Motor Pump Operator

Module 4

Basic Hand line Hydraulics

General Description:

The student pump operator must have a thorough working knowledge of the movement of water and perform basic mathematical calculations common to fireground hydraulics.

References:

- IFSTA Fire Stream Practices (7th edition)
- MFA Worksheets
- Trade Magazines

Lecture Time:

3 hours

Method of Instruction:

Lecture, discussion, and practical exercises

Recommended Visual Aids and Equipment:

- LCD projector
- Laptop computer
- Powerpoint disk
- Screen
- Extension cord
- Markers
- Chalkboard
- Chalk

Module Revision Date:

November 2005

LEARNING OBJECTIVES

Terminal:

- The student shall have a basic understanding of the components of a pump and calculating handline hydraulics.
- The student shall demonstrate the steps in calculating the correct pump pressure for a handline evolution.

Enabling:

- The student shall have an understanding of hydraulic theory
- The student shall be able to produce proper safe and efficient fire streams.
- The student shall be able to describe the following pressures:

Static	Flow
Residual	Forward
Negative	Back
Line	Discharge
Nozzle	Operating

- The student shall be able to use simple fireground hydraulics to perform a pressure source evaluation.
- The student motor pump operator shall demonstrate the ability to supply water to variable sized handlines with different types of nozzles.
- The student motor pump operator shall demonstrate the ability to supply various sized supply lines.
- The student motor pump operator shall demonstrate the ability to supply various master streams.
- The student motor pump operator shall demonstrate the ability to supply water to sprinkler and standpipe systems.

N.F.P.A. PROFESSIONAL QUALIFICATION STANDARDS

Firefighter I

3-12.1	Describe the application of each size and type of hose on a pumper as required to be carried by NFPA 1901, *Standard for Pumper Fire Apparatus*
3-12.2	Demonstrate the use of nozzles, adapters, and hose appliances and tools on a pumper as required to be carried by NFPA 1901, *Standard for Pumper Fire Apparatus*
3-12.8	Define a fire stream.
3-12.9	Define water hammer and at least one method for its prevention.
3-12.11	Given a selection of nozzles and tips, shall identify the type, design, operation, required nozzle pressure, and flow of each.
3-19.1	Connect a supply hose to a hydrant, and fully open and close the hydrant.
3-19.2	Demonstrate hydrant to pumper hose connections for forward and reverse hose lays.
3-19.3	Assemble and connect the equipment necessary for drafting from a static water source.

Firefighter II

4-12.2	Select adapters and appliances to be used in three (3) specific fire ground situations.
4-12.3	Demonstrate the procedures for cleaning and maintaining fire hose, couplings and nozzles; and inspecting for damage.
4-12.5	Describe and demonstrate the operation of fog and solid stream nozzles.
4-19.4	Define the following terms as they relate to water supply:

a) Static pressure
b) Normal operating pressure
c) Residual pressure
d) Flow pressure

Firefighter II (cont'd)

4-19.6 Describe how the following conditions reduce hydrant effectiveness:

a) Obstructions to use of hydrant
b) Direction of hydrant outlets to suitability of use
c) Mechanical damage
d) Rust and corrosion
e) Failure to open the hydrant fully
f) Susceptibility to freezing

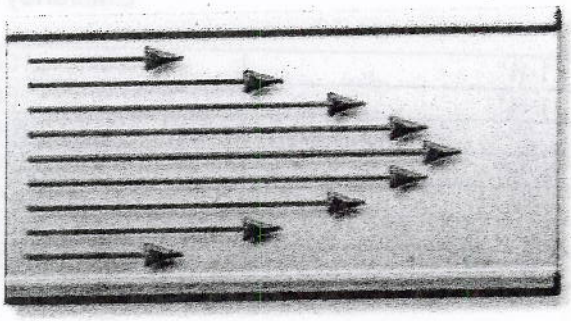
4-19.9 Given a Pitot tube and gauge, read and record flow pressures from three different sized orifices.

FRICTION LOSS

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

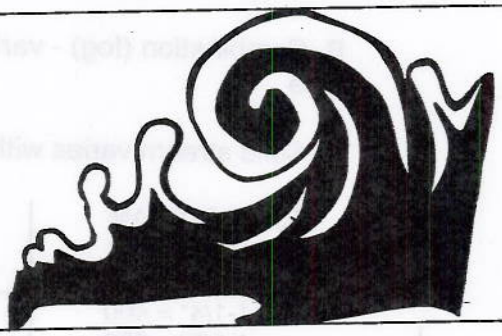
1. Quality of Flow

A. Laminar - water movement in a straight line.



LAMINAR FLOW
This diagram indicates laminar flow through a conduit. The length of the arrows represents the relative speed of the fluid in the conduit. The fastest flow is at the very center of the conduit, and the slowest is adjacent to the conduit walls. If the conduit is round, you can picture this as concentric layers of flow, gradually increasing in speed from the outside toward the center. The thicker the fluid, the greater the variation in speed of the layers will be. If the density of the fluid is high enough, tumbling between the layers will occur, significantly reducing flow through the conduit.

B. Turbulent - water moving in a swirling motion.



TURBULENT FLOW
Water is moving in a swirling motion

2. Hose

Type of construction and age – rough inner lining of the hose increases resistance.

A. Quality and age.

B. Diameter of hose.

Larger hose, less friction loss for same GPM.

Efficiency carrying capacity of hose.

1-½"	100 GPM
1-¾"	150 GPM
2"	200 GPM
2-½"	300 GPM
3"	500 GPM
4"	1000 GPM
5"	2000 GPM

3. Appliances

A. Siamese, wyes, master streams, ladder pipes, eductor

B. Varies with type and amount of flow

C. For problem solving:
- 10 PSI for master streams and ladder pipes
- 5 PSI for wye, siamese, etc.
- 25 PSI for standpipes

Start at 10 psi for heavy stream appliances. It can go as high as 25 psi depending on the flow and age of appliances

4. GPM's To Be Delivered

A. Varies with type of nozzle

B. Combination (fog) - varies with nozzle pressure and type

Combination nozzles @ 100 psi
@ 75 psi

C. Solid stream varies with the nozzle size

80 psi – Lowest pressure

SOLID STREAM MASTER STREAMS 80 psi	SOLID STREAM HANDLINES 50 psi
1-1/4" = 400	3/4" = 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

TIP SIZE

TYPES OF PRESSURE

Ask for examples:
Ponds
Swimming Pool
River Cistern

1. Static Pressure - stored potential energy that is available to move water through pipes, hoses and appliances

   A. Shown on compound gauge with NO water flowing

   B. Static pressure remains the same at any point in the closed system if elevation is the same. (No matter what size hose or piping).

What else could cause the residual pressure to be lower?

Partly clogged mains due to interruption etc.

2. Residual Pressure - kinetic energy that is available to perform work. Water pressure that was not used to overcome back pressure due to elevation or friction loss

   A. Incoming pressure shown on compound gauge with water flowing

   B. Residual pressure different at various points due to friction loss and elevation

3. Negative Pressure - any pressure created in the fire pump or in hard suction hose which is less than atmospheric pressure

'hat would cause a change in :rmal operating pressure?

   A. Atmospheric pressure is 14.7 PSI at sea level

4. Normal Operating Pressure - pressure through water distribution system during normal consumption demands

   A. Fluctuates during day and night and according to time of year

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

6. Discharge Pressure - in situations requiring multiple lines, the pump develops pressure for the highest line (greatest pressure)

   A. Gate back for all others to get the proper line pressure

Combo
Fixed Gallonage
Adjustable Gallonage
Automatic
Solid Stream
Tip Size

7. Nozzle Pressure - the pressure required at the nozzle tip to develop a proper fire stream from a nozzle

A. Nozzle pressure and tip size of the nozzle determine flow capability

B. Standard nozzle pressure:
- combination – 100 –75 – 50 psi
- solid handline – 50 psi
- solid master stream – 80 psi

P – pounds
S – square
I – inch
G – gauge

8. Net Pump Pressure - combined total pressure (PSI), developed by the fire pump

A. Net pump pressure = PSIG pressure + PSIG vacuum (in. of Hg)/2

9. Flow Pressure - forward velocity pressure at a discharge opening measured with pitot gauge

10. Forward Pressure - pressure gained by water flowing, when the nozzle is lower than the pump figured at 0.5 PSI per foot

A. 5 PSI per floor below ground level

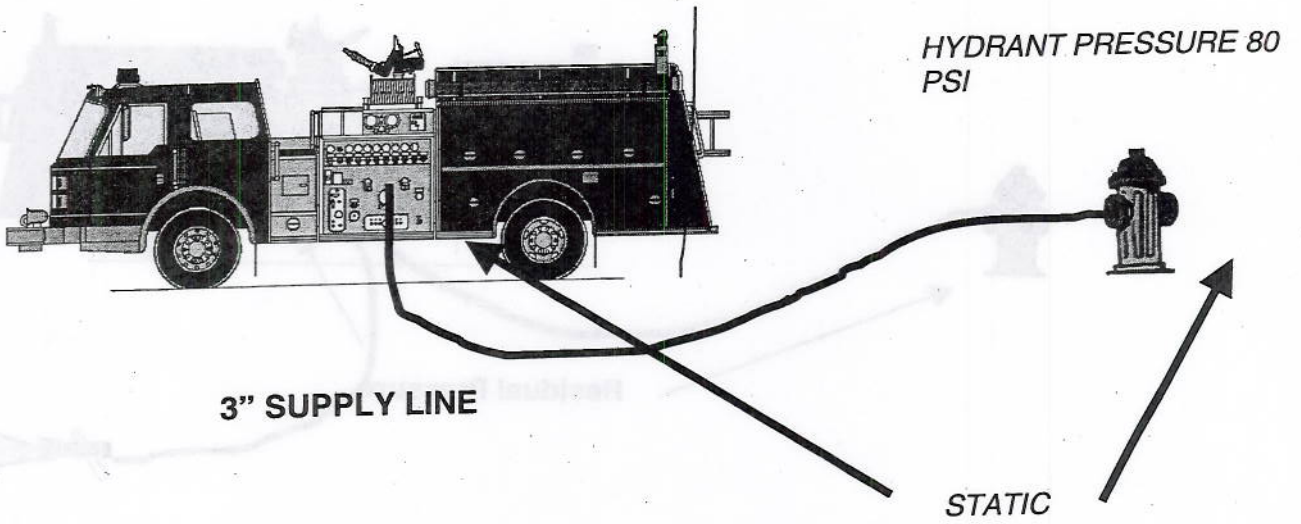
11. Back Pressure - pressure that must be overcome when the nozzle is above the pump. Figured at 0.5 PSI per foot

- 5 PSI per floor above ground level

Floor height – 10'
Add .5 per foot
Or
5 psi per floor after the first floor

FIREGROUND HYDRAULICS

Static Pressure - Stored potential energy that is available to move water through pipes, hoses and appliances. This pressure is shown on the compound gauge with NO water flowing.

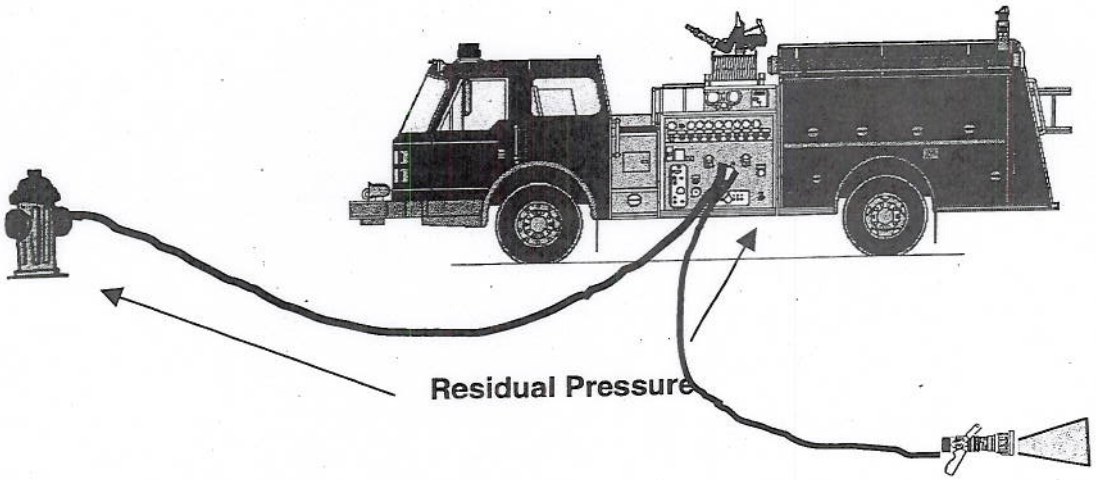


NOTE: Static pressure will be the same at any point in a closed system if the elevation is the same, regardless of the diameter of the waterway.

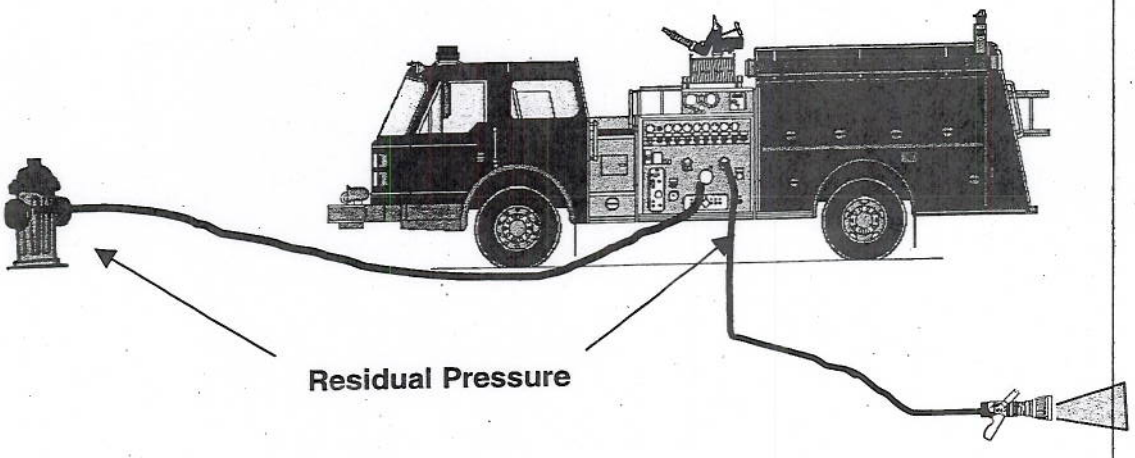
Operating Pressure – Pressure in the water distribution system under normal demand for domestic and industrial use. (Shows as static pressure on the compound gauge).

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

Shown on the compound gauge **with water flowing**.

