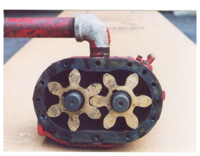
Basic Pump Operations And Hydraulics

Day One - Pump Theory

- This section will cover
  - Types of pumps
  - Pump drives
  - Pump controls
  - Pressure control devices
  - Pump instrumentation
  - Basic pump operations

Fire Pumps 2 Types

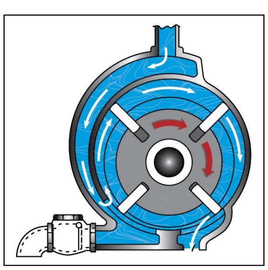
- Positive displacement will pump anything
  - Water
  - Air
  - Semi-solids



- Non-positive displacement
  - Will not pump air
  - 750 TO 2000 gpm typical

Positive Displacement Pumps

Rotary Vane Pumps



- Free traveling vanes
- Eccentric rotor
- Oil lubricated
- Driven by an electric motor
- Newer pumps are oiless

Priming Pump Assembly

- Electric starter motor
- Uses truck electricity
- Crank 45 seconds maximum

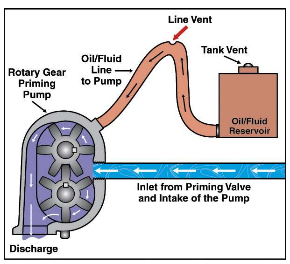
Primer Valve Control

- Engages primer
- Opens valve between fire pump & priming pump

Priming Oil

- Cools
- Lubricates
- Seals clearances

Priming Pump Assembly



Oil-less Primers

- Hale recommends running the pumps regularly and to let water flow out for a little while to clean out dust

Air Primer

- Chassis Air Supply
- No Electric Motor
- No Lubrication Required
- Cleanable Inline Strainer

Air Primer

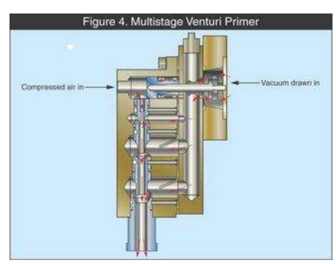


Figure 4. Multistage Venturi Primer

Air Primer

- The following 4 slides have different modes and ways of using an air primer

Centrifugal Pumps

Single & Two Stage Pumps

Purpose of a Fire Pump

- Add pressure to available water
  - Most municipal water systems lack required pressure for handlines
- Pumps can not increase the volume available from a given source

Advantages

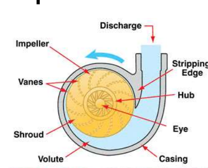
- Takes advantage of incoming pressure
  - If a pump is making 100 PSI and takes a pressurized water supply at 50 PSI, the total pump output will be 150 PSI
- Mechanically simple
  - Only one moving part

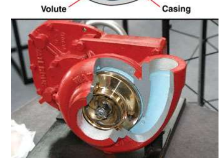
Disadvantages

- Not self-priming
- Subject to cavitation
- Limited lift capabilities

Centrifugal Pump Operation

- Water enters the impeller eye
- Water is accelerated as the impeller spins
- Water is discharged to the manifold





Centrifugal Pump Discharge

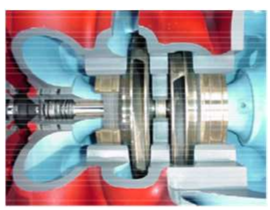
- Determined by-
  - Number & size of impellers
  - Pump displacement
  - Impeller speed
  - Incoming pressure

Single Stage Pump

- One impeller
- Single or dual suction
- Discharge pressure and volume controlled by engine speed & valves

Two Stage Pump

- Two impellers on a single shaft
- Pressure (series) mode
- Volume (parallel) mode



Transfer Valve

- Determines pump "mode"
  - Series
  - Pressure
- Operation
  - Manual
  - Electric
  - Hydraulic
  - Pneumatic

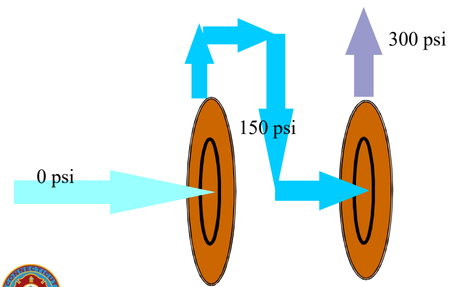
Two Stage Pump

- In pressure/series mode, one impeller discharges into the intake of the second impeller
- In volume/parallel mode, both impellers discharge into the discharge manifold

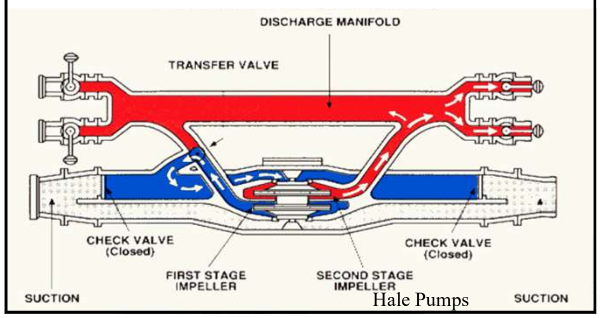
Two Stage Pump

- Use pressure mode when-
  - Higher pressures are needed
  - Less than half the pump capacity is needed
- Use volume mode when-
  - You will be flowing more than 50% of the pump capacity

