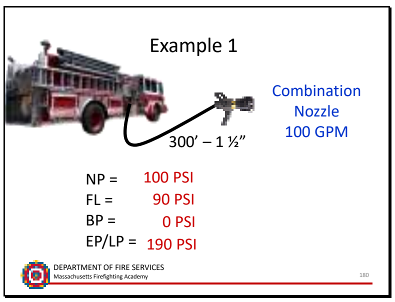
ECC is 100 GPM for 1-½, and 150 GPM for 1-¾, both 30 PSI per 100’. The FL is the same, except there is 50 GPM more from the 1 ¾”

Slide 180



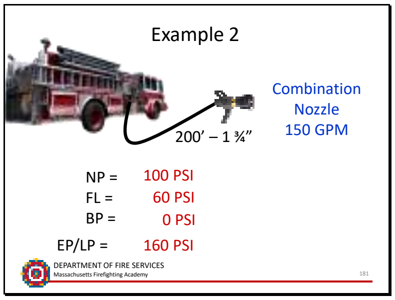
Combination Noz = 100 PSI; 1 ¾’ hose@ 150 GPM equals 30 PSI/100 x 2 100’ lengths = 60 PSI,

NP = 100 PSI
FL = 60 PSI
BP = 0
EP/LP = 160 PSI

To deliver the required GPM in a given problem, we need to use proper fire ground hydraulics.

Example, if a fire requires 300 GPM to extinguish and we deliver less, yes the will eventually go out; but at a greater loss to the building, mv, airplane, etc.

Slide 181



Combination Noz = 100 PSI; 1 ¾' hose@ 150 GPM equals 30 PSI/100 x 2 100' lengths = 60 PSI,

NP = 100 PSI
FL = 60 PSI
BP = 0
EP/LP = 160 PSI

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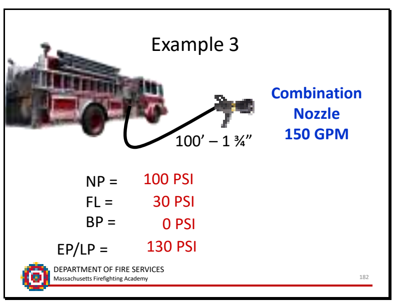
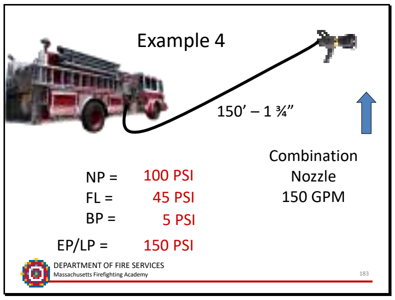
Example, if a fire requires 300 GPM to extinguish and we deliver less, yes the_will eventually go out; but at a greater loss to the building, mv, airplane, etc.

Slide 182



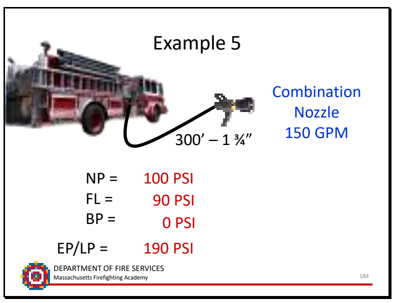
Combination Nozzle, 100 PSI, FL in 1 ¾' hose @ 150 GPM = 30 PSI per 100 ft X 1 – 100 ft length = 30 PSI.
NP = 100 PSI
FL = 30 PSI
BP = 0
EP/LP = 130 PSI

Slide 183



MENTION: if no flow is given always use efficient carrying capacity, for any size hose. In this problem, we added a new variable BP – back pressure. This Q gives 10' of elevation or 5 PSI of BP. When the height/ elevation is given divide that number by 2, and this will give the MPO the BP PSI.

Slide 184



Please ask RFF's if they are getting this. If not try a few more minutes with examples, if possible.

Combination Nozzle, 100 PSI, FL in 1 ¾' hose @ 150 GPM = 30 PSI per 100 ft X 3 – 100 ft lengths = 90 PSI.

NP = 100 PSI
FL = 90 PSI
SP = 0
EP/LP = 190 PSI

Slide 185

Efficient Carrying Capacity
of 2" Hose – 200 GPM

Flow	Fl/100'
100 GPM	6
150 GPM	15
200 GPM	25
250 GPM	40
300 GPM	55

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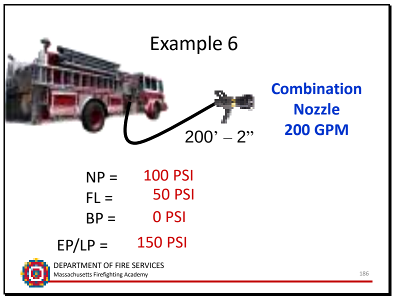
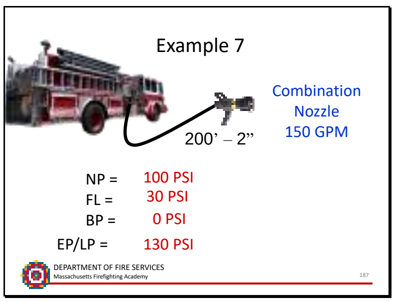
Slide 186