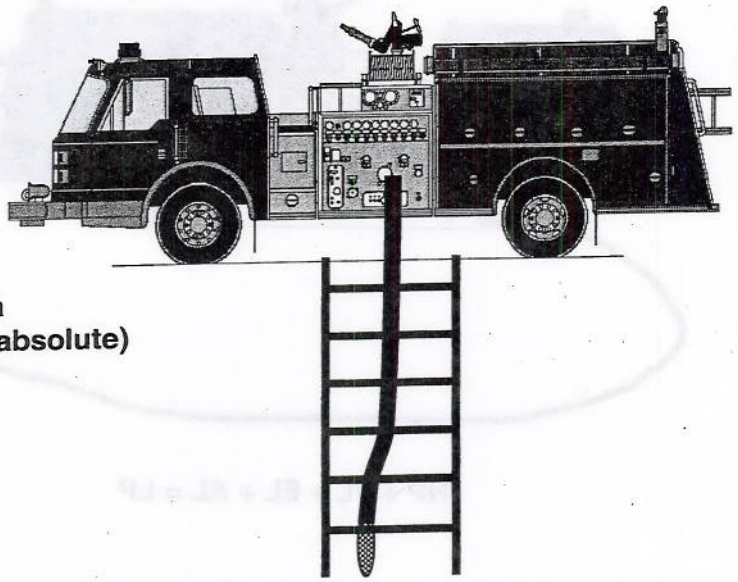


Residual pressure will vary at different points due to elevation and friction loss.



Why is there a difference between the residual pressure at the hydrant and that at the suction side of the pump?

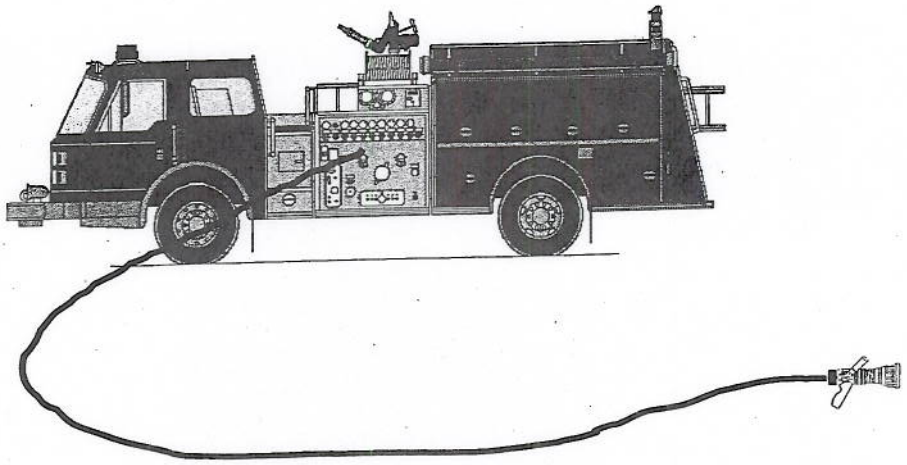
Negative Pressure – any pressure less than atmospheric



14.7 psia
(per square inch absolute)

	Height of Lift	Suction Size	Inches Hg
Single Suction	20'	4-1/2"	Approximately 7
	20'	5"	Approximately 7.5
	20'	6"	Approximately 7
Dual Suction			
	20'	5"	Approximately 2
	20'	6"	Approximately 2

Line Pressure – Pressure required to provide proper nozzle pressure with a given hose layout.



NP + FL + EL + AL = LP

Line pressure is usually calculated from the nozzle back to the pump.

Discharge Pressure – in situations requiring multiple lines, the pump must develop adequate pressure for the line receiving the greatest pressure and all other lines run at reduced pressure (gated back).

Nozzle Pressure – the pressure required at the nozzle to develop a proper fire stream from a nozzle of given design. The nozzle pressure and the tip size (cross sectional area) of the nozzle determine flow capability. Standard nozzle pressures are as follows:

Low Pressure Combination Nozzle	50/75 psi
Combination Nozzle	100 psi
Solid Stream Handline Nozzle	50 psi
Solid Stream Master Stream	80 psi

Flow Pressure – forward velocity pressure at a discharge opening.

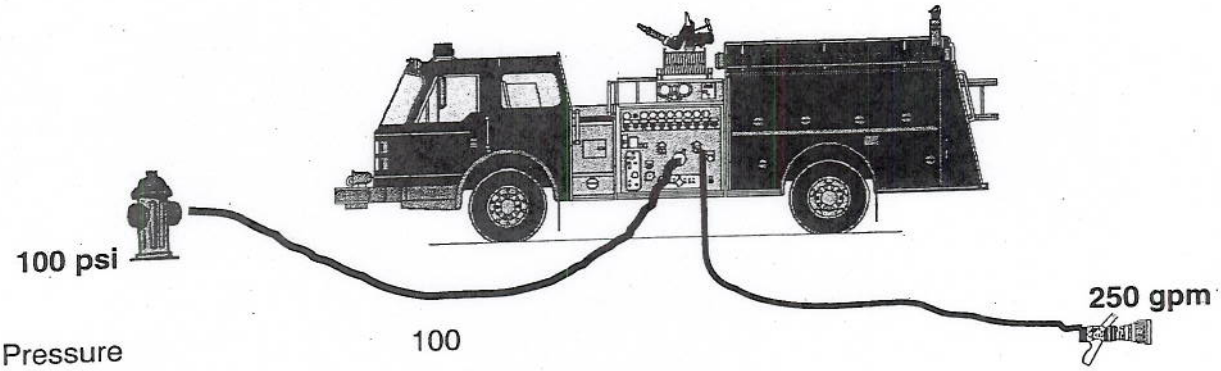
Pressure Source Evaluation – Static/Residual Rule

Pressure drop 10% / 15 = 3x present flow still available

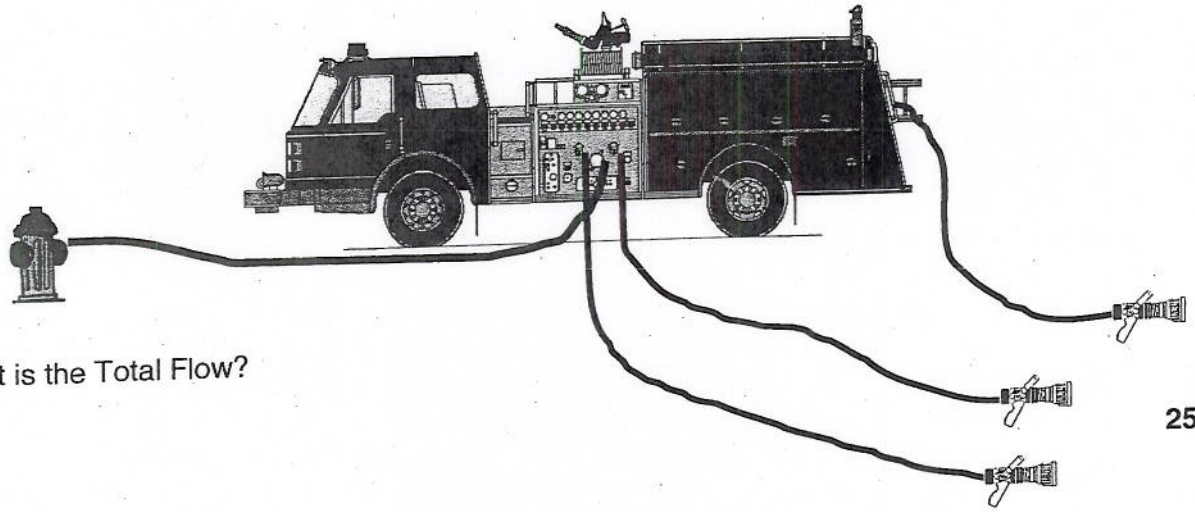
Pressure Drop 15% / 25 = 2x present flow still available

Pressure Drop more than 25% = 1x present flow still available

These calculations are an approximation and decisions must be balanced by the pump operator's judgment.



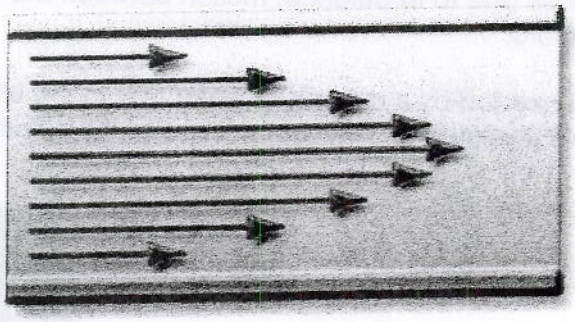
Static Pressure 100
psi
Residual Pressure 85 psi
Pressure Drop 15%
500 gpm still available



What is the Total Flow?

250 gpm

**NO ADDITIONAL 250 GPM LINES MAY BE RUN.
AVAILABLE FLOW IS LESS THAN 250 GPM.**



LAMINAR FLOW

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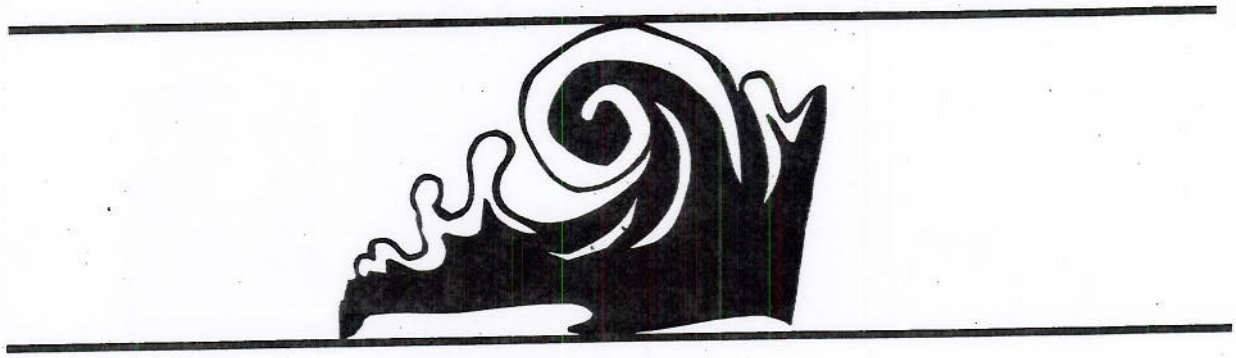
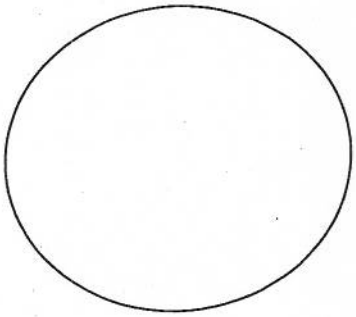
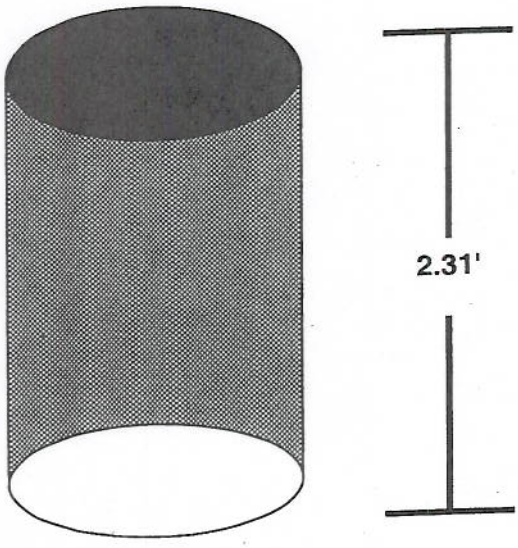


TURBULENT FLOW
Water is moving through the hose in a swirling motion

Friction Loss – pressure loss due to turbulence, friction between the liquid and the conduit and viscosity are influencing factors.

Back Pressure – pressure exerted by a column of water due to the effects of gravity. A column of water 2.31 feet high exerts a pressure of 1 psi at the base of the column.





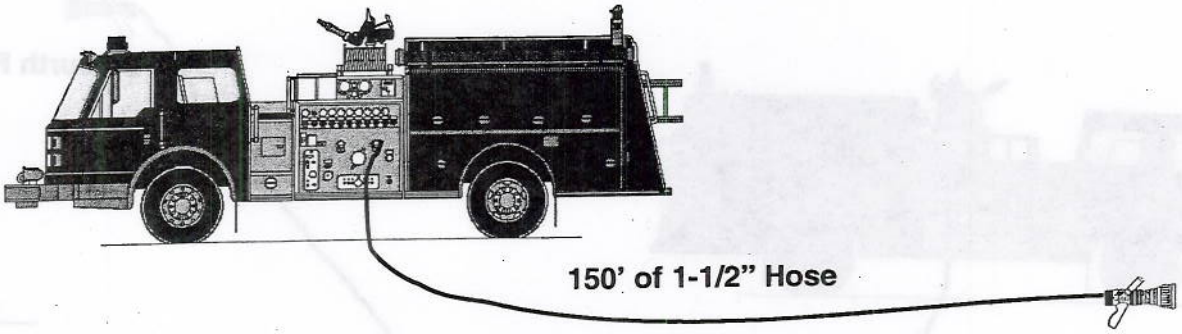
FLOW	1-1/2" Hose FL/100'	1-3/4" Hose FL/100'	2" Hose FL/100'
50 gpm	10 psi	5 psi	
80 gpm	20 psi	10 psi	
100 gpm	30 psi	15 psi	
125 gpm	50 psi	25 psi	10 psi
150 gpm		30 psi	15 psi
200 gpm		60 psi	25 psi
250 gpm			40 psi
300 gpm			55 psi

Required fire flow for a structure or car fire is 100 gpm.