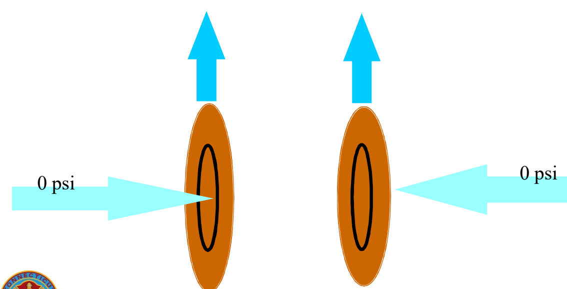
Series (Pressure) Operation



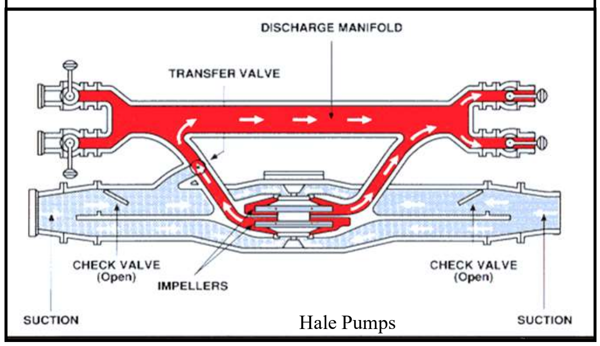
Series (Pressure) Operation



Volume (Parallel) Operation



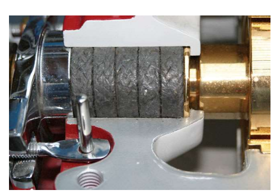
Volume (Parallel) Operation



Pump Wear Rings

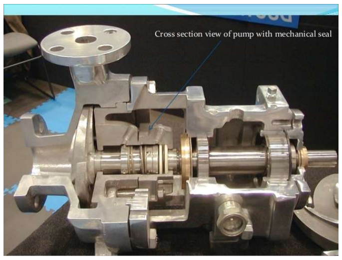
- Prevents water from leaking back into the inlet
- Tolerances of 0.0” to 0.01”
- Will be damaged by heat

Pump Packing



- Seals the pump shaft
- Lubricated by water
- Slow leaking is normal
- Adjustable

Mechanical Seal

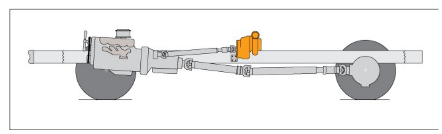


Pump Drive Types

Auxiliary Engine Drives

- Independent from the apparatus engine
- Pump & roll capable
- Some capable of very high flows

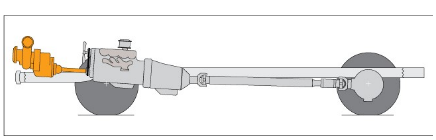
PTO Driven



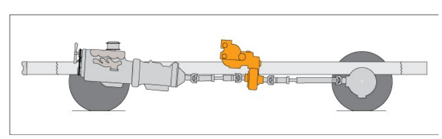
- Power comes from the transmission
- Lower capacity pumps
  - 1250 GPM or less

Front Mounted Pump Drive

- Driven from the engine crankshaft
- Common on water source pumpers
- Manual clutch on the pump shaft to engage



Mid-Ship Pump Drive



- Most commonly used today
- Split driveshaft
- Transmission must be engaged to drive the pump

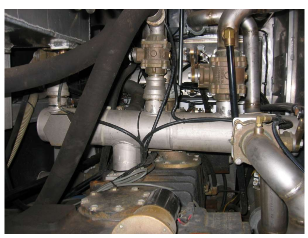
Transfer Case

- Shifts the transmission output to either the rear axle or the pump
- Pneumatic, electric, or manually activated

Pump Controls

Pump Piping & Valves

- May be steel, brass, plastic, or stainless steel
- Must withstand a 500 PSI static test



Steamer Intakes

- Direct line to the pump impeller
- Best choice for drafting

Intake Valves

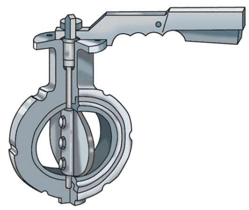
- Located below the impeller eye
- Various locations
- Larger than 2 ½” must be slow acting valves
- Must have an air bleeder

Intake Relief Valve

- Adjustable relief pressure
- Dumps excess pressure from supply lines
- Absorbs some water hammer

Butterfly Valves

- Not slow acting
- May be difficult to control
- Found on intakes



Auxiliary Intakes

- Used for supplementing main supply
- Must have an air bleeder
- Bends and fittings may reduce flow

Front Intakes

- Must have slow acting valves
- Long plumbing runs
- Multiple 90° bends
- High loss
- May not be the best choice for drafting

Remote Control Intakes

- Electric or pneumatic
- Allows intake to be received away from the pump panel

Tank to Pump Valve

- Discharges from the bottom of the tank
- 3" minimum piping
- 1 way check valve prevents bottom filling of the tank
- 500 GPM minimum

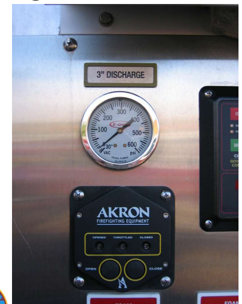
Discharge Valves

- Must have individual pressure gauges
  - Except tank fill & booster
- Self or mechanically locking

Quarter Turn Valves

- Found on most pumps
  - Push / pull valves are ¼ turn valves
- Found on some intakes
- May be manually locking


Large Diameter Valves



- Must be slow acting
- Electric, manual, pneumatic
- Required on valves greater than 2 ½”

Drain Valves

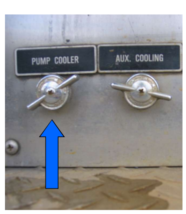
- Used to relieve pressure in between the valve and the nozzle

Tank Fill Line

- Used to fill booster tank
- Used to circulate water

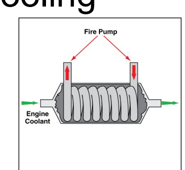
Re-Circulating Line

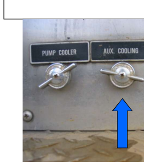
- Sends a small amount of water from the discharge back into the intake
- May be too small to cool during high pressure operations