Repeat his method for each example:
A combination nozzle = 100 PSI, FL in 2” hose @ 200 GPM = 25 PSI etc.
100’ x 2 – 100’ lengths = 50 PSI

NP = 100 PSI
FL = 50 PSI
<u>BP = 0</u>
EP/LP = 150 PSI

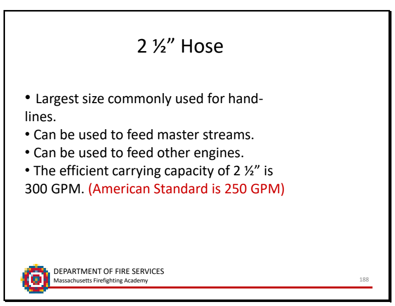
Slide 187



A combination nozzle = 100 PSI, FL in 2” hose @ 150 GPM = 15 PSI
100’ x 2 – 100’ lengths = 30 PSI

NP = 100 PSI
FL = 30 PSI
<u>BP = 0</u>
EP/LP = 130 PSI

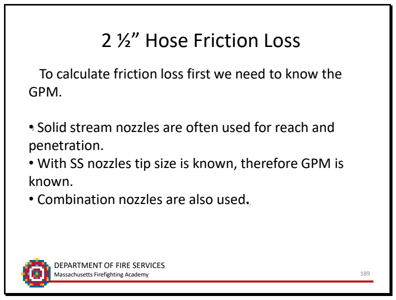
Slide 188



The workhorse of the American Fire Service. Also referred to as “THE BIG LINE”.
The Standard Fire Service stream from the 2 ½” hose is 250 GPM.

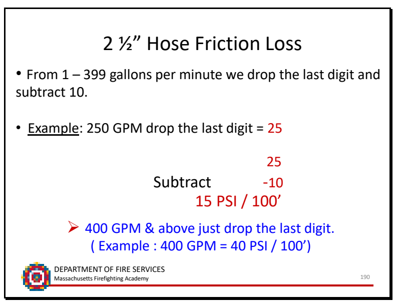
When given a Q with 2 ½’ hose we almost always will give the GPM. If GPM is not given use the ECC.

Slide 189



Constant gallonage.
Adjustable gallonage.
Briefly discuss Freeman's experiments for most efficient nozzle, solid bore, cylindrical length is 1-½ times the diameter. No larger than ½ the hose diameter.
Standard fire ground stream which all others were built upon 2-½ hose, 1-1/8 solid tip, 50PSI, 250GPM for hand lines.

Slide 190

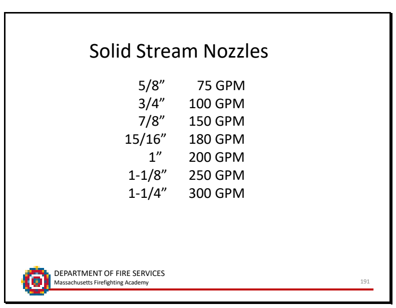


Fire ground hydraulics are a simpler way, not exact but close enough.
This is why we change at 400 GPM, to get back on track with more precise formulas.

So, when GPM for 2 ½” hose is given, drop the last digit and reduce the remaining digits by 10.

300, 100, 200, 240 whatever, follow this rule

Slide 191

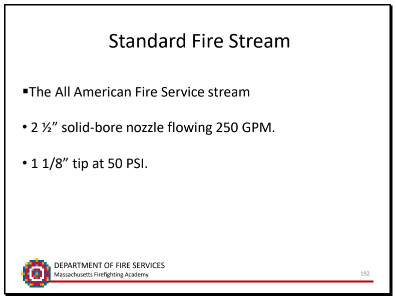


*Standard American Service Fire Stream hand line each 1/8” = 50 GPM @ 50 PSI for hand lines.
Tip size relates to efficient carrying capacity of the hose, tip size ½ that of hose diameter

¾” – 100GPM – 1 ½” hose
7/8” – 150GPM – 1 ¾” hose
1” - 200GPM – 2” hose
1 ¼” – 300GPM – 2 ½” hose

Freeman experiments, 2 ½”, 1 1/8” tip, 50 PSI
Most common are 1”, 1 1/8”, 1 ¼”

Slide 192

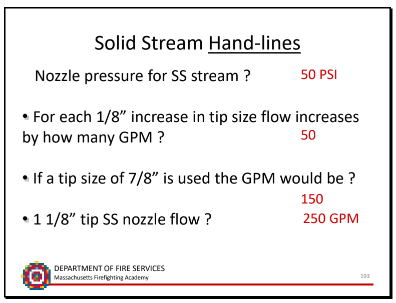


The maximum reach for a solid stream is 32 degrees from the earth's surface with a range of 150 ft., 30' maximum elevation.

The higher the angle the less of a reach.

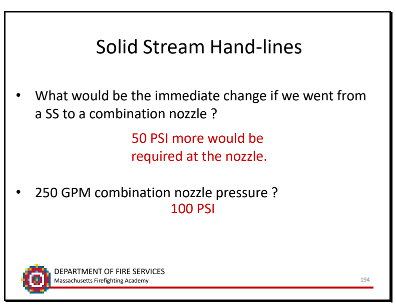
60 degrees = 120' at 80' maximum elevation.
75 degrees = 70' at 95' maximum elevation.