The efficient carrying capacity of 1-1/2" hose is?_____

The efficient carrying capacity of 1-3/4" hose is? _____

The efficient carrying capacity of 2" hose is? _____

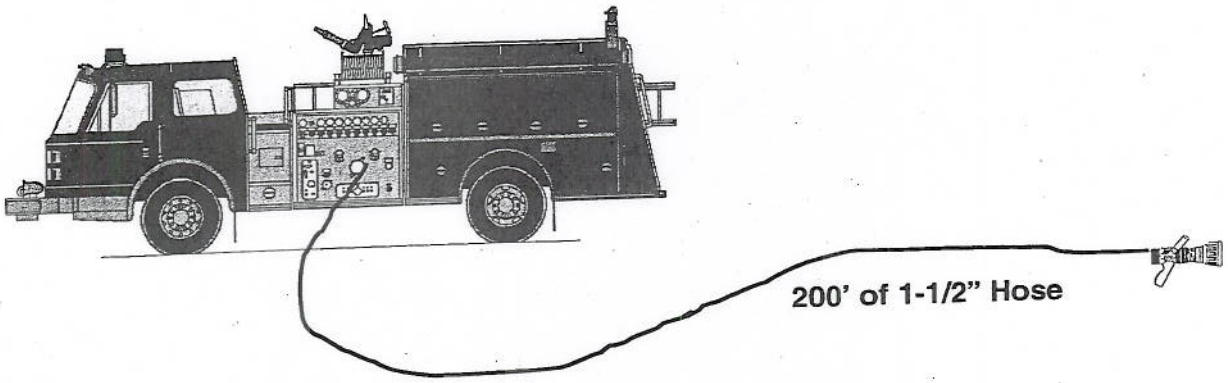


100 gpm Combination

NP =
FL =
EL =
AL =

LP =

NP – Nozzle Pressure
FL – Friction Loss
EL – Elevation
AL – Appliance Loss
LP – Line Pressure

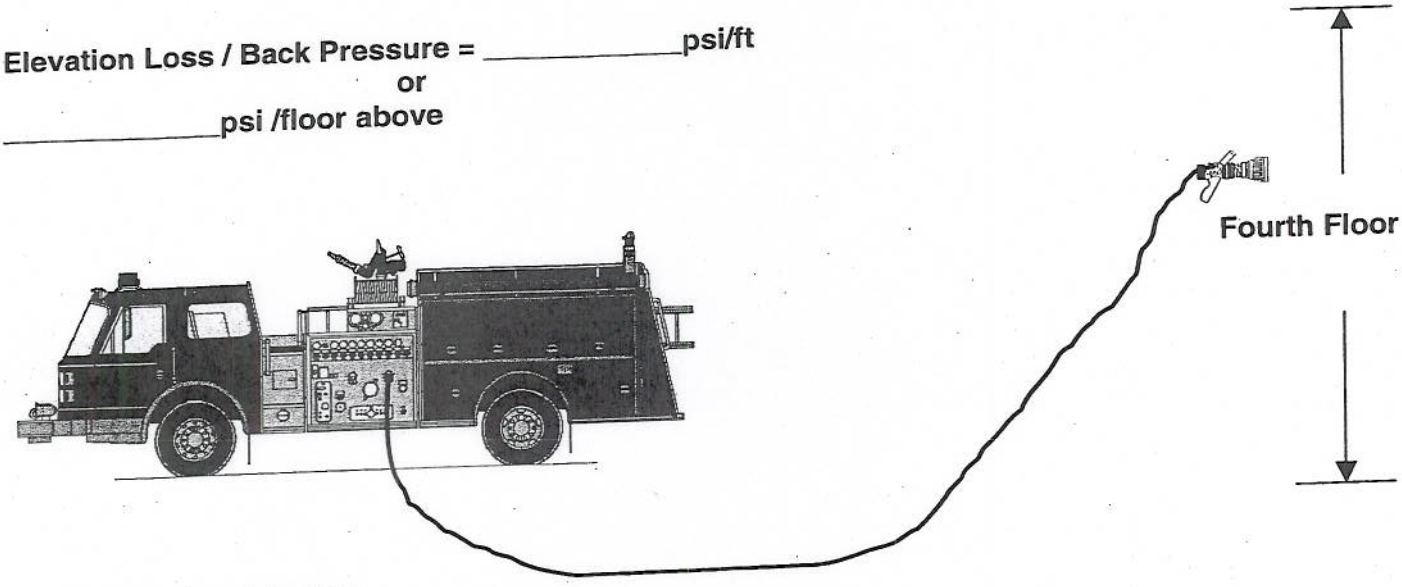


100 gpm Combination

NP =
FL =
EL =
AL =

LP =

Elevation Loss / Back Pressure = _____psi/ft
or
_____psi /floor above



150 gpm Combination

250' of 1-3/4" Hose

NP =
FL =
EL =
AL =

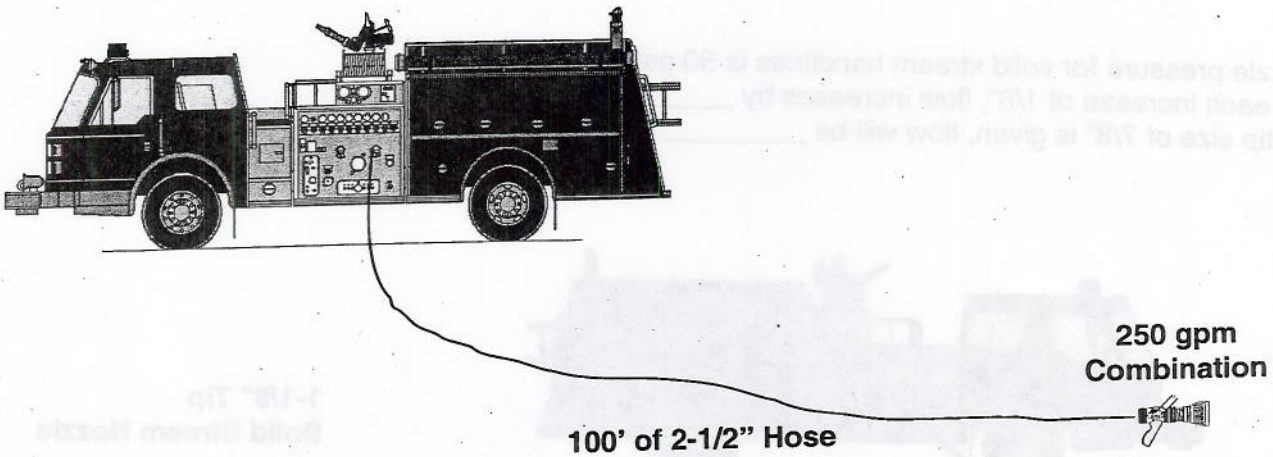
LP =

Elevation should be considered at any level above the first floor or comparable distance.
One floor = approximately 10'.

2-1/2" Hose

2-1/2" hose is commonly used for handline operations.
The carrying capacity of 2-1/2" hose is _____gpm?

Friction Loss Calculations – 2-1/2" Hose



The flow through this line is 250 gpm

250	Drop the last digit
-10	Subtract 10
15	Friction Loss / 100'

Note: This method is used for flows up to 399 gpm.

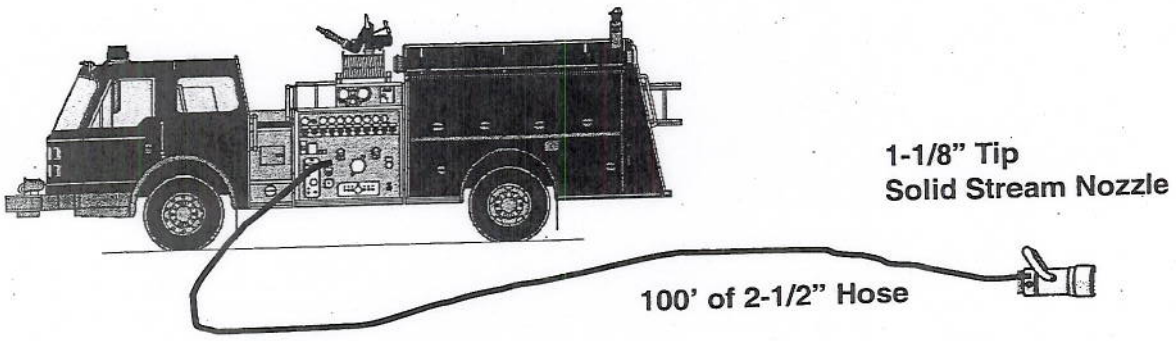
NP =
FL =
EL =
AL =

LP =

With 2-1/2" hand lines, solid stream nozzles are often used for maximum reach and penetration. With solid stream nozzles, tip size (diameter) is known and flow must be determined. Three tip sizes are normally used on 2-1/2" handlines.

1"	200 gpm
1-1/8"	250 gpm
1-1/4"	300 gpm

Nozzle pressure for solid stream handlines is 50 psi.
For each increase of 1/8", flow increases by _____gpm.
If a tip size of 7/8" is given, flow will be _____gpm.



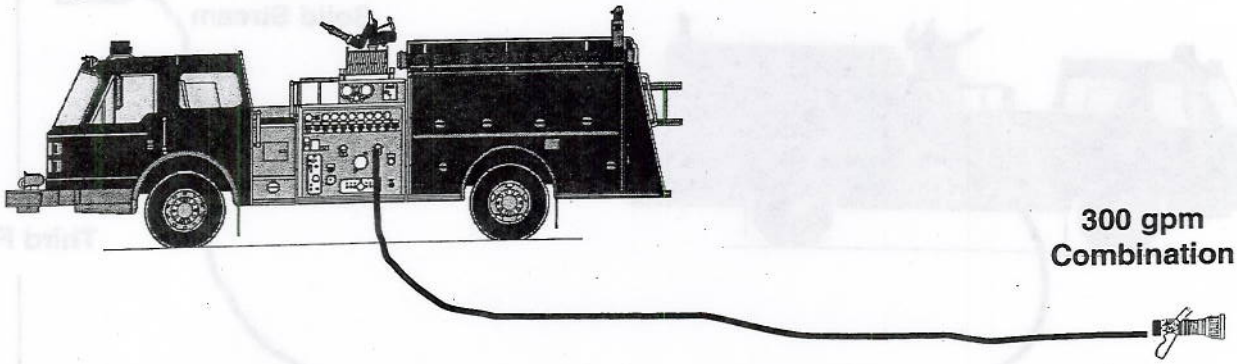
NP =
FL =
EL =
AL =

LP =

Compare the line pressure above to the line pressure required with 100' of 2-1/2" using a 250 gpm combination nozzle.