Auxiliary Engine Cooling

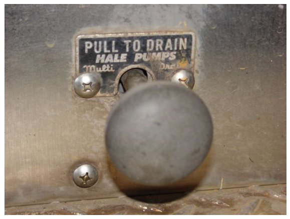
- Circulates pump water through a heat exchanger
- Does not mix with coolant





Main Pump Drain

- Low point drain in the pump cavity
- Removes debris from the pump



Throttle Control

- Controls engine RPM
- Manual or electric
- Includes an emergency idle button

Pressure Control Devices

Relief Valves & Pressure Governors

Pressure Control Devices

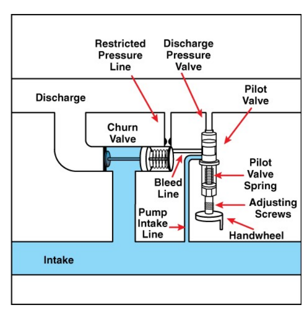
- Must operate in 3 to 10 seconds
- React at a pressure rise of no greater than 30 PSI
- Must have a visual indication of operation
  - Idiot light
- These are NFPA minimums

Relief Valves

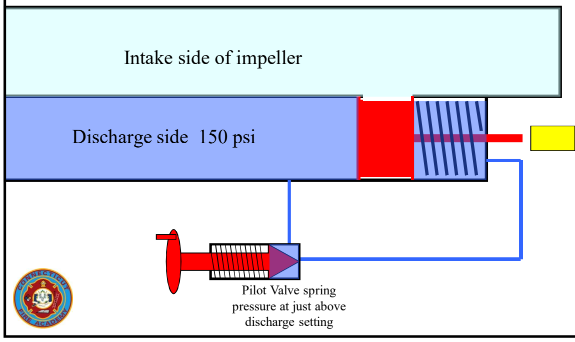
- Assembly of springs & valves designed to re-direct excess pressure

How it Works

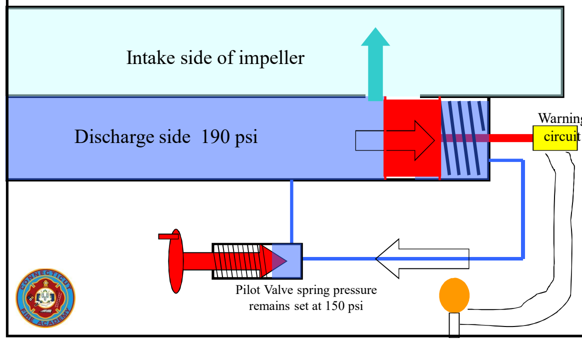
- The valve is set to open at the highest pressure for the operation
- When the pressure is exceeded, the valve opens and diverts excess pressure to the intake



Discharge Pressure Relief Valve
set at 150 psi



Discharge Pressure Relief Valve
overpressure activation



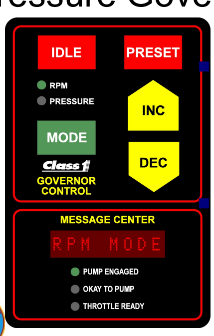
Relief Valve Problems

- Springs wear out over time
- Debris in the screen / pilot valve
- Incoming pressure must be at least 40 PSI less than discharge pressure
- Relief valves must be exercised weekly

Pressure Governors

- A pressure sensor in the pump sends a signal to the computer
- The computer maintains the set pressure by increasing / decreasing throttle

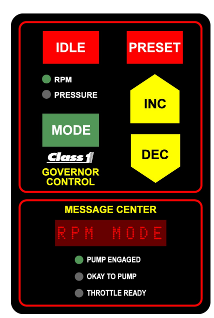
Pressure Governor Controls



- RPM mode
  - Works like a manual throttle
  - Engine speed remains the same regardless of the flow or incoming pressure
- PSI mode
  - Maintains discharge pressure
  - Adjusts pressure by changing engine speed

Pressure Governor Controls

- Preset button
  - Adjusts engine speed to achieve a preset pressure
- Idle button
  - Returns engine to idle
  - Governor exits operating mode
  - Pump mode must be selected again to adjust throttle



Setting a Pressure Governor

- 1) Set the pump to the desired pressure
- 2) Press the “mode” or “PSI” button
- 3) Monitor discharge pressure

Pressure Governor Advantages

- When additional lines open, the pump pressure will increase to supply the additional flow
- Hydrant transitions can be done without manually throttling down
  - Only if all air is bled

Pressure Governor Problems

- Any air in the supply line will be read as cavitation by the governor
- All air must be bled completely from supply lines

Pressure Governor Problems

- If using strong hydrants, the governor can not dump excess pressure
- Example- a 125 PSI hydrant feeding a pump that makes 40 PSI at idle
  - 165 PSI output at idle
  - Low pressure lines may be over-pressurized even if gated down

Pressure Governor Problems

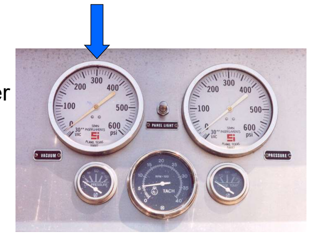
- Failure of electronic systems will disable the governor *and the throttle*
- This can be dangerous for interior crews

Pump Instrumentation

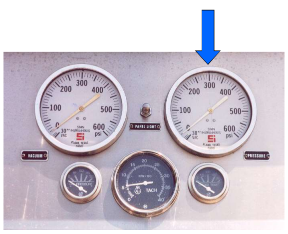
The Big Five

Master Intake Gauge

- Reads vacuum and pressure
- Tells how much water is available



Master Discharge Gauge



- Measured as water leaves the impeller
- Set for the highest pressure required

Tachometer

- Used to help indicate early cavitation
- Used to gauge pump efficiency when testing

Water Temperature

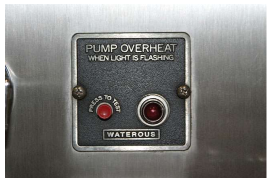
- Used to gauge when to open or close auxiliary engine coolers