Slide 193



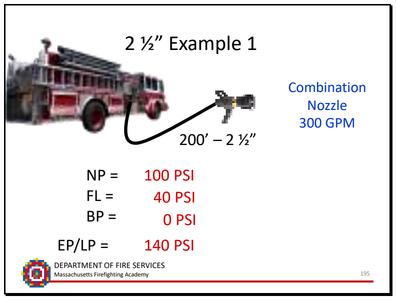
Ask – all combinations are <u>100</u> PSI
- all hand lines with SS nozzles are <u>50</u> PSI

Slide 194



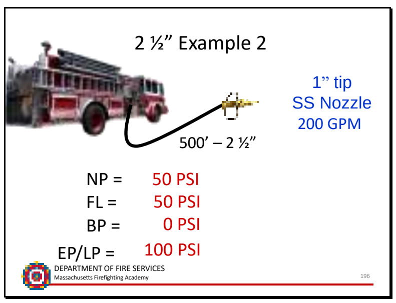
Why, because a combination nozzle requires 100 PSI, 50 PSI more than a SS nozzle.

Slide 195



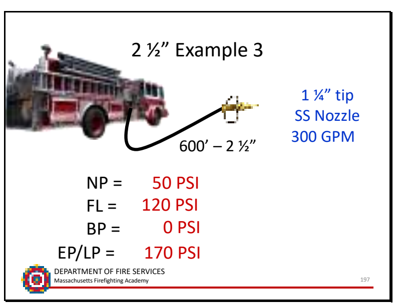
Combination nozzle = 100 PSI, FL in 2 ½" hose @ 200 GPM, drop the last digit, reduce by 10 = 10 PSI
100' x 2 – 100' lengths = 40 PSI.
NP = 100 PSI
FL = 40 PSI
<u>BP = 0</u>
EP/LP = 140 PSI

Slide 196



A solid stream hand line nozzle requires 50 PSI, FL in 2 ½" hose @ 200 GPM, drop the last digit, reduce by 10 = 10 PSI
100' x 5 – 100' lengths = 50 PSI.
NP = 50 PSI
FL = 50 PSI
<u>BP = 0</u>
EP/LP = 100 PSI

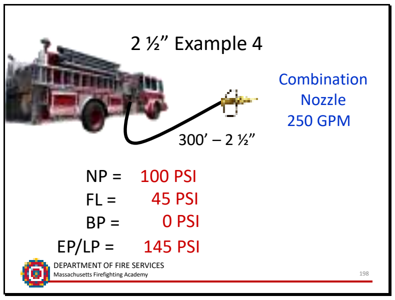
Slide 197



A solid steam hand line nozzle = 50 PSIFL in 2 ½" hose @ 300 GPM, drop the last digit, reduce by 10 = 20 PSI FL per 100' X 6 – 100' lengths = 100 PSI.

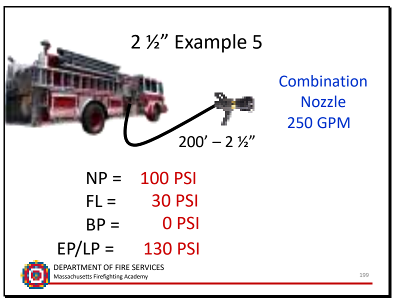
NP = 50 PSI
FL = 120 PSI
<u>BP = 0</u>
EP/LP = 170 PSI

Slide 198



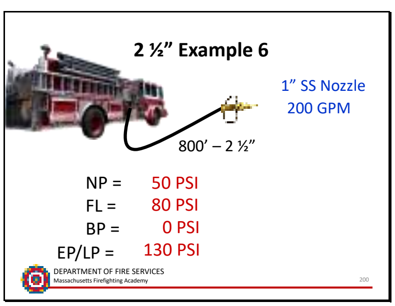
Combination nozzle = 100 PSI.
FL in 2 ½" hose @ 250 GPM, drop the last digit, reduce by 10 = 15 PSI
100' x 3 – 100' lengths = 45 PSI. NP = 100 PSI
FL = 45 PSI
<u>BP = 0</u>
EP/LP = 145 PSI

Slide 199



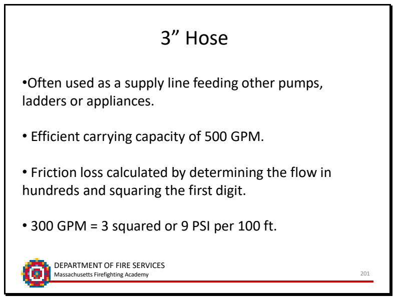
For testing, when no flow is given, use efficient carrying capacity of the hose size given in the question
Combination nozzle = 100 PSI.
FL in 2 ½" hose @ 250 GPM, drop the last digit, reduce by 10 = 15 PSI
100' x 2 – 100' lengths = 30 PSI.
NP = 100 PSI
FL = 30 PSI
<u>BP = 0</u>
EP/LP = 130 PSI

Slide 200



A solid stream hand line nozzle = 50 PSI.
FL in 2 ½" hose @ 200 GPM, drop the last digit, reduce by 10 = 10 PSI
100' X 8 – 100' lengths = 80 PSI.
NP = 50 PSI
FL = 80 PSI
<u>BP = 0</u>
EP/LP = 130 PSI

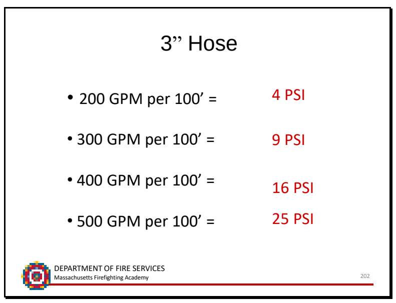
Slide 201



It is important to remember that the 1st digit is squared, or multiplied by itself.