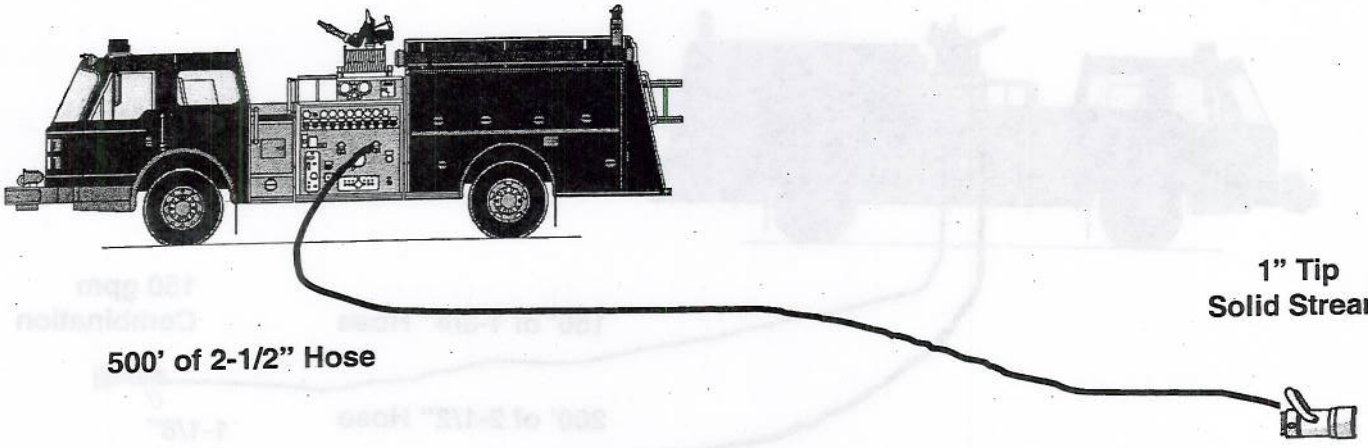
NP =
FL =
EL =
AL =

LP =



NP =
FL =
EL =
AL =

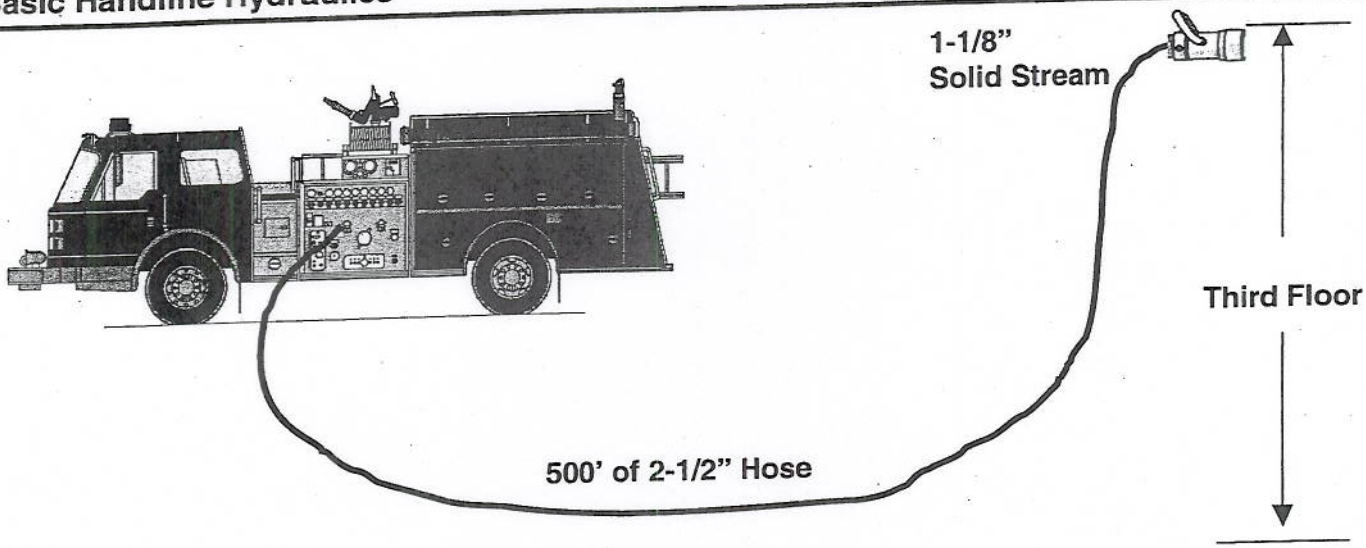
LP =



Flow_____ gpm

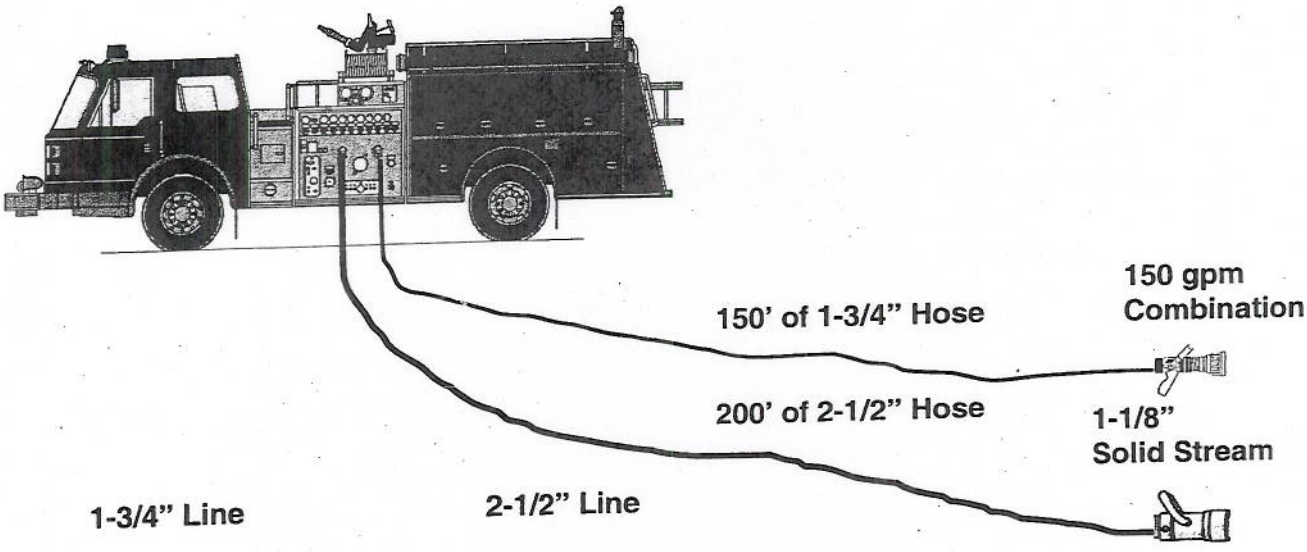
NP =
FL =
EL =
AL =

LP =



NP =
FL =
EL =
AL =

LP =



1-3/4" Line

NP =
FL =
EL =
AL =

LP =

2-1/2" Line

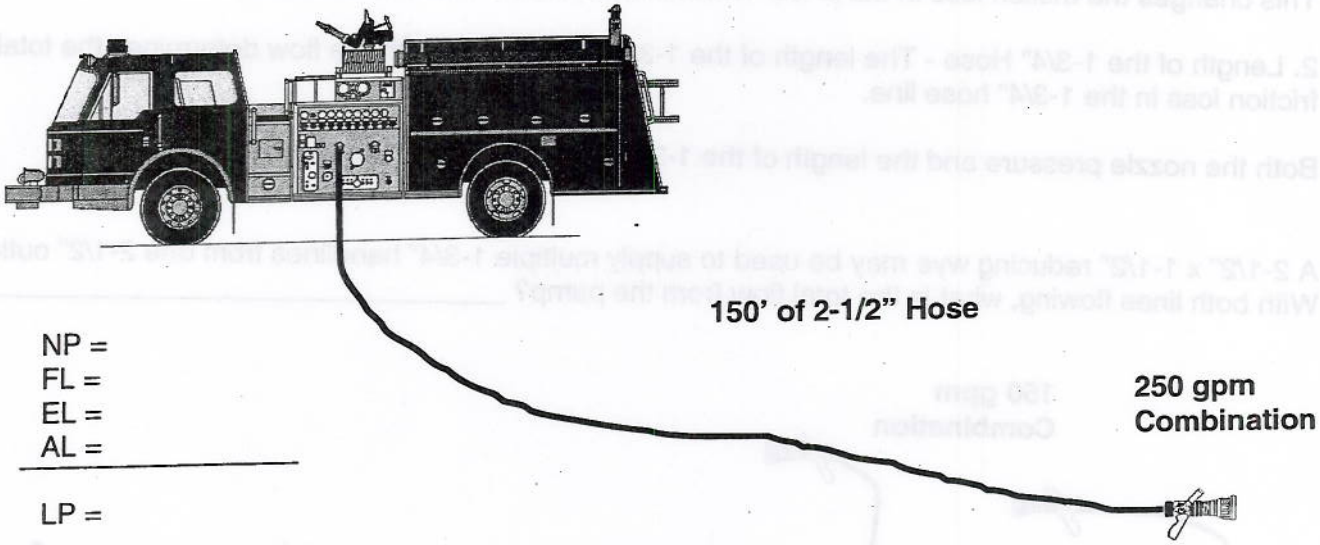
NP =
FL =
EL =
AL =

LP =

Total Flow _____gpm

Engine Pressure_____psi

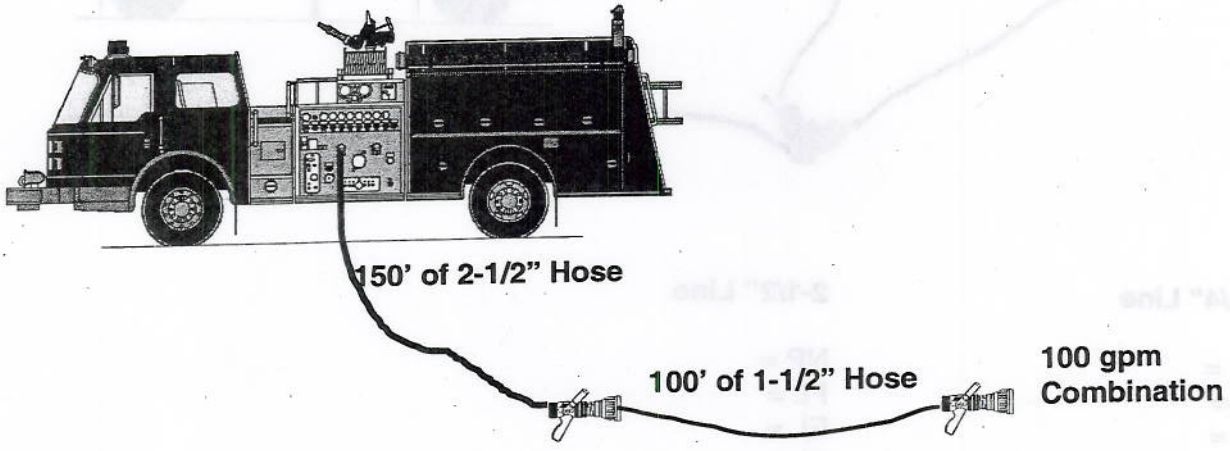
Large supply lines or attack lines are often broken down into a smaller line or lines for increased mobility. The pump operator must adjust his/her line pressure to maintain proper nozzle pressure.



NP =
FL =
EL =
AL =

LP =

The line above is equipped with a variable flow, break-apart nozzle. After the fire is knocked down, the tip is removed and 100' of 1-1/2" is added onto the line and the tip is placed on the 1-1/2" line with the flow reduced to 100 gpm.



1-1/2" Line

NP =
FL =
EL =
AL =

LP =

2-1/2" Line

NP =
FL =
EL =
AL =

LP =

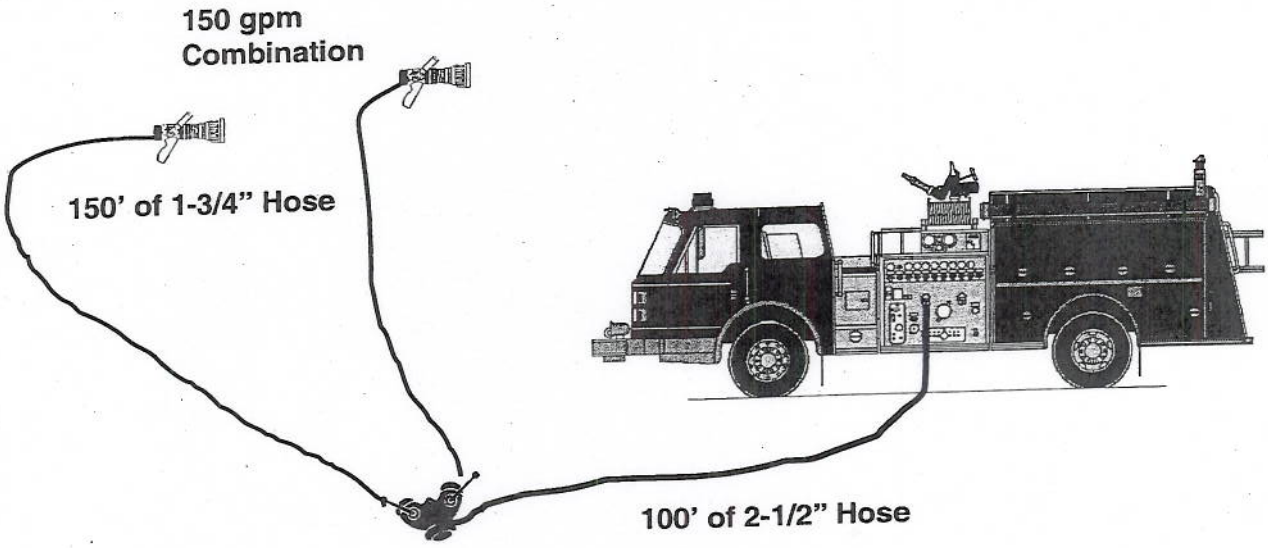
There are several factors that influence the change in line pressure required in the preceding problem:

1. Flow – The flow is reduced.
This changes the friction loss in the 2-1/2" hose and determines the friction loss in the 1-3/4" hose.

2. Length of the 1-3/4" Hose - The length of the 1-3/4" hose, along with the flow determines the total friction loss in the 1-3/4" hose line.

Both the nozzle pressure and the length of the 1-3/4" hoseline remain the same.

A 2-1/2" x 1-1/2" reducing wye may be used to supply multiple 1-3/4" handlines from one 2-1/2" outlet. With both lines flowing, what is the total flow from the pump? _____



1-3/4" Line

NP =
FL =
EL =
AL =

LP =

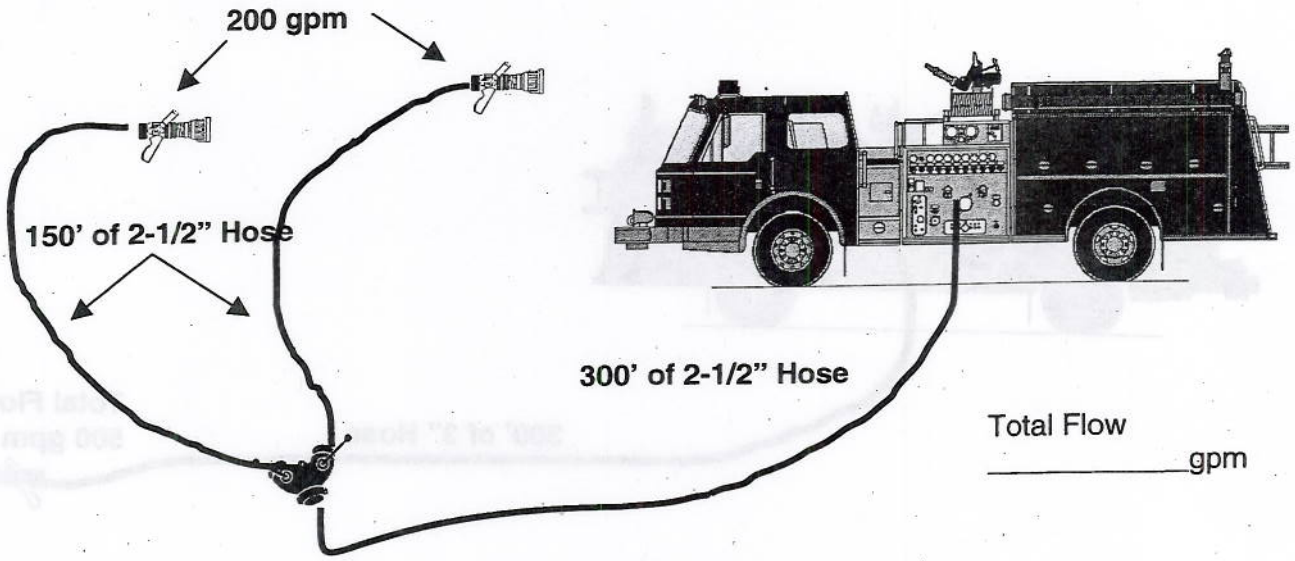
2-1/2" Line

NP =
FL =
EL =
AL =

LP =

When the efficient carrying capacity of a hose line is exceeded, the friction loss increases and calculations must be adjusted to compensate for this increase.

With 2-1/2" hose, when the flow exceeds 399 gpm, turbulent flow increases and friction loss is calculated as follows: Drop the last digit of the flow



Total Flow
_____gpm

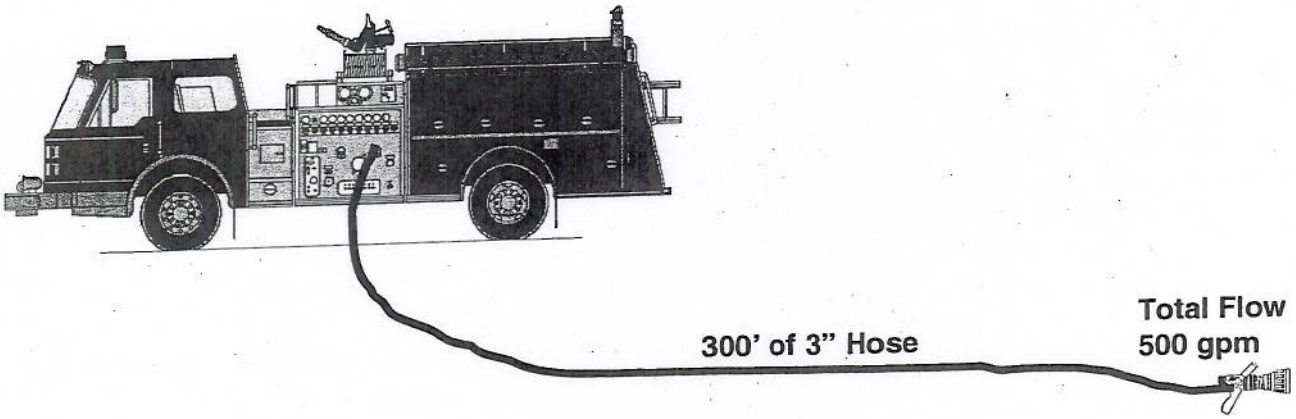
(2-1/2")
(2-1/2" Supply)

NP =
FL =
FL =
EL =
AL =

LP =

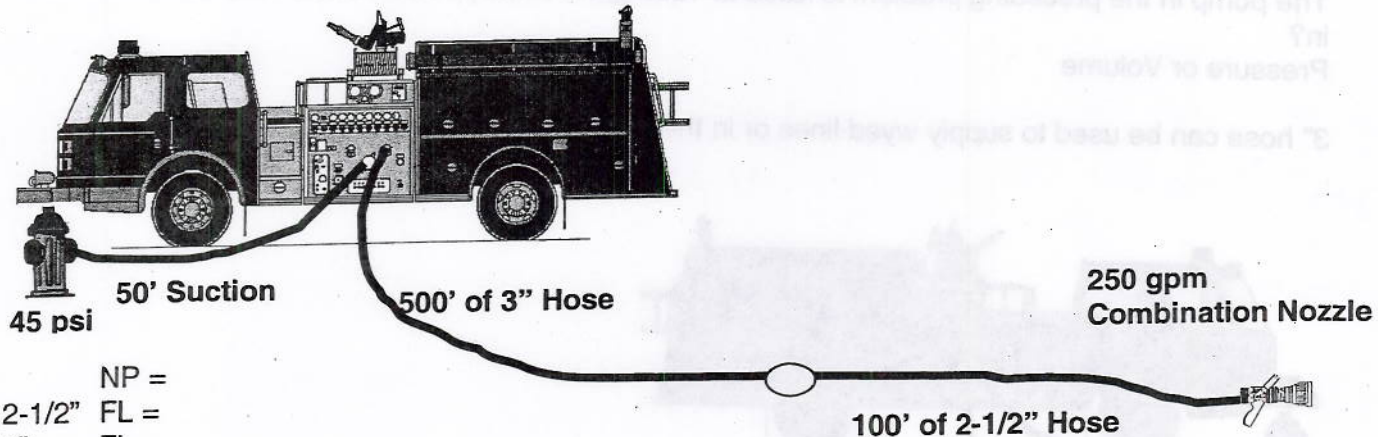
3" hose is often used as a supply line feeding pumps, appliances or handlines.
The efficient carrying capacity of 3" hose is _____gpm.