Oil Pressure Gauge

- May decrease as pumping operations are extended
- If not reading, confirm with the gauge in the cab before taking action

Pump Overheat Indicator

- Heat sensor in the pump manifold

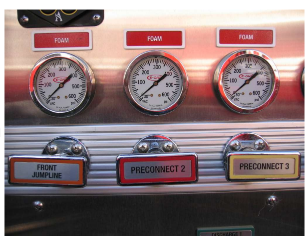


Voltmeter

- Some apparatus have one on the pump panel
- Readings less than 12 volts may affect electric throttles and pressure governors

Discharge Gauges

- Measures pressure after the discharge valve
- Gated to desired pressure if lower than master pressure



Water Tank Level Lights

- Most measure in ¼ increments
- May not be accurate if on uneven ground

Engaging the Pump

Mid-ship Pumps

Steps to Engage the Pump

- 1) Position the apparatus
- 2) Set parking brake
- 3) Shift to neutral
- 4) Operate pump shift
- 5) Place transmission in proper gear

Indicators of a Successful Shift

- Sound
- Indicator light
- Speedometer
- Electronic transmission readout

Indicators of a Successful Shift

- Pressure on master gauge
- Relief valve lights
- Manual override position (if equipped)

Air Pump Shifts

- Air pressure must be greater than 90 PSI to actuate the pump shift
- Glance at your air pressure before shifting

Troubleshooting

- If the pump won't engage-
  - Retrace your steps
  - Start from the beginning (shifting slower)
  - Use manual override
  - Notify command / other companies if unsuccessful again

Disengaging the Pump

- Return to idle
- Place transmission in neutral
  - Wait for the speedometer to stop
- Disengage the pump shift

Hydrant Operations

And Other Pressurized Water Sources

Types of Pressurized Sources

- Hydrants
  - Most common
- Relay pumps

Hydrants

- The closest is not always the best
- Accessible?
- Lack of maintenance?
- Dead end main?

Hydrants

- Should always be fully dressed
- Flush before connecting hoses

Rocks

Residual Pressure

- Maintain no less than 20 PSI incoming
  - Allows for minor system fluctuations
  - Gives a buffer in case of burst hoses
  - Allows for inaccurate gauges

Hydrant Assist Valves

- Allow first due companies to establish their own water supply
- Later arriving apparatus can tie in and boost pressure without interrupting flow

Estimating Hydrant Flow

- Note static pressure
- When flowing, note the residual pressure
- The percentage difference between the two will tell you approximately how much water is still available

Estimating Hydrant Flow

- 100 PSI static, 80 PSI residual
  - 20% drop

- 0-10% = 3 times the current flow
- 11-15% = 2 times the current flow
- 16-25% = same as the current flow
- Greater than 25% = less than current flow

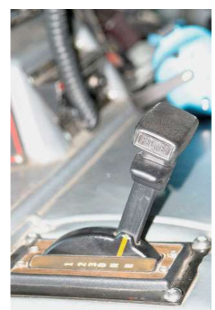
Shutting Down Hydrant Ops

- Ensure a full tank
- Idle down
- Close intake & hydrant
- Break connections
- Drain hydrant fully

Troubleshooting

Pump Won't Generate Pressure

- Is the pump is engaged?
- Does the pump have water?
- Am I flowing too much?



Failure of Supply Line

- Immediately close the intake
- Immediately open the tank to pump
- Close exterior / non-essential lines
- Adjust throttle
- Notify interior companies & command

Residual Pressure Decreasing

- Burst hose line?
- Did somebody change tip sizes?
- Debris clogging intake?

Low Pressure / Flow Complaint

- Burst hose line?
- Kinks?
  - The driver is often responsible for all kinks between the pump and the door

Low Pressure / Flow Complaint

- Cavitation?
- Clogged nozzle?

Practical

Booster Tank And External Water Supply Transitions

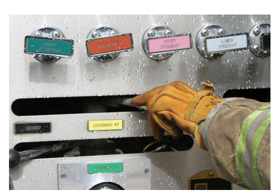
Pumping From the Tank

- Most fires are extinguished with one line supplied by the booster tank
- Rarely will you begin operations from a hydrant

Pumping From the Tank

- Engage the pump
- Chock the wheels
- Circulate water

Pumping From the Tank



- Charge the selected line ***only when called for***
- Set desired pressure
- Set relief valve / engage pressure governor

Setting a Relief Valve

- 1) Set pump to highest pressure for the operation
- 2) Turn counter-clockwise (lower) until the light comes on

Setting a Relief Valve

- 3) Turn clockwise (increase) until the light goes out
  - Count your turns
- 4) Turn counter clockwise half of the turns it took to close the valve

Pumping From the Tank

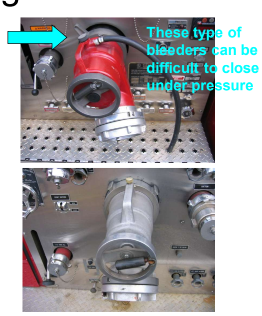
- Monitor water tank level
- Establish an external water supply

Transitioning to External Water

- Make intake connections
- Call for water
- Do not open the valve until water is at the intake and air is bled

Bleeding Incoming Air

- All air must be bled
- Failing to bleed all air can effect pressure governors



Transitioning to External Water

- *Slowly* open the intake valve
- Throttle down as needed
- Close tank to pump
- Refill tank

Basic Pump Operations And Hydraulics

Day 2 - Hydraulics Theory

- This section will cover-
  - Pump discharge pressure
  - Nozzles
  - Friction loss in hose
  - Appliance loss
  - Elevation loss
  - Fire ground hydraulics

Line Pressure Control

- Responsibilities of the pump operator:
  - Safe working pressures
  - Sufficient water
  - Safe application of principles