300 GPM 3 X 3 = 9
450 GPM 4 X 4 = 16
580 GPM 5 X 5 = 25

Slide 202

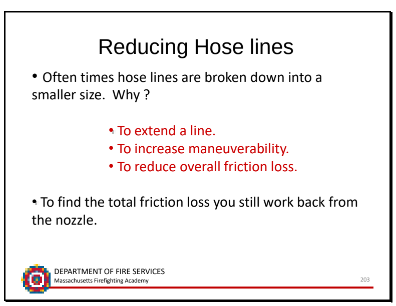


FL in 3” hose @ 200 GPM = 2 X 2 = 4 PSI
100’ x 100’ Length = 4 PSI

300 GPM = 3 x3 + 9 PSI per 100’ x 1 - 100’ Length = 9

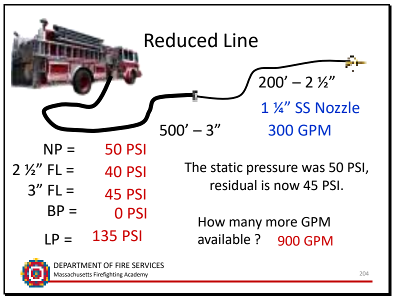
Etc.

Slide 203



*MENTION: “reduced overall friction loss” explain that to avoid the friction loss in 600’ of 1 ¾ we could have 500’ of 2 ½ then reduce down to 1 ¾.
Have them figure 600’ 1 ¾ @ 150 GPM = 180 PSI.
500’ of 2 ½ + 100’ 1 ¾ = 500’ 2 ½ = 25 PSI + 30 PSI for 1 ¾ = 55 PSI total.

Slide 204

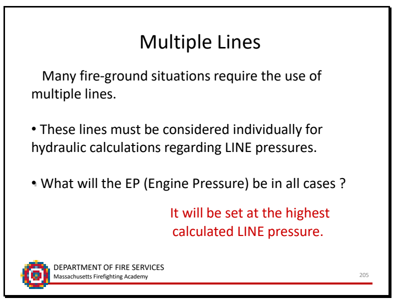


	TF = Total flow/GPM
	TF = 300 GPM
	NP = 50 PSI (SS Nozzle)
2 ½"	FL = 40 PSI
3"	FL = 45 PSI
	EP = 135 PSI

Whatever the TF/GPM being delivered, must be flowing in any and all hose behind the nozzle.

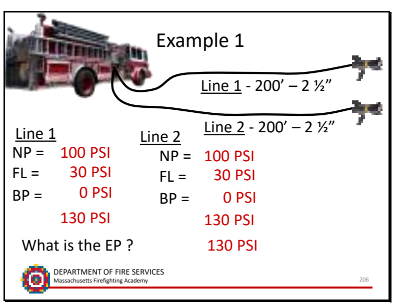
Lecturer, be clear that one FL is the 2 ½" hose, and the other FL is the 3" hose.

Slide 205



Each line will be calculated individually.
ASK-If two or more lines are of the same layout do we need to do any other calculations after the first line?
ASK-Where will the pressure relief valve be set? (at the highest pressure, from the master discharge gauge).
ASK-As we charge each line what will happen to the current discharge pressure? It will drop.
ASK-What will the pump operator have to do at this time? Throttle up.
ASK-What will happen to the residual pressure as each line is charged? It will drop.
What must the driver NOT allow? Residual to drop below 20 PSI.

Slide 206



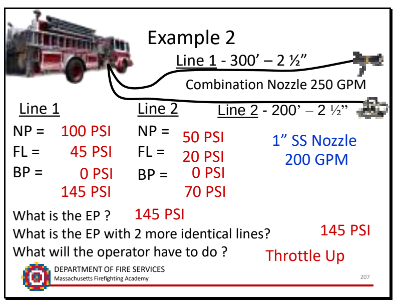
What would the discharge pressure be? 130 PSI.
What is the total flow? 500 GPM. Each line has 250 GPM.

Both lines are equal in length, GPM and NP.
FL in 2 ½" hose @ 250 GPM, drop the last digit, reduce the remaining numbers by 10 = 15 PSI
100' x 2 – 100" lengths = 30 PSI.

L-1	NP = 100 PSI (combo nozzle)
	FL = 30 PSI
	BP = 0
	AFL= 0
	FP = 0
	EP/LP = 130 PSI

L-2 NP = 200 PSI
FL = 30 PSI
BP = 0
AFL= 0
FP = 0
EP/LP = 130 PSI

Slide 207



This example is a little different.

What would the discharge pressure be? 145 PSI.
ASK-What will the pressure relief valve be set at? 145 PSI.
ASK-How will the operator get line two set to 70 PSI. Gate back, the lesser pressure line.

As you can see L-1 is longer, has a combination nozzle and a higher GPM than L-2, therefore there are difference in the LP's.