Friction loss in 3" hose is calculated by squaring the first digit of the flow.



5x5 = 25 psi – Friction Loss / 100'
25 psi/100'

NP =
FL =
EL =
AL =
_____
LP =



NP =
2-1/2" FL =
3" FL =
EL =
AL =

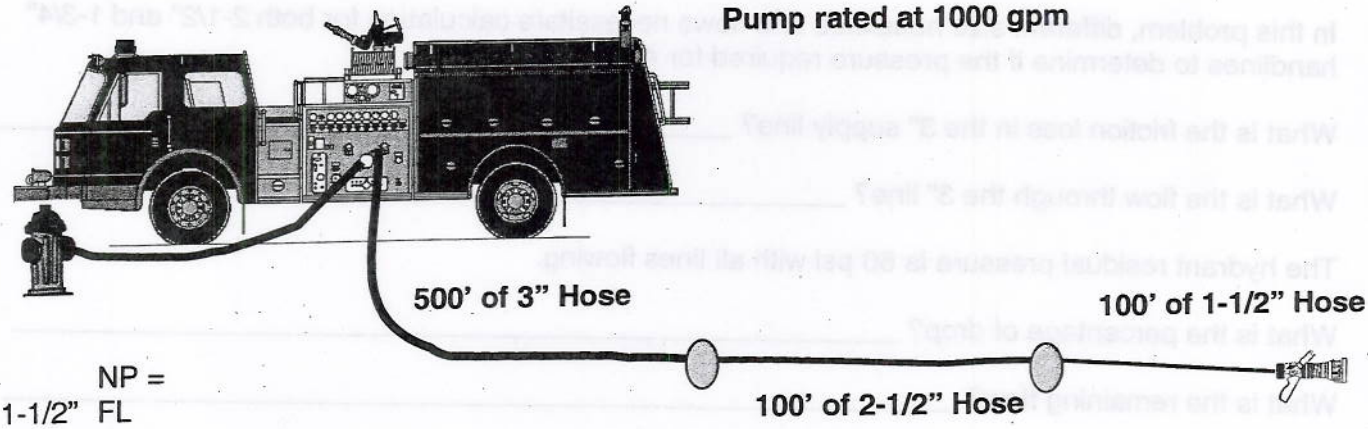
LP =

Static pressure was 45 psi, residual pressure is now 40 psi. Your pump is rated at 1500 gpm. Can you supply a second pump rated at 750 gpm with its rated capacity?

What is the percentage of drop? _____

Why? _____

You are informed that the nozzleperson has broken down to 1-1/2" line and has added 100' of 1-1/2" hose and has reduced the flow to 100 gpm. Calculate the required line pressure.

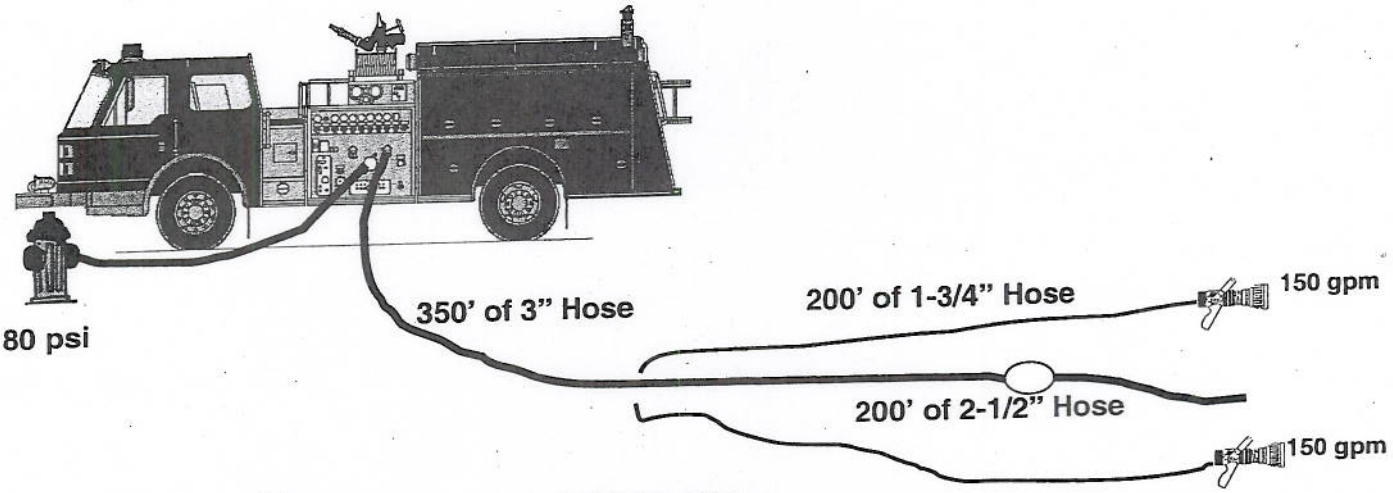


NP =
1-1/2" FL
2-1/2" FL =
3" FL =
EL =
AL =

LP =

The pump in the preceding problem is rated at 1000 gpm. What position should the transfer valve be in?
Pressure or Volume

3" hose can be used to supply wyed lines or in the following problem, a water thief.



1-3/4" Handline

NP =
FL =
EL =
AL =

LP =

2-1/2" Handline

NP =
FL =
EL =
AL =

LP =

In this problem, different size hoselines and flows necessitate calculation for both 2-1/2" and 1-3/4" handlines to determine if the pressure required for each is the same.

What is the friction loss in the 3" supply line? _____

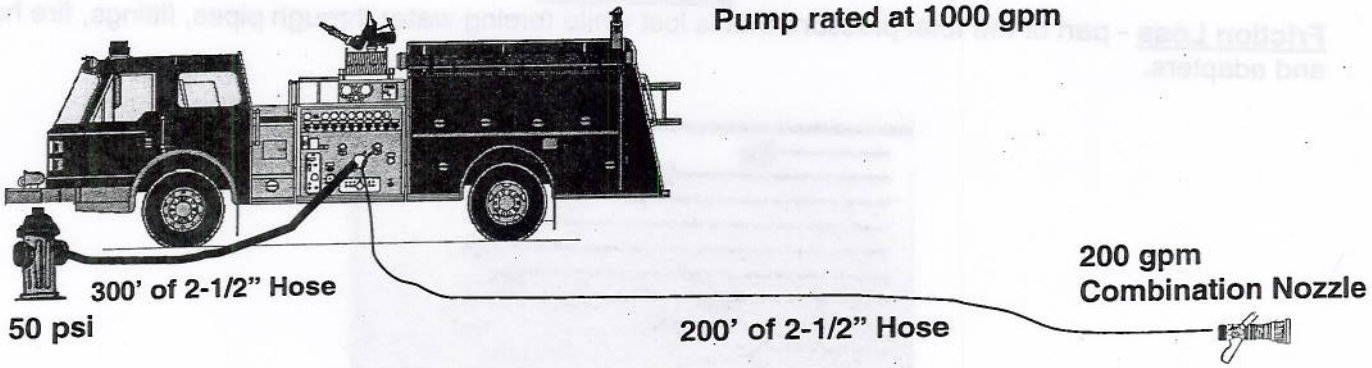
What is the flow through the 3" line? _____

The hydrant residual pressure is 60 psi with all lines flowing.

What is the percentage of drop? _____

What is the remaining flow? _____

Why? _____



The pump above is a single stage pump. Does this pump have a transfer valve? _____

What is the friction loss in the 2-1/2" supply line? _____

What is the flow through the 2-1/2" supply line? _____

Using the static residual pressure rule, what is the remaining flow available at the pump? _____

Pressure drop was? _____

What %? _____

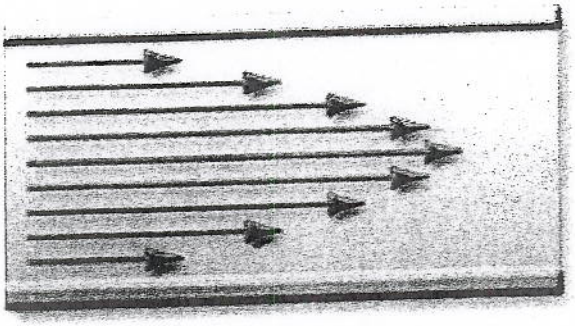
Flow available? _____

How can the flow in the problem be increased? _____

_____

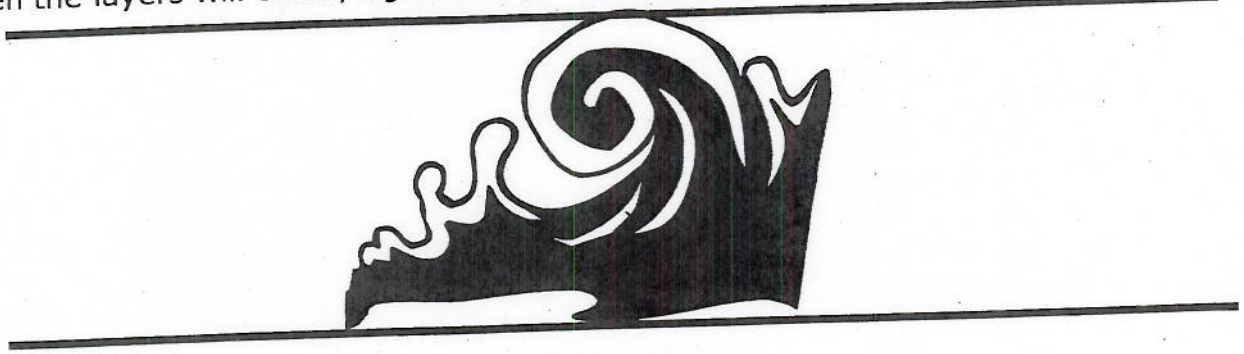
HYDRAULICS

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



LAMINAR FLOW

This diagram indicates laminar flow through a conduit. The length of the arrows represents the relative speed of the fluid in the conduit. The fastest flow is at the very center of the conduit, and the slowest flow is adjacent to the conduit walls. If the conduit is round, you can picture this as concentric "layers" of flow, gradually increasing in speed from the outside toward the center. The thicker the fluid (high density), the greater the variation in speed of the layers will be. If the density of the fluid is high enough, tumbling between the layers will occur, significantly reducing flow through the conduit.



TURBULENT FLOW

Water is moving through the hose in a swirling motion

Turbulent Flow – the flow of a fluid past an object such that the velocity at any fixed pointing the liquid varies irregularly.

Factors that influence friction loss:

1) Quality and age of hose
2) Diameter of hose
3) Length of hose
4) Appliances in hose line
5) Quantity of water being pumped
6) Elevation
7) Nozzle and flow

1) Quality and age of hose - type of jacket, older hose is more rough and therefore creates more friction.
2) Diameter of hose - the larger the hose the less friction loss for the same gallons per minute flowing.

EFFICIENT CARRYING CAPACITY OF HOSE:

Size	GPM
1-1/2"	_____
1-3/4"	_____
2"	_____
2-1/2"	_____
3"	_____
4"	_____
5"	_____

3) Hose length - the longer the lay the higher the friction loss will be for the same gallons per minute being pumped.

Hose lay of 500 feet has friction loss of #
Hose lay of 1,000 feet has friction loss of # X2
Hose lay of 1,500 feet has friction loss of # X3

4) Appliances in hose line - examples, wyes, siamese, deluge guns, ladder pipe, adapters, etc. Friction loss will vary with type and amount of flow.

RULE OF THUMB FOR PROBLEM SOLVING:

- **Add 10 PSI for deluge sets, ground guns and ladder pipes**
- **Add 5 PSI for wyes, Siamese, etc.**
- **Add 25 PSI for standpipes**

5) Quantity of water- friction loss will vary with the amount of water (GPM) being delivered and the appliance it is delivered through.

Combination nozzles – Various (100 psi and low pressure 50/75 psi)

MASTER STREAM WITH SMOOTH BORE NOZZLES: 80 PSI

Tip Size	GPM
1-1/4"	_____
1-3/8"	500
1-1/2"	_____
1-3/4"	_____
2"	1,000

HANDLINES WITH SMOOTH BORE NOZZLES:

Tip Size	GPM
7/8"	____
15/16"	____
1"	____
1-1/8"	____
1-1/4"	300

NOZZLE PRESSURES: (Three main nozzle pressures)

Low pressure fog	____ PSI
Fog nozzle (combination nozzle)	____ PSI
Smooth bore handlines	____ PSI
Masterstreams: Smooth bore	____ PSI
Fog nozzle	____ PSI

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

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

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

Shown on the compound gauge **with water flowing**. Residual pressure will vary at different points due to elevation and friction loss.

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

This will fluctuate during the day and night as well as the time of year.

Line Pressure - Pressure needed to provide **proper nozzle pressure** within a given layout. This is normally calculated from the nozzle back.

Discharge Pressure - **The highest pressure the pump is supplying**. All other lines with lower pressures are gated back.

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

Low Pressure Combination and Automatic 50 or 75 PSI
Combination 100 PSI
Smooth Bore Handline 50 PSI
Master Stream Combination 100 PSI
Master Stream Smooth Bore 80 PSI

Net Pump Pressure - Combined total pressure developed by the pump.
Discharge pressure - Intake pressure.

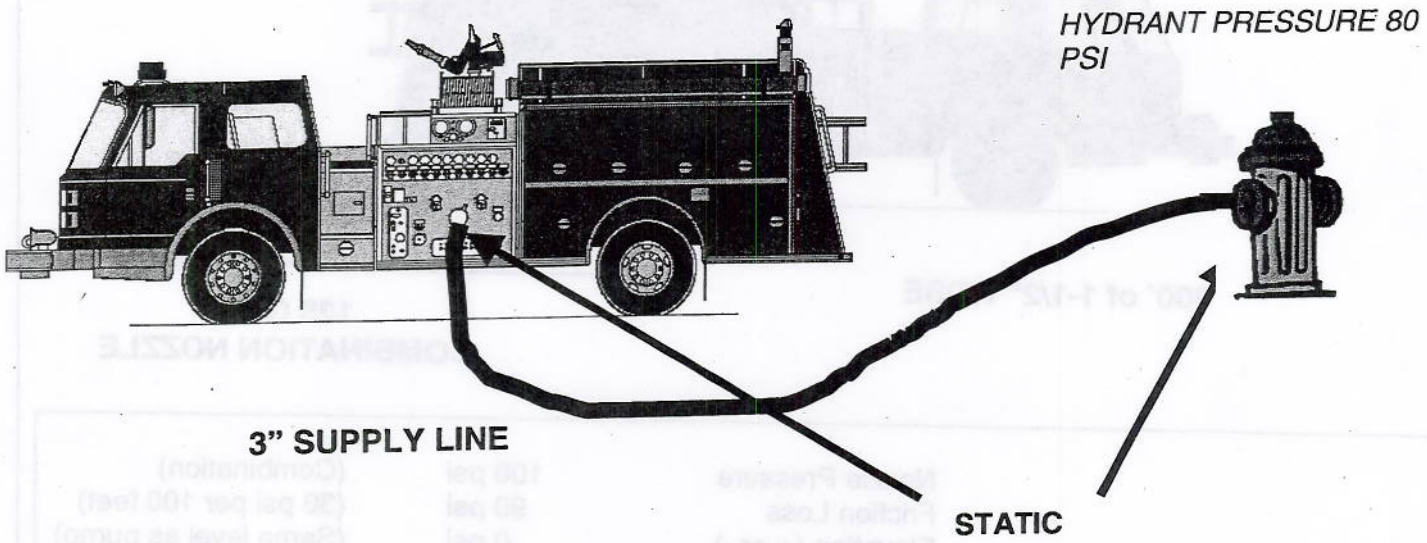
Flow Pressure - Forward velocity pressure at a discharge opening measured by a pitot gauge.