Hydraulics THEORY

- Not for use on the Fireground !
- Useful for:
  - Preconnects
  - Maximum water movement through supply line
  - Preplanning problems
  - Designing drills
  - Passing the Pump Operator Certification exam
  - Enhances understanding of shortcuts

Pump Pressure

- **PP = NP + FL +/- EL**
  - **PP = Pump Pressure**
  - **NP = Nozzle Pressure**
  - **FL = Friction Loss**
  - **EL = Elevation Loss (Gain)**

Pump Discharge Pressure

- The pressure required at the discharge of the pump to deliver an adequate volume of water at sufficient pressure to the nozzle

Determining Operating Pressure

- 1)- Determine the flow rate
- 2)- Determine friction loss
- 3)- Determine nozzle pressure
- 4)- Determine elevation loss or gain
- 5)- Determine appliance loss
- 6)- Add all of the numbers together

Nozzles & Flows

This section will cover:

Types of nozzles
Nozzle flow rates
Nozzle operating pressures
Nozzle reaction

Hose Maximum Flows

- 1 ½" – 125 GPM
- 1 ¾" – 200 GPM
- 2" – 250 GPM
- 2 ½" – 325 GPM
- 3" – 500 GPM
- 4" – 1000 GPM
- 5" – 1500 GPM

3 Basic Nozzle Types

- Smoothbore
  - Fixed diameter orifice
- Fog
  - Deflecting or impinging
- Special application
  - Cellar, chimney, piercing, etc.

Smoothbore Nozzles

Smoothbore Nozzles

- Compact stream with great reach
- Little water lost to steam before breakover
- 50 PSI nozzle pressure for hand lines
- 80 PSI nozzle pressure for master stream

Flow Rates

- Since friction loss is related to flow rate, we must know the flow of the nozzle before we and determine friction loss
- Determined by
  - Diameter of orifice
  - Nozzle pressure

Determining Flow Rate

- Freeman's Formula
- $29.7 x D^2 x \sqrt{NP}$
  - 29.7 is constant
  - D^2 is the square of the orifice diameter
  - $\sqrt{NP}$ is the square root of the nozzle pressure

Freeman's Formula Example

- Determine the flow rate from a 1" tip on a hand line
  - $29.7 x D^2 x \sqrt{NP}$
  - $29.7 x (1^2) x \sqrt{50}$
  - Flow rate = 210 GPM

Solid Bore Nozzle Flows

Tip	NP	Actual	Rounded
15/16"	50	185	185
1"	50	210	200
1 1/8"	50	266	250
1 1/4"	50	328	300
1 1/4"	80	415	400
1 3/8"	80	502	500
1 1/2"	80	598	600
1 3/4"	80	814	800
2"	80	1063	1000
2 1/4"	100	1503	1500

Handline Flows

- For every increase of 1/8" in tip there is a 50 GPM increase in flow (approximately)
- If we remember the flow of the smallest tip, we know that for each tip size increase the flow increases 50 GPM

Master Stream Flows

- For every increase of 1/8" in tip there is a 100 GPM increase in flow (approximately)

Smoothbore Stream Reach

- However, if a smoothbore tip is removed ***and pressure is not added to make up for the increased flow, the stream will fall shorter***
- Therefore, pump operators must know what tip size is being used

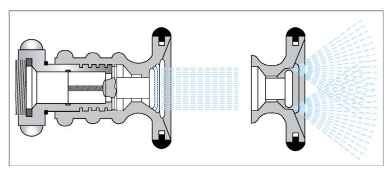
Stream Reach & Volume

- If tips are removed without notifying the pump operator you will only get these flows
  - 1” tip at 50 PSI = 210 GPM
  - 1 1/8” tip drops to 40 PSI = 238 GPM
  - 1 ¼” tip drops to 30 PSI = 254 GPM

Fog Nozzles

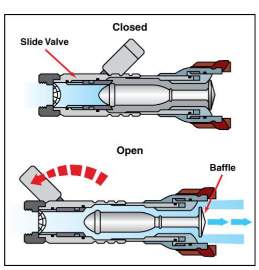
Fog Streams

- Water is deflected against itself or the stem head of the nozzle



Automatic Nozzles

- A baffle moves against a spring to try to maintain the nozzle pressure
  - The more pressure, the more the baffle opens
  - Inadequate pressure = inadequate volume



Constant Gallonage Nozzles

- Designed to flow a specific volume
- No spring

Adjustable Gallonage Nozzles

- A collar on the nozzle adjusts the flow
- The pump operator must know what GPM is selected

Fog Nozzle Pressures

- Fog nozzles are usually pumped at 100 PSI nozzle pressure
  - Many are available that operate at 75 or 50 PSI
- Most master stream fog nozzles are 100 PSI
  - Some are available that operate at 75 PSI

Adjustable Pressure Nozzles

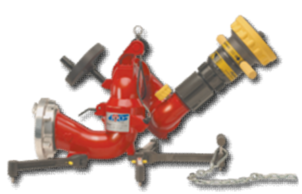
- Reduces the spring pressure in the nozzle
  - This allows more water to pass through
- Pump for the standard pressure
  - Pump operator does not need to know which "mode" it is in

Fog Nozzle Flows

- We assume 1 ¾" fog nozzles to flow 150 GPM
  - Flows up to 200 GPM are possible
- We assume 2 ½" fog nozzles to flow 250 GPM
  - Flows up to 325 GPM are possible

Master Stream Fog Nozzles

- Flows up to 1000 GPM
  - Some may be greater
- Pumped according to desired flow



Portable Master Stream

- TFT "Blitz-Fire" & Elkhart "R.A.M."
- No bends to generate loss
- Pump as an 80 or 100 PSI nozzle

Nozzle Pressure Review

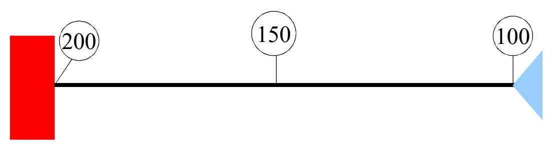
- Fog- 100 PSI
  - Some may be lower
- Smoothbore handline- 50 PSI
- Smoothbore master stream- 80 PSI
- Relay pumper– 20 PSI