The main pump gauge is @ 145 PSI.

What will the MPO have to do to L-2? Gate back, when we gate back, pressure is increased inside the pump and we will have to throttle down to keep the higher pressure line @ 145 PSI.

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Gated Wyed Lines

- There are several reasons to have wyed lines:
  - Additional lines off limited discharges.
  - Fill in a long lay with one large line to reduce friction loss.
  - Breaking down one large line into multiple smaller lines after initial knockdown.

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Gated Wye

- When wyed lines are of the same size, length and GPM, what will the required line pressures of the wyed lines be ?

The same PSI.

- When wyed lines are of different size, length and/or GPM, the exact calculations become difficult without individual line gauges at the gated wye.

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If you come across a gated back wye leave it alone, someone may have gated it back for the lesser pressure line.

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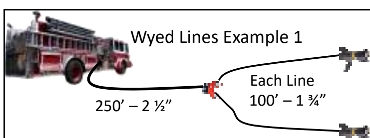
Wyed Lines Example 1



NP	=	100 PSI
2 ½" FL	=	65 PSI
1 ¾" FL	=	40 PSI
AFL	=	10 PSI
BP	=	0 PSI
LP	=	215 PSI

Each Nozzle
180 GPM
Combination

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The wye has friction loss 0 – 349 GPM = 0 PSI, 350 GPM and above = 10 PSI of appliance loss, AFL.

What is the TF/GPM? 300 GPM. Therefore there is 300 GPM being delivered thought the 2 ½" hose. Is there any AFL? No under 350 GPM.

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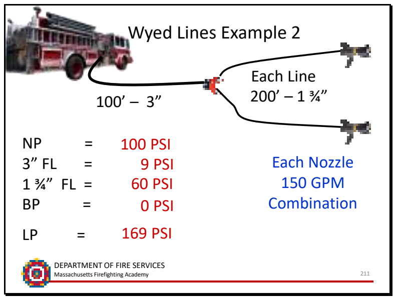
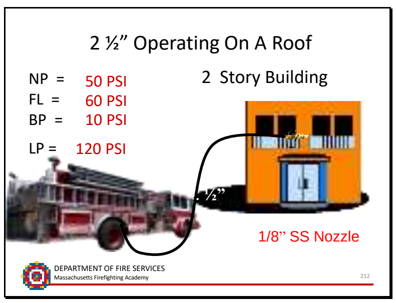


TF/GPM = ? 300 GPM

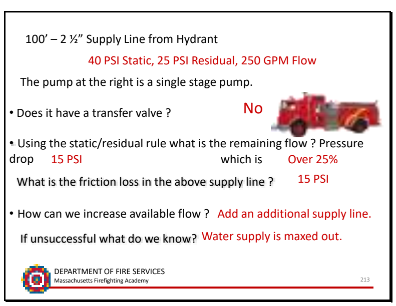
Slide 212



If the pump is on the same level as the 1st floor – do not count the 1st floor as 5 PSI BP! Because the line is operating off the roof, the BP is 5 PSI for the 2nd floor and 5 PSI for the roof.

Remember if you are given the height in feet – divide by 2 for the answer.

Slide 213



No.
Remember we're nearing the 20 PSI residual rule.
Increase flow by adding or increasing size of intake lines.
If it does work the problem was in the hose not the hydrant.

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References

- Hale Pumps
- IFSTA
- NFPA
- Waterous Pumps

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References

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One last point every pump operator needs to understand –

YOU run the pump.

Don't let the pump run you.

What are the gauges telling you?

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Pump Panel Tells a Story

- Understand what the gauges are indicating.
  - Compound Intake and Discharge Gauges
  - Individual Line Gauges
  - Tachometer
- You don't always have to react to a pump change.
  - Did you "create" the current issue?
  - Is it isolated to one line, or every line?
  - Is it an incoming water issue?
  - Bail closed – bail half closed – flowing?
  - Kink in line?

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Pump panel story – Compound Gauge registers pressure ONLY when there is outside water being fed to pump. Feeder line.

Master Discharge Gauge will tell you the HIGHEST pressure the pump is set. Line gauges show individual line pressures.

Tach – reacts to demand for more lines pushing water. Less rpm's needed as lines close down. LET THE E-GOVENOR DO ITS JOB.

Gauge changes – closed bail will have line gauge go to the max pressure set on the pump. A partial rise in the pressure can indicate a partially closed bail or a kink.

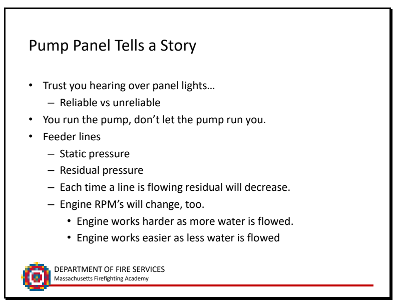
Incoming water problem ALL lines will be effected. Pump operator should shut-down low priority lines such as exposure lines.

DON'T SHUT DOWN LINES WITH PEOPLE IN THE BUILDING.

Stabilize a partial water loss. Don't resort tank water if only a partial loss of incoming water. Save it in case you lose everything.

REMEMBER TO COMMUNICATE CHANGES LIKE THIS TO COMMAND.