Forward Pressure - Pressure gained by water flowing when the nozzle is lower than the pump.
Figured at .5 PSI per foot or 5 PSI per floor below ground level.

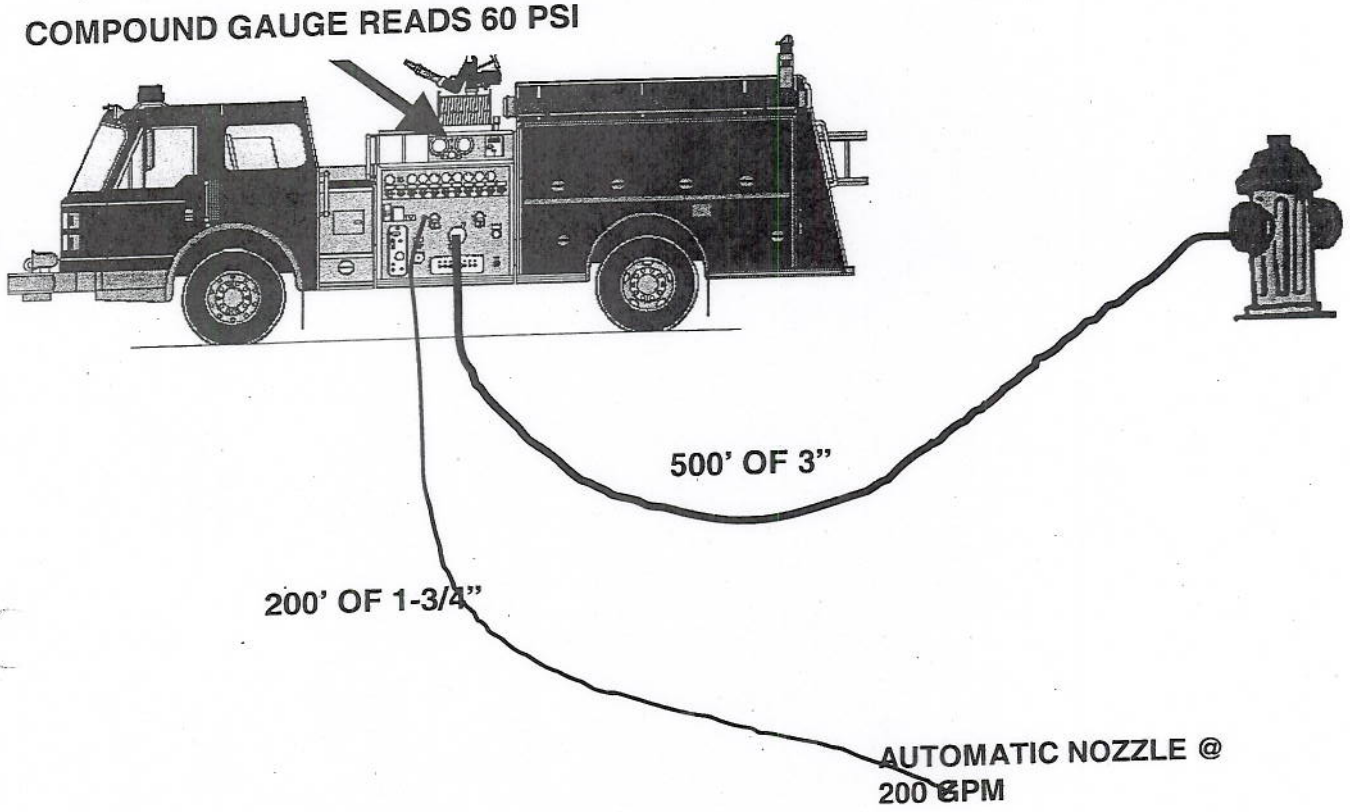
Back Pressure - Pressure that must be overcome when the nozzle is above the pump. Figured at .5 PSI per foot or 5 PSI per floor above ground level.

Negative Pressure - Any pressure created in the pump or hard suction hose which is less than atmospheric (14.7 PSI at sea level)

ATIC - Stored potential energy that is available to move water through pipes, hoses and appliances. This pressure is shown on the compound gauge with NO water flowing.



.SIDUAL - Kinetic energy that is available to perform work. This pressure is shown on the compound gauge with water flowing.
(NOTE: The pressure will vary at different points in the system due to elevation as well as friction loss.)

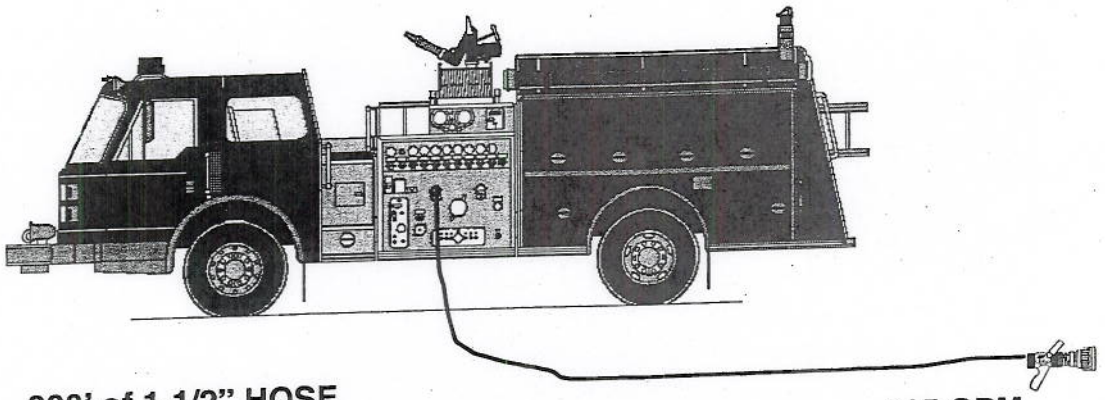


What is the % of drop? _____

What is the remaining flow available from the hydrant? _____

Why? _____

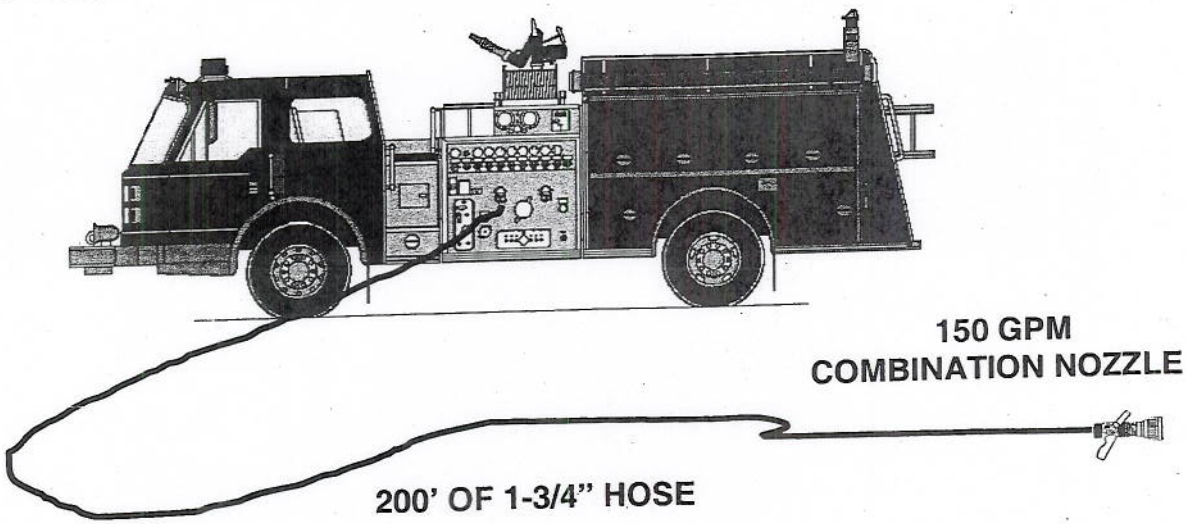
1-1/2" & 1-3/4" EXAMPLE



300' of 1-1/2" HOSE

125 GPM COMBINATION NOZZLE

Nozzle Pressure	100 psi	(Combination)
Friction Loss	90 psi	(30 psi per 100 feet)
Elevation (+ or -)	0 psi	(Same level as pump)
Appliance Loss	0 psi	(No Appliances)
		190 psi Line Pressure



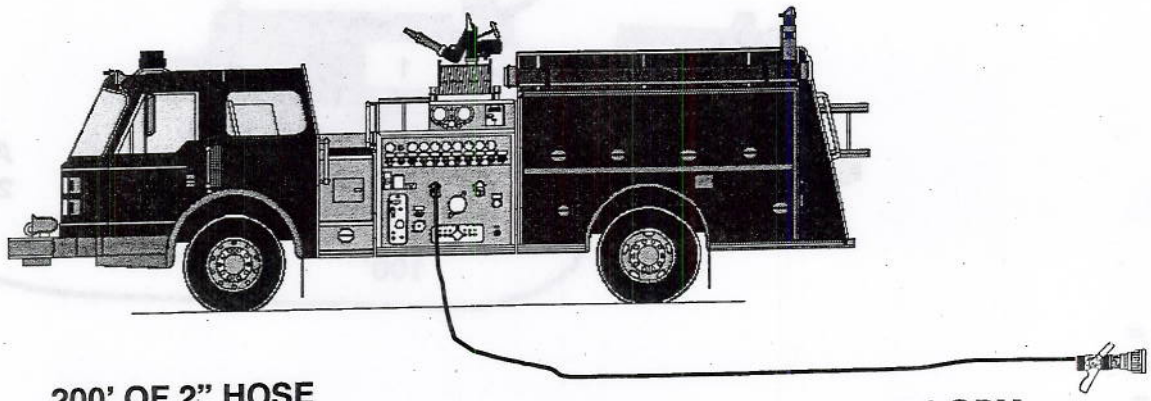
150 GPM COMBINATION NOZZLE

200' OF 1-3/4" HOSE

NP =
FL =
EL =
AL =

LP =

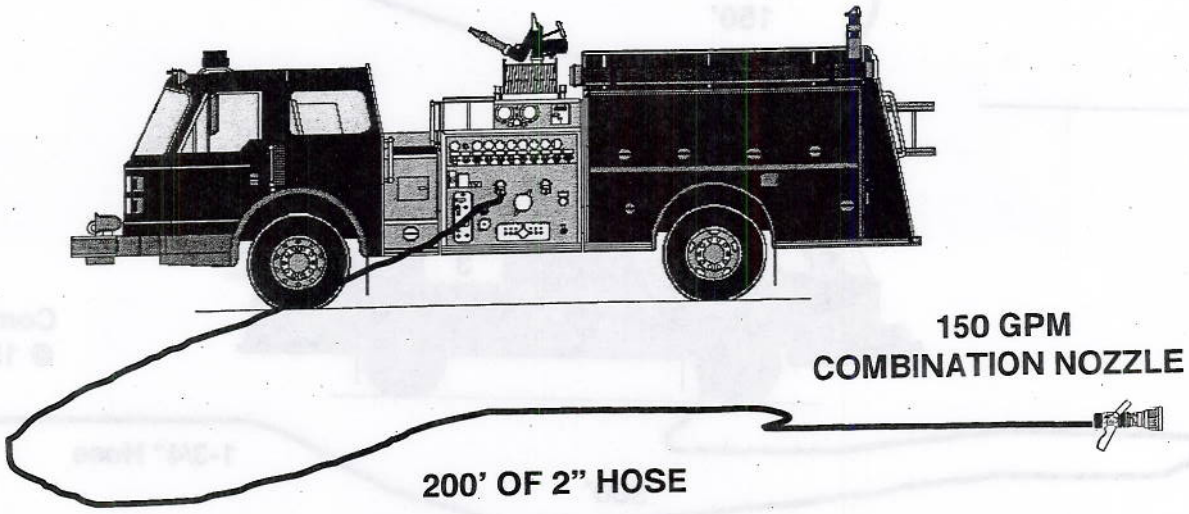
2" EXAMPLE



200' OF 2" HOSE

250 GPM COMBINATION NOZZLE

Nozzle Pressure	100 psi	(Combination)
Friction Loss	80 psi	(40 psi per 100 feet)
Elevation (+ or -)	0 psi	(Same level as pump)
Appliance Loss	0 psi	(No Appliances)
		180 psi Line Pressure