Principles of Friction Loss

Friction Loss

- Defined
  - That part of the total pressure lost while forcing water through pipe, fittings, hose, and adapters

Friction Loss
An estimate, until measured



PP=NP+FL+/-EL

200=100+100 +/-0

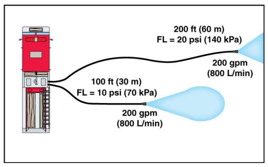
Friction Loss

- Friction losses have reduced over the years with advances in hose manufacture
  - Rubber linings
  - Synthetic linings
- New advances continue as technology changes

Causes of Friction Loss

- Type & condition of hose lining
- Couplings
- Bends & kinks
- Improper gaskets

Principle 1



- For the same flow, friction loss varies with the length of hose
  - Double the length = double the friction loss

Principle 2

- Higher flows yield higher friction loss
  - Given the same size hose, if you double the flow, you quadruple the friction loss
- Example
  - 200 GPM in a 2 ½" has a friction loss of 8 PSI
  - 400 GPM in the same hose would have 32 PSI of friction loss

Principle 3

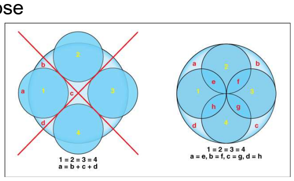
- For the same flow, larger diameter hose has less friction loss than a smaller hose
  - Double the diameter of the hose, friction loss is reduced to 1/32nd
- Example
  - 500 GPM through a 2 ½" hose = 50 PSI FL
  - 500 GPM through a 5" hose = 2 PSI FL

Principle 4

- For the same flow, friction loss is the same regardless of system pressure
  - If a 40 PSI system had 10 pounds of friction loss at a certain flow, a 4000 PSI system would have be same
- Friction loss is a product of volume (GPM), not pressure

Hose Principles

- When hose diameter doubles, the area of the hose quadruples
  - It would take 4- 2 ½" hoses to equal the same area as 1- 5" hose



Friction Loss in Conductors

- Common causes of friction loss are;
  - Water molecules 'rubbing' against each other
  - Hose lining
  - Couplings
  - Sharp bends & kinks
  - Change in hose size by adapters
  - Improper gasket size

Friction Loss Pressure

- Pressure has little to do with the FL
  - 4000 psi hydraulic system would experience roughly the same FL as a 40 psi system.
    - FL IS A FUNCTION OF ***<u>VELOCITY</u>***, NOT PRESSURE!
  - Hard suction tubes have friction loss when working below atmospheric pressure

Friction Loss & Operating Pressures

Single Hose Layouts

Friction Loss Formula

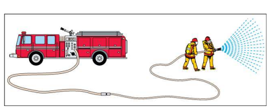
- $FL= Cx(Q^2)xL$
  - C= the coefficient for the particular hose
  - Q= hundreds of gallons per minute
    - GPM / 100
  - L= length in hundreds of feet
    - Feet / 100

Coefficients

- ¾" booster________1,100
- 1" booster__________150
- 1 ½" rubber lined______24
- 1 ¾" rubber lined____15.5
- 2" with 1 ½" couplings__8
- 2 ½" rubber lined_____2
- 3" with 2 ½" couplings__0.8
- 3" with 3" couplings_0.677
- 3 ½"____________0.34
- 4"______________0.2
- 4 ½"______________0.1
- 5"______________0.08
- 6"______________0.05

Friction Loss Example 1

- 100ft of 1 ¾" with a 100psi fog nozzle flowing 150gpm
  - $FL=CQ^2L$
    - C=15.5
    - Q=1.5
    - L=1
  - $FL=15.5x(1.5^2)x1$
  - FL=34.875



Friction Loss Example 1

- When adding pressures, work in rounded numbers
  - 34.875 is rounded to 35psi
- Now add the nozzle pressure
  - 100psi (nozzle) + 35psi (friction loss)
  - 135psi pump discharge pressure

Friction Loss Example 2

- 200ft of 1 ¾" with a 15/16" smoothbore
- Step 1- before anything else can be done, the flow must be determined
  - Freeman's formula from chapter 7
  - $29.7 \times D^2 \times \sqrt{NP}$
  - $29.7 \times 0.9375^2 \times \sqrt{50}$
  - Flow = 184.5gpm (rounded to 185gpm)

Friction Loss Example 2

- Now that the flow is determined, the friction loss can be calculated
  - $FL=CQ^2L$
    - C=15.5
    - Q=1.85
    - L=2
  - $FL=15.5 \times (1.85^2) \times 2$
  - FL=106psi

Friction Loss Example 2

- Now add the nozzle pressure
  - 106psi (FL) + 50psi (NP)
  - 156psi pump discharge pressure

Multiple Hoselines

- Many operations involve more than one hoseline
  - When the diameter and lengths are the same, you only need to calculate one line
  - The pump discharge pressure will be set the same for both

Appliance & Elevation Loss

Appliance Loss

- Wye, Siamese, reducer, water thief, etc.
  - Add 10 PSI if greater that 350 GPM
- Deck gun or aerial master stream
  - Add 25 PSI
- These are estimates!