Slide 217



Reliability of lights can be shaky. They do burn out. When changing from Road to Pump the pitch change sound is the most reliable indicator the pump is engaged.

Talk about the "air-bound" pump. No water in pump cavity will register as zero pressure on the Master Discharge gauge. Prime pump first to get water in pump.

Feeder line – Static pressure is when you first open the incoming gate. Residual shows on Intake and changes each time a line is open and closed.

Same goes for the RPM's, as lines are open and closed the RPM's will change. Increase RPM's mean more lines are opened and pushing water. RPM's reduce and residual will increase as lines close.

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For more information, contact:

Stow, Massachusetts 01775
Phone: 978-567-3200
Fax: 978-567-3229
Website: mass.gov/dfs

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[Grab your reader's attention with a great quote from the document or use this space to emphasize a key point. To place this text box anywhere on the page, just drag it.]

Thank You
&
Stay Safe

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Slide 135
The End

Resource Guide

RESOURCE GUIDE

Hale Fire Pump Company 700 Spring Hill Road Conshohocken, PA 19428 800-220-4253 www.haleproducts.com	*National Fire Protection Association* 1 Battery March Park Quincy, MA 2169 800-344-3555 www.nfpa.org
W.S. Darley & Company 2000 Ansen Drive Melrose Park, IL 60160 800-323-0244 www.edarley.com	*IFSTA* Oklahoma State University Stillwater, OK 74078 800-654-4055 www.ifsta.org
Waterous Company 300 John E Carroll Way South Saint Paul, MN 55075 612-450-5000	*National Transportation Safety Board* 1490 L''Enfant Plaza, SW Washington, D.C. 20596 202-314-6000 www.ntsb.gov
Elkhart Brass 1302 West Beardsley Avenue Elkhart, IN 46515 1-900-346-0250 www.elkhartbrass.com	*Volunteer Fireman's Insurance Services* PO BOX 2726 York, PA 17405 800-233-1957
Akron Brass Company PO Box 86 Wooster, OH 44691 800-228-1161 www.akronbrass.com	*Department of Fire Services* *Massachusetts Firefighting Academy* PO Box 1025 – State Road Stow, MA 01775 978-567-3200 www.mass.gov/dfs
Task Force Tips 2800 East Evans Valaraisio, IN 46383 800-348-2686	*Massachusetts Registry of Motor Vehicles* 100 Nashua Street Boston, MA

Glossary of Terms

Absolute Pressure: True pressure that is equal to Atmospheric pressure and gauge pressure.

Acceptance Test: Pumper service test conducted by a third party (Underwriter's Laboratories etc.) that determines the pump's ability to work.

Air Hammer: Air that precedes water in the line; compressed air can exert excess pressure on hose and equipment.

Air Pressure Gauge: Shows the amount of air pressure available in the braking system.

Air Priming System: Device used in pulling water from a source (i.e. tank, or drafting site) displacing air with water in the fire pump.

Altitude: The geographic position of a location in relation to sea level.

Ammeter: Shows the amount of current flowing in and out of an electrical system.

Anode System: Helps to prevent damage caused by galvanic corrosion within the pump. Sacrificial metal which helps to diminish and prevent pump and pump shaft galvanic action. The Hale system requires 4 bolts and a gasket. The other type is a round installed in the suction tube. This is not a screen, but a sacrificial anode.

Approved: Acceptable to the Authority Having Jurisdiction.

Atmospheric Pressure: Pressure that is exerted down by the weight of the air in the atmosphere (14.7 psi at sea level). The pressure increases as the elevation is decreased below sea level and decreases as elevation increases above sea level.

Authority Having Jurisdiction: Refers to the organization, office, or individual responsible for approving equipment, installations and/or procedures.

Automatic Nozzle: A combination nozzle that has a spring activated sensing unit to deliver 100 psi at the tip without losing the pattern.

Auxiliary Cooling Valve: Allows water from the pump to cool the radiator water through a heat exchanger.

Back Pressure: Pressure exerted by the elevation of water above the pump.

Baffles: Interior panels of a water tank that prevent the water from surging.

Ball Distributor Valve: A simple way to feed multiple small lines with one large line.

Barrel: On a hydrant, conducts water from the foot piece to the bonnet.

Bonnet: The top of the hydrant, protects the operation valve from damage.

Bourdon Tube: A hollow tube which activates a pressure gauge.

British Thermal Unit: The amount of heat energy required to raise the temperature of one pond of water by one degree Fahrenheit.

Broken Stream Nozzle: A nozzle that produces coarsely divided drops of water.

Capacity: See Parallel Stage

Cavitation: Caused by the pump attempting to deliver more water than it is supplied with.

Centrifugal Force: A force which tends to make rotating bodies move away from the center of rotation.

Centrifugal Pump: A pump that creates pressure by rapidly spinning a disk to create pressure for water movement.

Chauffer: Another term for apparatus driver.

Check Valve: A one-way valve that does not allow water to move in the wrong direction.

Cistern: A tank normally found in the ground to store water

Combination Nozzle: A nozzle that can be adjusted to different patterns.

Compound Gauge: A gauge that indicates both positive and negative pressures.

Control Valve: A valve that regulates flow of water into a standpipe or sprinkler system.

Dead End Main: A water main that is not connected to any other main.