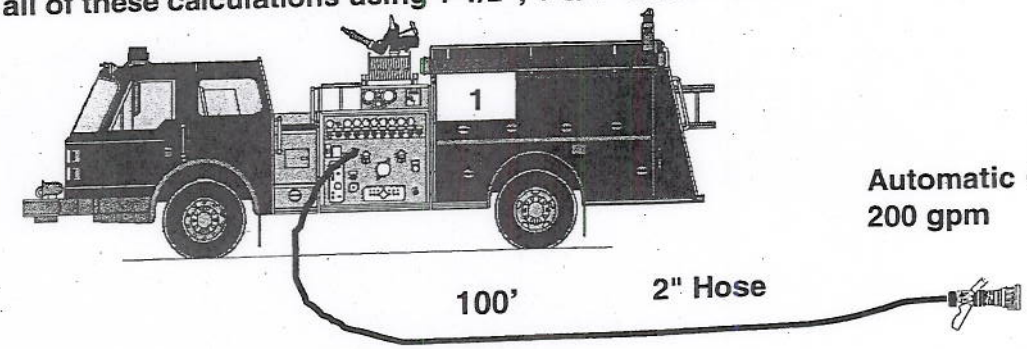
150 GPM COMBINATION NOZZLE

200' OF 2" HOSE

NP =
FL =
EL =
AL =

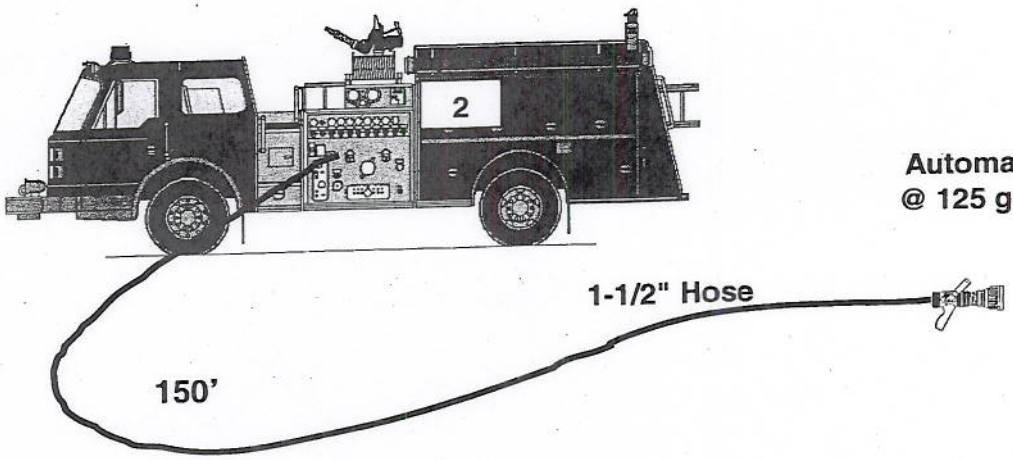
LP =

Do all of these calculations using 1-1/2", 1-3/4" and 2" hose



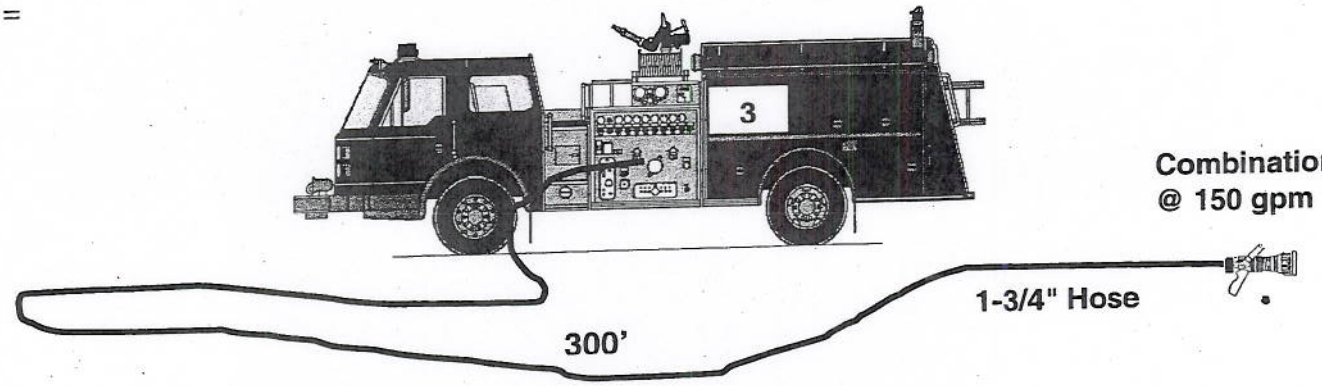
NP =
FL =
EL =
AL = _____

LP =



NP =
FL =
EL =
AL = _____

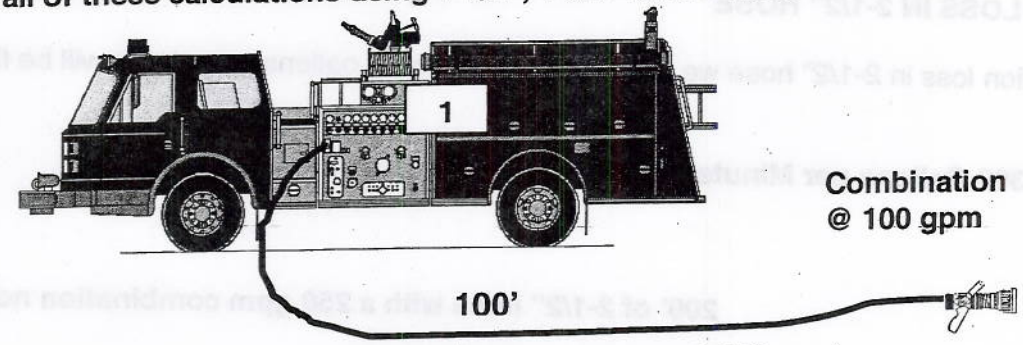
LP =



NP =
FL =
EL =
AL = _____

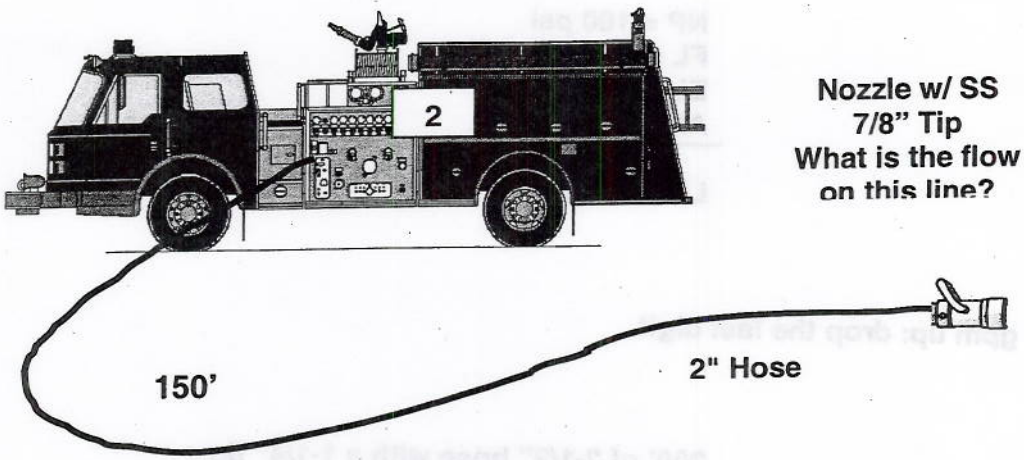
LP =

Do all of these calculations using 1-1/2", 1-3/4" and 2" hose



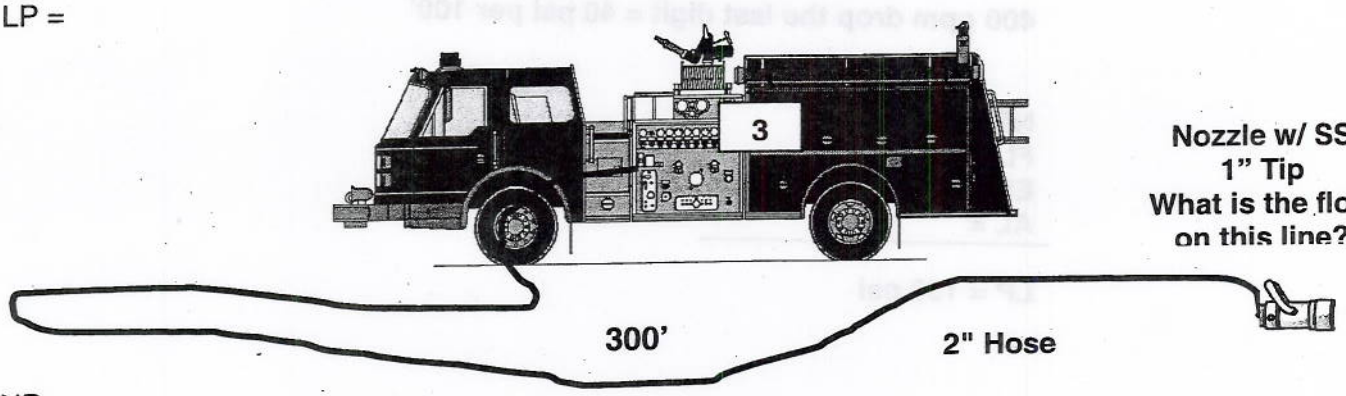
NP =
FL =
EL =
AL = _____

LP =



NP =
FL =
EL =
AL = _____

LP =



NP =
FL =
EL =
AL = _____

LP =

ICTION LOSS IN 2-1/2" HOSE

To find friction loss in 2-1/2" hose we first need to know what gallons per minute will be flowing in the line:

From 0 to 399 Gallons per Minute: drop the last digit and subtract 10.

200' of 2-1/2" hose with a 250 gpm combination nozzle

250 drop the last digit = 25
Minus 10

15 psi friction loss per 100'

NP = 100 psi
FL = 30 psi
EL =
AL =

LP = 130 psi

From 400 gpm up: drop the last digit.

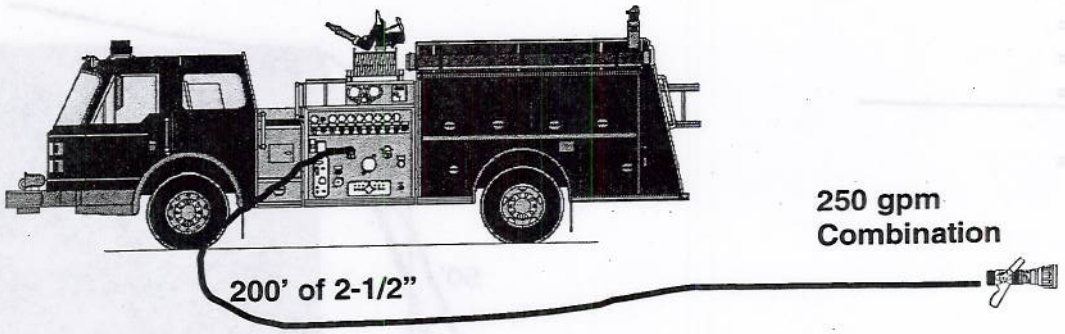
200' of 2-1/2" hose with a 1-1/4" tip

400 gpm drop the last digit = 40 psi per 100'

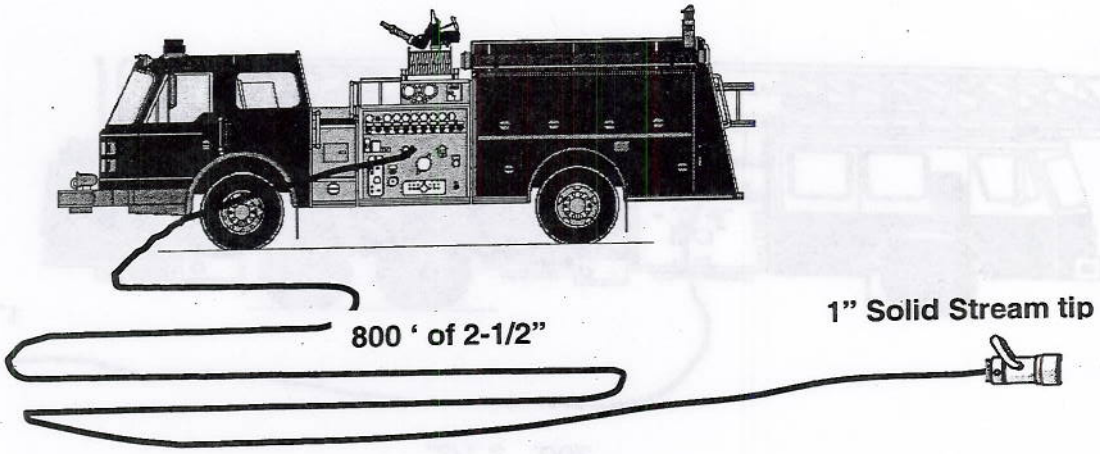
NP = 50 psi
FL = 80 psi
EL =
AL =

LP = 130 psi

2-1/2" EXAMPLE



Nozzle Pressure	100 psi	Combination
Friction Loss	30 psi	Flow drop last digit less 10 = 15 psi/100'x2
Elevation (+ or -)	0 psi	Same level as pump
Appliance Loss	0 psi	No appliances
	130 psi Line Pressure	

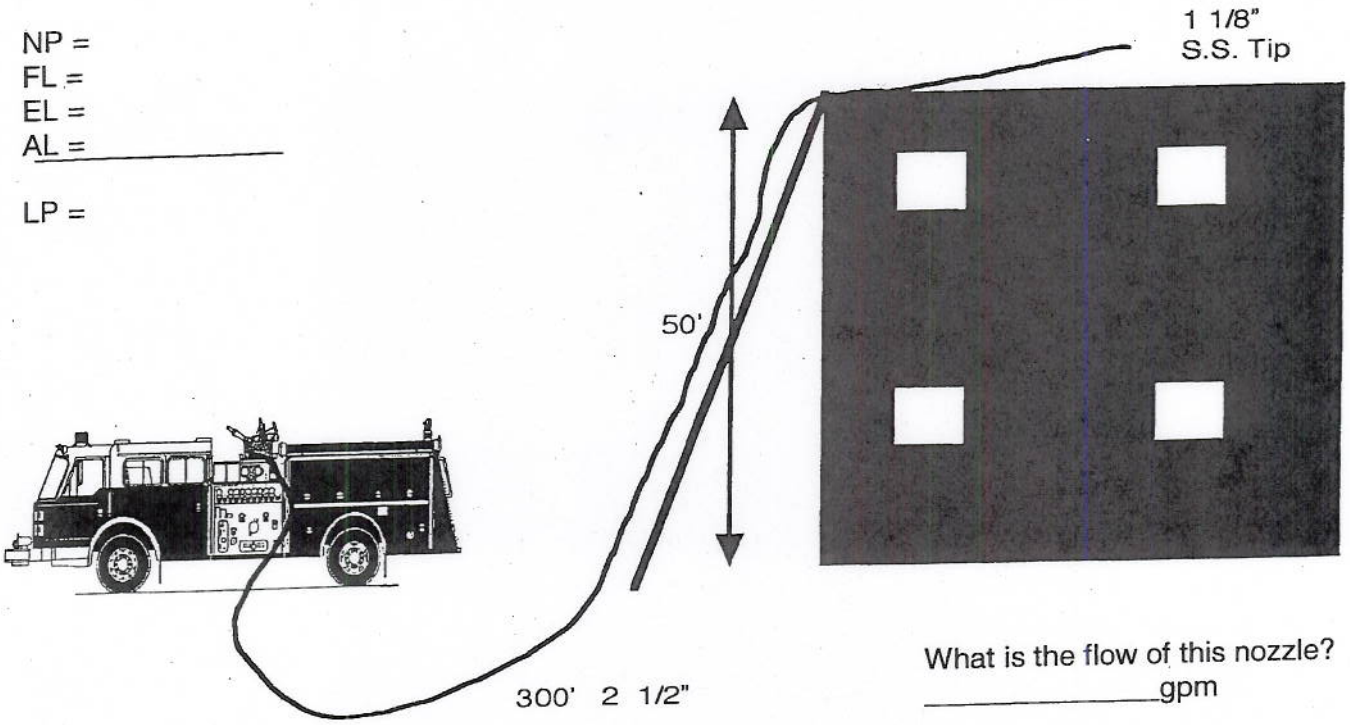


NP =
FL =
EL =
AL = _____

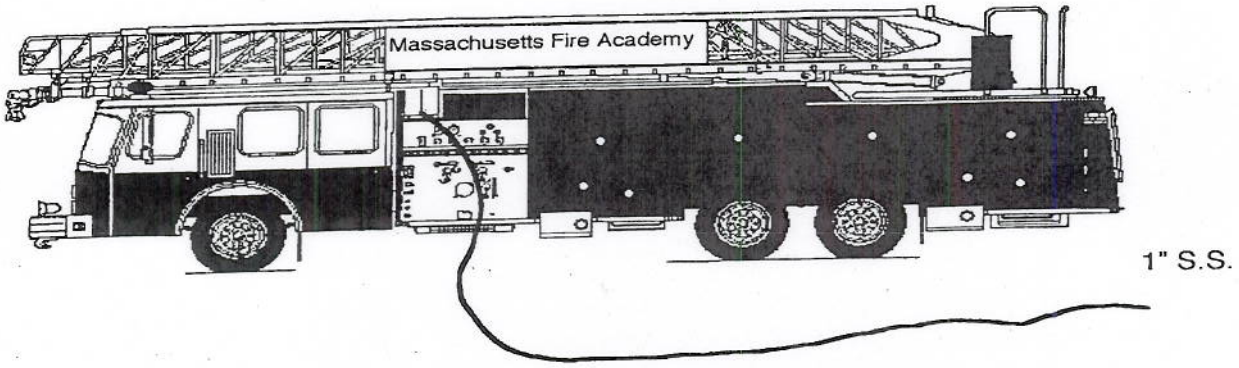
LP =

NP =
FL =
EL =
AL = _____

LP =



What is the flow of this nozzle?
_____gpm



What is the flow of this nozzle?
_____gpm

NP =
FL =
EL =
AL = _____

_ =

2-1/2"