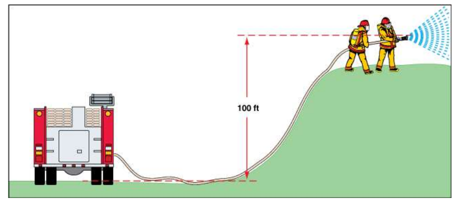
Excess casting in deck gun base

Elevation Loss & Gain

- 5 PSI loss for every 10 feet above the pump
  - For buildings, use 5 PSI per story above ground level
- 5 PSI gain for every 10 feet below the pump
- Regardless of hose diameter or flow

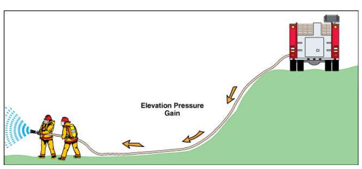
Elevation Loss

- Determine the pressure loss due to elevation



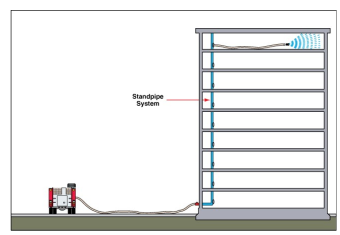
Elevation Gain

- Determine the pressure gain due to elevation if the nozzle is 40 feet below the pump



Elevation Loss

- Determine the pressure loss due to elevation



Supplying Master Streams

Apparatus Mounted & Ground Based

Apparatus Mounted Master Stream

- Determine the pump discharge pressure for this apparatus mounted master stream

Ground Based Master Stream

- Determine the pump discharge pressure for this deck gun flowing 500 GPM through 200 feet of 5” hose

Fireground Hydraulics

Formulas

- Useful for new hose loads
- Useful for pre-planning
- Not for fireground use

Marked Gauges

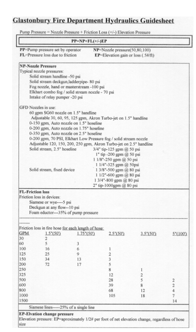
- Some departments chose to mark the pressure gauges for pre-connects
  - Example- this deck gun is marked for 105 PSI with a green line

Marked Gauges

- These departments may put two different colored lines on the gauge
- The pump operator can then pump at the maximum or the minimum for the line

Prepared Charts

- May be generic or custom made
- Keep them simple & easy to read



Glastonbury Fire Department Hydraulics Guidesheet

Pump Pressure = Nozzle Pressure + Friction Loss (+/-) Elevation Pressure

PP=NP+FL(+/-)EP

PP=Pump pressure set by operator **NP**=Nozzle pressure(50,80,100)
FL=Pressure loss due to friction **EP**=Elevation gain or loss (.5#/ft)

NP-Nozzle Pressure
Typical nozzle pressures:
Solid stream handline -50 psi
Solid stream deckgun,ladderpipe- 80 psi
Fog nozzle, hand or masterstream -100 psi
Elkhart combo fog / solid stream nozzle - 70 psi
Intake of relay pumper -20 psi

GFD Nozzles in use:
60 gpm SG60 nozzle on 1.5" handline
Adjustable 30, 60, 95, 125 gpm, Akron Turbo-jet on 1.5" handline
0-150 gpm, Auto nozzle on 1.5" hoseline
0-200 gpm, Auto nozzle on 1.75" hoseline
0-350 gpm, Auto nozzle on 2.5" hoseline
0-200 gpm, 70 PSI, Elkhart Low Pressure fog / solid stream nozzle
Adjustable 120, 150, 200, 250 gpm, Akron Turbo-jet on 2.5" handline
Solid stream, 2.5" hoseline 3/4" tip-125 gpm @ 50 psi
1" tip -200 gpm @ 50 psi
1 1/8"-250 gpm @ 50 psi
1 1/4"-325 gpm @ 50psi
Solid stream, fixed device 1 3/8"-500 gpm @ 80 psi
1 1/2"-600 gpm @ 80 psi
1 3/4"-800 gpm @ 80 psi
2" tip-1000gpm @ 80 psi

FL-Friction loss
Friction loss in devices:
Siamese or wye----5 psi
Deckgun at any flow--10 psi
Foam eductor---35% of pump pressure

Friction loss in fire hose for each length of hose:

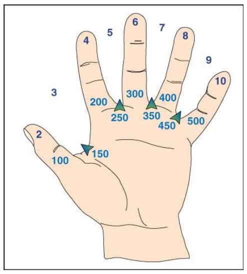
GPM	1.5"(50')	1.75"(50')	2.5"(50')	3.5"(50')	5"(100')
30	2				
60	5	3			
100	16	6	1		
125	25	9	2		
150	34	13	3		
200	72	17	5		
250			8	1	
325			12	2	
500			28	5	2
600			39	8	2
800			68	12	4
1000			105	18	7
1500					14

Siamese lines-----25% of a single line

EP-Elvation change pressure
Elevation pressure: EP=aproximately 1/2# per foot of net elevation change, regardless of hose size

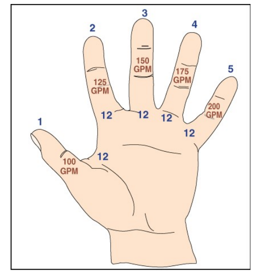
Hand Method for 2 ½”

- Multiply the number at the fingertip by the first digit of the number on the palm
- Example
  - 200gpm
  - 4x2=8psi / 100ft



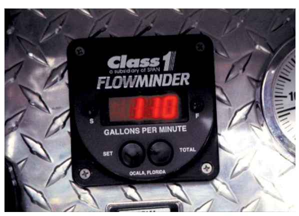
Hand Method for 1 ¾”

- Multiply the number at the fingertip by 12
- Example
  - 150gpm
  - 3x12=36psi / 100ft



Flowmeters

- Reads GPM
- Set the discharge gate & throttle to the desired flow
- Water must be continuously flowing to set



Flowmeters

- May be paired with a pressure gauge
- Trust your pressures, but verify with the flowmeter

Flowmeter Troubleshooting

- If interior companies are reporting a loss in pressure-
  - And pressure is good but the flowmeter shows a *high flow*, there is probably a *burst line*
  - And pressure is good but the flowmeter shows a *low flow*, there are probably *kinks in the line*

Hydraulic Calculations

- Not for fireground use
- As a pump operator, you must be able to memorize some flows and losses