Defensive Mode Attack: An all exterior fire attack when the fire flow is not sufficient or when the building is lost.

Deluge System: A sprinkler system which delivers water to a large area all at once.

Direct Attack: The fire attack when the stream of water is directed directly on the burning fuel.

Discharge Pressure: Shows the highest pressure the pump is delivering.

Distribution Mains: A series of small pipes that feed individual streets or service areas.

Domestic Consumption: Water consumed from the water distribution system by residential or commercial properties.

Double Action Pump: A type of piston pump that discharges water while the piston moves in either direction. These are now used on some Class A foam systems.

Drafting: Taking water from a static source via a pump.

Dry Barrel Hydrant: A hydrant drains its barrel after the water is shut-off.

Dry Hydrant: A permanently installed pipe that is designed for drafting purposes at a static source.

Dry Prime Test: Provides information on the pump's ability to evacuate air and draft water.

Dual Pumping: Connecting two pumps together intake to intake; so the second pumper can receive the excess water from the hydrant.

Dynamic Suction: Suction lift – the sum of the vertical lift, friction loss and entrance loss due to the flow through suction hose and strainers.

Elevated Storage: Water storage reservoir located well above the discharge point to take advantage of head pressure.

Energy: The capacity to do work.

Exhaust Primer: Primer that uses a venturi principle of fast flowing exhaust gases to remove air from the pump. This is used on portable pumps.

Eye: The part of the impeller where the water enters.

Fill Site: The location where tankers will be filled during water shuttle.

Fire Flow: The total quantity of water available for firefighting in a given area.

Fire Stream: A stream of water or other agent between its leaving the nozzle and reaching the desired point.

Flap Valve: A valve, which controls the flow of water inside a multi-stage pump.

Flinger Ring: Prevents water from continuing to travel along the impeller shaft to the gears and ball bearings of the pump.

Flow Pressure: Forward velocity pressure at a discharge opening.

Forward Pressure: Pressure that is gained when the discharge is below the supply.

Four Way Hydrant Valve: An assembly used on a hydrant to increase the pressure in the supply line. Used with large diameter hose.

Friction Loss: Part of the total pressure that is lost when forcing water through pipes, hoses, fittings etc.

Front Mount Pump: A pump that is mounted ahead of the engine on a front engine type of apparatus.

Gauge Pressure: A pressure above atmospheric.

Governor: Minimizes pressure changes by controlling engine speed.

Grid: A series of different size piping which are connected to make a water distribution system.

Hard Suction Hose Line: A flexible hose that is set in its shape normally used for drafting.

Head: Height to which a given pressure will elevate water.

Horse Power: The amount of work an engine will provide.

Hose Bridges: A device used to allow vehicles to drive over hose without damage to hose or cause a water hammer.

Hose Rollers: An inexpensive tool used to roll out air in large diameter hose.

Hour Meter: Indicates the hours the engine and or the pump runs for. It is used primarily for maintenance scheduling.

Hydraulics: The study of fluids.

Hydrostatics: The study of fluids at rest.

Hydrokinetics: The study of fluid in motion.

ISO (Insurance Service Organization): An organization that provides information to insurance companies about individual towns and their ability to protect life and property.

Impeller: Part of the pump that produces the motion of water.

Incrustation: Found in water mains that increase resistance for water to flow by lining the interior of the pipe.

Inertia: A force that keeps moving objects in motion until acted upon by another force.

Jet Siphon: A section of pipe or hard suction with a 1-1/2" hose line used to increase the flow of water through the hose. Used between two portable tanks.

Kinetic Energy: Energy in motion.

Laminar Flow: Water movement in a straight line.

Line Gauge: Indicates pressure in individual line at a given place.

Line Pressure: Pressure needed to provide proper nozzle pressure with a given hose layout.

Looped Main: Cross-connected water main.

Manifold: Also referred to a s ball distributor valve, normally has one 4" or 5" discharge with 2 or more smaller ones. Can have up to (4) 2-1/2" discharges and (2) 4" or 5" discharges.

Master Stream: Master streams or heavy streams are those with discharges from appliances using tips larger than 1-1/4" in size.

Master Intake Valve: A butterfly valve built into the suction tube eliminating the bulky valve hanging from the running board. It also can be mounted in the front and rear suction tube. The MIV has a built in air bleeder.

Midship Pump: When the pump is located halfway between the front and the rear of the truck.

MPO (Motor Pump Operator): An operator of pumping fire apparatus.

Needle Valve: Installed on a gauge to permit a steady reading without vibration.

Negative Pressure: Pressure below atmospheric

Net Pump Pressure: The combined total pressure developed by the pump.

NFPA (National Fire Protection Association): An organization responsible for setting standards for fire protection.

Nozzle Pressure: The pressure required at the nozzle to develop a proper fire stream from a nozzle of given design.

Nozzle Reaction: Force found at the nozzle resulting from a jet action or discharge; also known as kickback.

Nurse Tanker: A large water tanker normally 4000 gallons or more that serves as a portable reservoir.

OS & Y (Outside Screw and Yoke): Outside stem and yoke valve used to control water supply to a sprinkler system.

Odometer: Records the distance the apparatus traveled in miles. Sometimes this will continue to record if the truck is in pump.