NP =
FL =
EL =
AL =

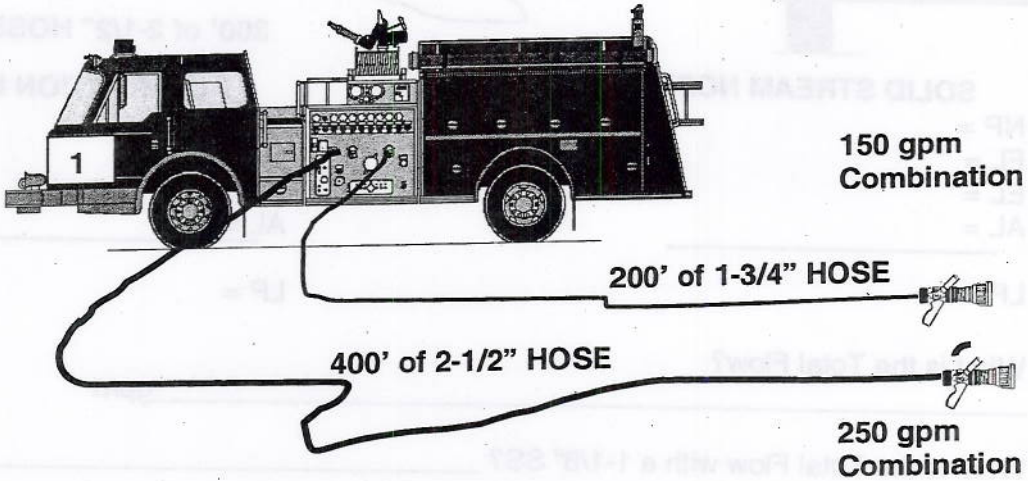
LP

1-3/4"

NP =
FL =
EL =
AL =

LP

Total Flow =



1-3/4"

NP =
FL =
EL =
AL =

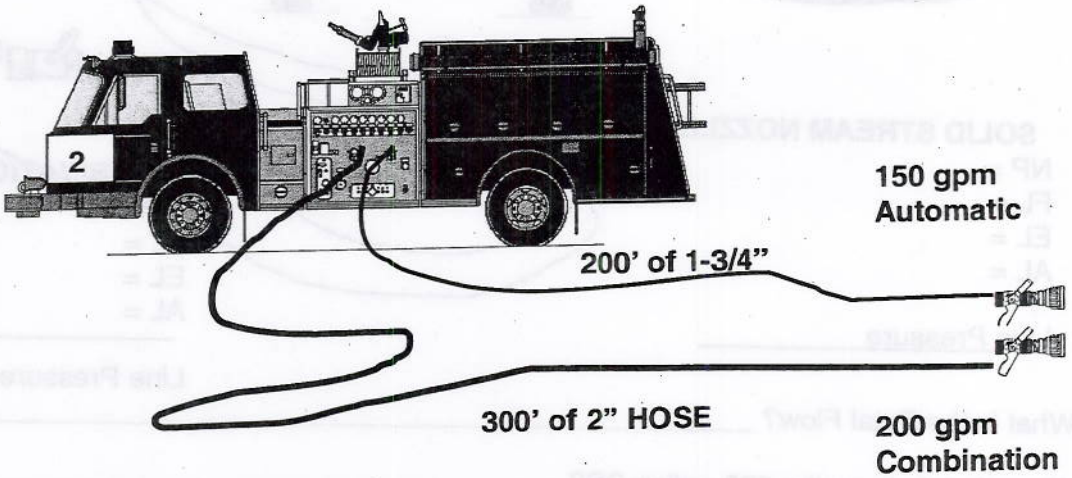
LP =

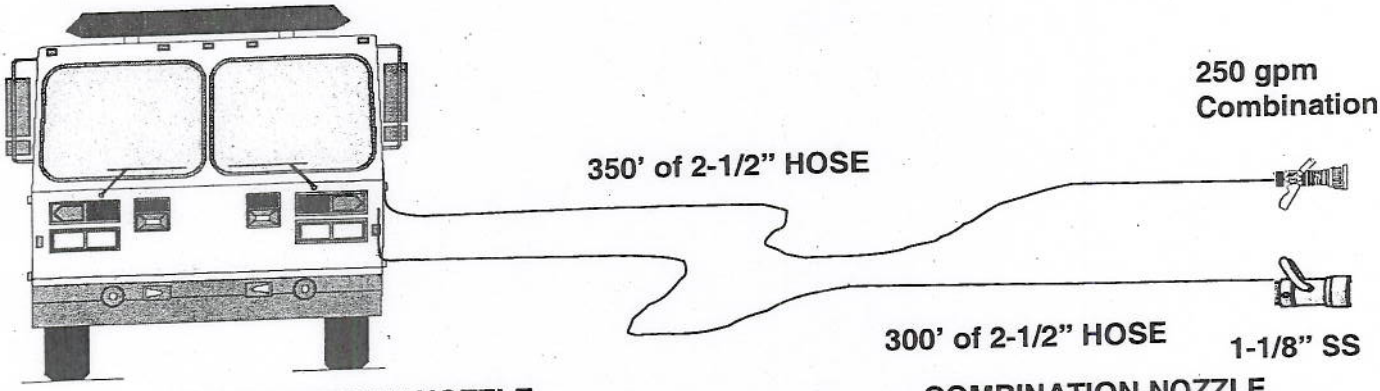
2"

NP =
FL =
EL =
AL =

LP =

Total Flow =





SOLID STREAM NOZZLE

NP =
FL =
EL =
AL = _____

LP =

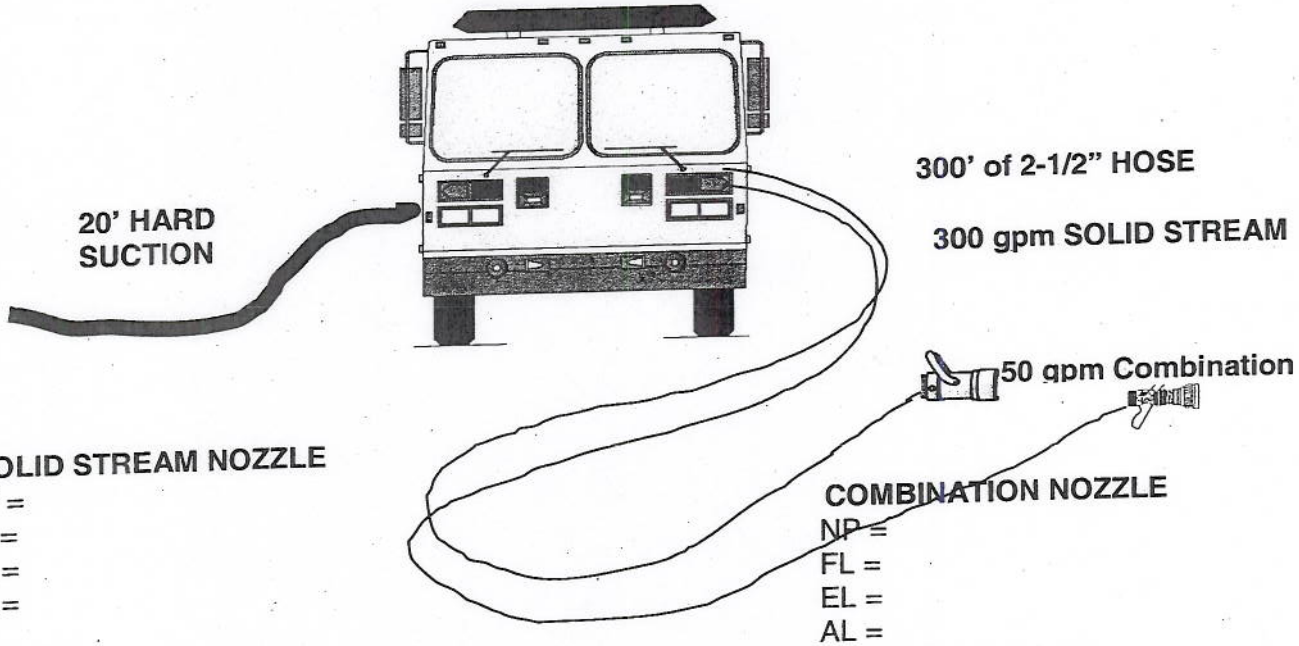
COMBINATION NOZZLE

NP =
FL =
EL =
AL = _____

LP =

What is the Total Flow? _____ gpm

What is the Total Flow with a 1-1/8" SS? _____ gpm



SOLID STREAM NOZZLE

NP =
FL =
EL =
AL =

Line Pressure _____

COMBINATION NOZZLE

NP =
FL =
EL =
AL = _____

Line Pressure

What is the Total Flow? _____ gpm

What size tip is on the 300 gallon SS? _____

Will a 1000 gpm pump supply these lines properly? _____

ICTION LOSS IN 3" HOSE

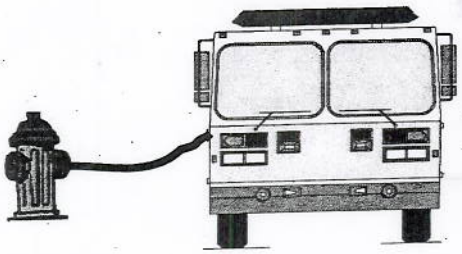
Square the first digit of the flow. Total flow 500 gpm.

5X5=25

25 PSI per 100 feet of hose
25 X 4 = 100 PSI friction loss in the lay

A hose lay of 400 feet of 3" hose is supplying 500 gallons per minute to a second truck at the same elevation.

Total flow of 500 divided by 100 = 5
5 x 5 = 25
25 PSI per 100 feet of hose
25 x 4 = 100 PSI friction loss in the lay



Residual Pressure 20

400' of 3"

Hydrant Pressure 40 psi

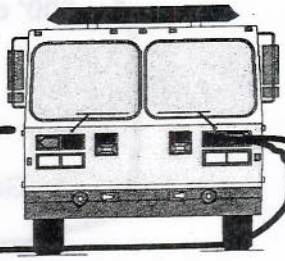
What is the % of drop? _____

How much flow is remaining?

_____

How many more 2-1/2" lines are available? _____

Received at _____psi?



100' of 2-1/2" HOSE

250 gpm Combo Nozzle

2-1/2" Line Combination

NP =
FL =
EL =
AL =
_____
LP =

2-1/2" Line

NP =
FL =
EL =
AL =
_____
LP =

1-1/8" Solid Stream Nozzle

2 1/2" OR 3" BROKEN DOWN TO SMALLER

Often times larger handlines are broken down to one or more smaller lines. To find the friction loss, work from the nozzle back in each line until you reach the one feeder line. From the wye, figure the total flow in the large feeder line by adding the flow of all the small lines.

100 feet of 2-1/2" hose reduced to 100 feet of 1-3/4" feeding a 100 GPM nozzle

NP =
FL 1-3/4" =
FL 2-1 /2" =
EL =
LP =

500 feet of 3" hose wyed to two 1 3/4" lines one 100 feet the second 200'. Both lines have 150 gpm nozzles.

Line 1

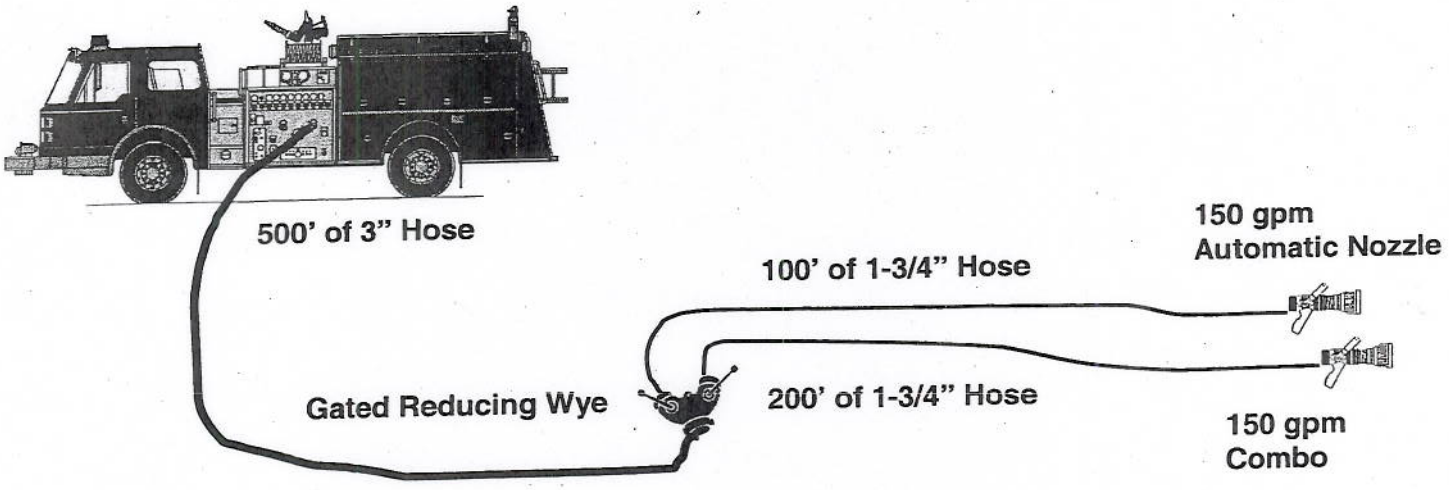
NP =
FL =
AL =
EL =

LP =

Line 2

NP =
FL =
AL =
EL =

LP =



What is the pump pressure? _____

Why? _____

What is the total flow on both lines? _____

ESSURE SOURCE EVALUATION

STATIC /RESIDUAL RULE:

Pressure Drop of 10% = 3 X present flow available
Pressure Drop of 15% = 2 X present flow available
Pressure Drop of 25% = 1 X present flow available