Memorization

- As a pump operator, it is your job to know proper pumping pressure
- At a minimum you should know your pre-connect pressures without hesitation
  - You should also know what to add if lengths are added

Condensed Q

- 3” Hose
  - FL(per 100’) = Q^2
- 4” Hose
  - FL (per 100’) = $Q^2/5$
- 5” Hose
  - FL(per 100’) = $Q^2/15$
- Not accurate for long hose lays

Condensed Q

- FL in 600’ of 3” with 400 GPM flow?
  - Q^2
- FL in 900’ of 4” with 600 GPM flow?
  - $Q^2/5$
- FL in 1000’ of 5” with 900 GPM flow?
  - $Q^2/15$

Fireground Math

- Know pump discharge pressures for pre-connects
  - Calculated at the firehouse
- Work backwards to determine pressures required for added lengths
  - Example- 200ft 1 ¾” crosslay w/100psi nozzle
  - 170psi PDP – 100psi NP = 70psi FL for 200ft
    - Or 35psi per 100ft

Fireground Math

- Know your discharge pressures before you leave the firehouse
- Use simple fireground math to add or remove lengths
- Commit common pressures to memory

Common 1 ¾” Friction Losses

- 1 ¾” @ 95gpm = 14psi / 100ft
  - Foam line
- 1 ¾” @125gpm = 24psi / 100ft
  - Foam line
- 1 ¾” @ 150gpm = 35psi / 100ft
- 1 ¾” @ 185gpm= 53psi / 100ft
  - 15/16” smoothbore
- 1 ¾” @ 200gpm = 62psi / 100ft

Common 2 ½” Friction Losses

- 2 ½” @ 210gpm = 9psi / 100ft
  - 1” smoothbore
- 2 ½” @ 266gpm = 14psi / 100ft
  - 1 1/8” smoothbore
- 2 ½” @ 328gpm = 22psi / 100ft
  - 1 ¼” smoothbore

Common 3” Friction Losses

- 3” @ 300gpm = 7psi / 100ft
- 3” @ 400gpm = 13psi / 100ft
- 3” @ 500gpm = 20psi / 100ft
- 3” @ 600gpm = 29psi / 100ft

Common 4” & 5” Friction Losses

- 4” @ 500gpm = 5psi / 100ft
- 4” @ 750gpm = 11psi / 100ft
- 4” @ 1000gpm = 20psi / 100ft
- 5” @ 500gpm = 2psi / 100ft
- 5” @ 750gpm = 5psi / 100ft
- 5” @ 1000gpm = 8psi / 100ft
- 5” @ 1500gpm = 18psi / 100ft

Rule of Thumb

Flow Rates

Hose

1 ½” = 125 GPM
1 ¾” fog = 150 GPM
1 ¾” SB = 185 GPM
2 ½” = 250 GPM
3” = 500 GPM
4” = 1000 GPM
5” = 1500 GPM

SMOOTH BORE **TIPS**

50 PSI HANDLINES	**80 PSI MASTER STREAM**
1” Tip= 200 GPM	1⅜” Tip = 500 GPM
1 1/8” Tip = 250 GPM	1 ½” Tip = 600 GPM
1 ¼” Tip = 300 GPM	1 ¾” Tip = 800 GPM
	2” Tip = 1000 GPM

Friction Loss

1 ½” = 25 psi per 50 ft length based on 125 GPM flow
1 ¾” = 15 psi per 50 ft length based on 150 GPM flow (actual 17)
1 ¾” = 25 psi per 50 ft length based on 185 GPM flow
2 ½” = 10 psi per 50 ft length based on 250 GPM flow
4” = 20 psi per 100 ft length based on 1000 GPM flow
5” = 10 psi per 100 ft length based on 1000 GPM flow
25 psi for deck gun
10 psi for wyes and Siamese
+/- 5psi for elevation

Nozzle pressures

Smooth bore hand line = 50 psi
Smooth bore master stream = 80 psi
Fog = 75/100 psi

Engine Pressure

Stand pipe = 150 psi
Supplying another pumper = 20 psi at their valve
Supplying a Aerial = 150 psi at their valve

Danbury Vol. Hydraulics Guidesheet

Pump Pressure = Nozzle Pressure + Friction Loss (+/-) Elevation Pressure

PP=NP+FL(+-)EP

PP=Pump pressure set by operator
NP=Nozzle pressure(50,75,80,100)
FL=Pressure loss due to friction
EP=Elevation gain or loss (.5#/ft)

NP=Nozzle Pressure

Nozzles:
70-200 gpm @ 100psi TFT Automatic nozzle on 1.75” hoseline
150 gpm @ 75 psi Fire Chief
185 gpm @ 50 psi,15/16 smooth bore nozzle on 1.75” hoseline
125, 175 & 250 gpm @50psi adjustable gallonage nozzle on 2.5” hoseline
100 gpm 3/4” smooth bore on 2.5” hoseline
200 gpm 1”smooth bore on 2.5” hoseline
300 gpm 1 ¼” smooth bore on 2.5” hoseline
450 gpm 1 ½” smooth bore on 2.5” hoseline

NFVFD Master Stream Nozzles:
350-500-750-1000 variable fog
1-3/8”-500 gpm @ 80 psi
1-1/2”-600 gpm @ 80 psi
1-3/4”-800 gpm @ 80 psi
2” tip-1000 gpm @ 80 psi

Foam Equipment:

Relay pumping:
Intake of relay pumper – 20 psi

FL-Friction loss

Friction loss in devices
Siamese or wye---5 psi
Deck gun at any flow—20 psi
Foam eductor---35% of eductor inlet pressure

Friction loss in fire hose **for each length of hose:**

GPM	1.75”(50’)	2.5”(50’)	3”(50’)	5”(100’)
95	7			
100	8	1		
125	12	2		
150	17	2.25		
175	24	3		
185	27			
200	31	3		
250		6		
300		9	4	
400			6	
500			10	2
600			14	
1000				8
1500				18