Offensive Attack Mode: An interior attack aimed directly at the base of the fire.

Oil Pressure Gauge: Measures the amount of pressure lubricating the engine. It does not show the amount of oil.

Operating Pressure: Pressure through the water distribution system during normal consumption demands.

PIV (Post Indicator Valve): A valve used on a sprinkler system that shows the on and off position in letters.

Packing: Allows the impeller shaft to pass from the outside of the pump to the inside while maintaining a tight seal.

Parallel Stage (Volume): Capacity position – when each of the two impellers on a pump work independently of each other.

Piston Pump: A positive displacement pump with a piston that moves back and forth to deliver water. (Ahrens Fox)

Pitot Gauge: A tool used to measure the velocity pressure at the tip of a nozzle.

Positive Displacement Pump: A pump in which the volume of space within the pump determines the amount of water in which the pump can deliver in one stroke or revolution.

Positive Pressure: Pressure above atmospheric pressure.

Pressure: Force per unit of area.

Pressure gauge: The pressure gauge is usually graduated in pounds per square inch only. It is connected to the discharge manifold, thus indicating discharge pressure.

Primary Main: Large diameter main which brings water from the source to the area being served.

Priming Pump: A positive displacement pump which creates a vacuum to prime the main pump. These pumps are now primarily rotary vane.

PTO (Power Take Off): The use of the engine that powers the wheels of a vehicle to power a secondary machine (pump).

Radiator Fill Valve: Permits water to enter the radiator directly from the pump at pump pressure.

Relay: The movement of water from a pumper at a water source through additional pumpers until the water reached the fireground.

Relief Valve: An automatic valve that will hold the pump speed and pressure steady when discharging valves or shut-off nozzles are closed. The system maintains the pressure by dumping the pump discharge flow back into the pump suction.

Residual Pressure: Kinetic energy that is available to perform work.

Rotary Gear Pump: A pump that uses two gears meshed together to move water or fluids. This is an older style pump that is not currently in use.

Rotary Vane Pump: A pump that has vanes that slide out to seal against the pump housing. Used as a priming pump with centrifugal pumps at draft.

SOG or SOP: A written statement on how an organization will function administratively and operationally.

Secondary Mains: An intermediate size water main used to supply a large section or service area in the water distribution system.

Sedimentation: A buildup of mud, clay, leaves etc. found in water supply mains.

Semi-automatic Priming Valve: Replaces the standard priming valve activated by a single push button which activates the priming motor creating a vacuum. The vacuum acts as the diaphragm in the valve causing the port to open and allow priming.

Series (Pressure): The impellers act in a series to develop pressure creating a two-stage pump. The discharge of one impeller goes directly into the suction of the other.

Service Test: A pumper service test is performed to determine if the pump can deliver at its rated volume and pressure.

Shrouds: Sides of the impeller which confine the water.

Siamese: Combines two or more lines into one. Has one male end and two or more female connections.

Single Stage (Pressure): See Series.

Siphon: A system used to keep two or more portable tanks at equal level.

Solid Stream Nozzle: A solid stream is a fire stream produced from a fixed orifice smooth bore nozzle. A powerful long range high volume stream for reach and penetration into the heat of the fire.

Staging Area: An area away from the scene where apparatus and personnel report to get their orders.

Static Pressure: Stored potential energy that is available to move water through pipes, hoses and appliances.

Static Source: An area of water that can be used to supply operations (rivers, lakes, ponds and pools).

Steamer Connection: The large outlet on a hydrant.

Tachometer: Shows the revolutions per minute of the drive shaft or pump shaft.

Thermal Relief Valve: Protects the pump from overheating. The TRV 120 automatically dumps a controlled amount of water to atmosphere or back to tank when the pump water exceeds the pre-set valve of 120 degrees.

Torque: Measures the ability of the engine to produce rotational force at a given speed.

Total Pressure Master Relief Valve: Provides complete control over the entire pump. Small changes in the pump pressure are normally handled internally by the recirculating relief valve. Large changes in either the inlet or discharge side of the pump are controlled by dumping excess pressure to the atmosphere.

Transfer Valve: To select series or parallel (pressure/volume) on a two stage pump.

Turbulent Flow: Water moving in a swirling motion.

Vacuum Primer: Uses the vacuum of the engine intake manifold to remove air from the pump.

Vapor Pressure: Pressure created when a confined liquid expands.

Vaporization: The process by which a substance in a solid or liquid state is changed to vapor.

Velocity: Speed or the rate of motion in feet per second or miles per hour.

Volute: A gradually increasing discharge waterway.

Water Hammer: Shock loading on hoses, nozzles, pumps, etc. due to the sudden movement of water (opening and closing gates and nozzles quickly).

Water Supply Officer: This is a person who oversees the entire water supply for the fireground, including areas immediately around the scene and filling stations that may be miles away.

Water Temperature Gauge: Indicates the temperature of the water in the apparatus cooling system.

Wet Barrel: When the hydrant has water in it from the main to the shut-off valve. Not found in cold climates like New England.

Wye: Divides one line into two or more lines. Has one female and two or more male connections.

Yard Hydrant: A hydrant found in a complex that is usually on a looped yard water system.

Z Valve: A valve assembly used in hose lays (normally large diameter) to increase the pressure in the supply line.