Hydraulics References

The hydraulics review module is intended to provide the driver trainee a summary of hydraulics and formulas that have been taught at various times in the fire service.

The "Q" Formula

Hand Lines		Supply Lines	
Hose size	**Friction Loss Formula**	**Hose size**	**Friction Loss Formula**
1 ½"	$24Q^2$	3" Hose	Q^2
1 ¾"	$12Q^2$	3 ½" Hose	$Q^2 \div 3$
2"	$6Q^2$	4" Hose	$Q^2 \div 5$
2 ½"	$2Q^2$	5" Hose	$Q^2 \div 15$
¾" Booster	$1100Q^2$		
1" Forestry	$150Q^2$		

ESTIMATING SQUARES

For the purposes of pump calculations, the square of any number that includes "½" can be estimated by multiplying the first whole number by the next higher whole number. For example:

$(1.5)^2 = 1 \times 2 = 2$ (actually = 2.25)

$(2.5)^2 = 2 \times 3 = 6$ (actually = 6.25)

MFRI Friction Loss for Attack Lines

30 psi Friction Loss per 100 foot Section

Size of Hose	Maximum Flow
1-1/2"	125 gpm
1-3/4"	150 gpm
2"	200 gpm

MCFRS Accepted Friction Loss per 100' Hose

	1 ½" Hose	1 ¾" Hose	2" Hose
100 GPM	25psi	10psi	5psi
150 GPM		30psi	15psi
200 GPM		50psi	25psi
250 GPM			40psi

GENERAL NOZZLE PRESSURES

Standard Fog	100psi	Smooth Bore Handline	50psi
Fog Master Stream	100psi	Smooth Bore Master Stream	80psi
Low Pressure Fog	50 or 75psi		

FORMULAS

PDP or EP = NP + FL + D ± EL
Pump Discharge or Engine Pressure = Nozzle Pressure + Friction Loss + Device ± Elevation

NR = 1.57 x D² x NP (Smooth Bore Nozzle)
Nozzle Reaction = 1.57 x (Diameter of Nozzle Tip)² x Nozzle Pressure

NR = 0.0505 x Q x √NP (Fog Nozzle)

GPM = 29.7 x D² x √NP (Smooth Bore Nozzle)
Gallons per minute = 29.7 x (diameter)² x √ nozzle pressure

RULE OF EIGHT'S FOR SMOOTH BORE MASTER STREAMS

This formula uses the diameter of the tip size in eighths of an inch plus a factor of 2 to rough calculate the gallons per minute flow from a smooth bore nozzle on a master stream device with nozzle pressure of 80psi.

Example: 1⅜" Tip = 3 + 2 = 500 GPM (A 1⅜" tip has 3 eighths associated with it so it is 3 eighths plus 2 to equal 500 gallons per minute flow at 80psi)

1 ⅜" Tip = 3/8 + 2 3 + 2 = 500 GPM
1 ½" Tip = 4/8 + 2 4 + 2 = 600 GPM
1 ⅝" Tip = 5/8 + 2 5 + 2 = 700 GPM
1 ¾" Tip = 6/8 + 2 6 + 2 = 800 GPM
1 ⅞" Tip = 7/8 + 2 7 + 2 = 900 GPM
2" Tip = 8/8 + 2 8 + 2 = 1000 GPM

SITUATIONAL CALCULATIONS

Elevation Loss/Gain: Changes in elevation add or reduce pressure in the hoseline. ±5psi per 10 feet of elevation change or per floor when fire is inside a building.

FDC - Standpipe and Combination Systems: 150 PSI ± 5 PSI per Floor unless otherwise specified on the connection. 200 PSI above the 10th Floor.

FDC - Sprinkler Systems: 150 PSI to the FDC.

Master Stream Devices: Nozzle Pressure + 10 PSI for the device. Older devices with multiple intakes and stream straightener Nozzle Pressure + 20 PSI.

Non-pre-piped Aerial Apparatus: Calculate friction loss for the flow in hose in ladder bed 3" or 3 ½" and 100 feet long + 10 PSI for the Siamese appliance + 10 PSI for nozzle appliance + nozzle pressure + elevation loss.

Pre-piped Aerial Ladders and Aerial Towers: Pump per the specifications of the apparatus.

Relay or Pressurized Water Source Residual Pressure:
50 PSI for 3" Hose
20 PSI for 4" and 5" Hose

Drafting: Maximum theoretical lift is 33.9 feet at sea level. The actual lift capacity varies based upon pump condition and elevation.

WMATA Standpipe: With no water flowing from the riser, fill the system using hydrant pressure until Master Intake and Discharge Gauge read the same pressure. If water is already flowing from the riser the pressures will not equalize. Allow for elevation gain when pressurizing the system, i.e. +5psi per 10 feet of drop. Hydrant pressure alone may sufficiently pressurize the system and hydrant pressure may even need to be gated back to compensate for the pressure.

Bresnan Cellar Nozzles:
Elkhart 2½" Nine Outlet (3-9/16"; 3-5/8"; 3-1/2")– 480gpm at 100psi or 340gpm at 50psi
Elkhart 2 ½" Six Outlet (3-9/16"; 3-5/8") – 385gpm at 100psi or 275gpm at 50psi
Akron 2 ½" Nine Outlet (3-1/4"; 6-13/32") – 250gpm at 100psi
Akron 1 ½" Six Outlet (3-1/4"; 3-5/16") – 95gpm at 50psi

ESTIMATING HYDRANT CAPACITY

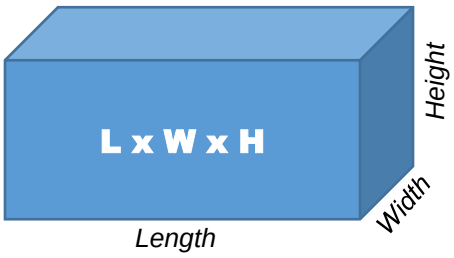
$$\frac{\text{Static} - \text{Residual}}{\text{Static}} \times 100 = \%\ \text{drop}$$

<10% drop: 2x water available
<25% drop: 1x water available
>25% drop: less than 1x water available

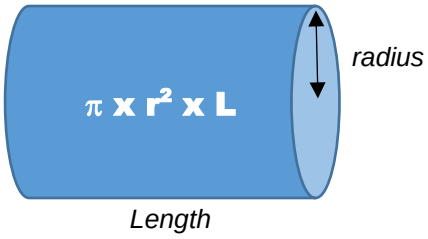
CALCULATING VOLUME

There are approximately 7.5 gallons of water per cubic foot or 1728 cubic inches. Volume is determined by multiplying length by width by height of the container. For a cylindrical container volume is determined by multiplying length by the radius squared by pi (π).

Example for a folding tank:
10' x 20' x 4' tank = 800 cubic feet
800 cubic feet x 7.5 = 6,000 gallons



Example for 100' of 4" hose:
1200 x 2^2x 3.14 = 15,072 cubic inches
15072 ÷ 1728 = 8.7 cubic feet
8.7 x 7.5 = 65.25 gallons



MCFR NOZZLES

Note: This chart may not include all nozzle variants found on MCFRS apparatus. Personnel must become familiar with the appliances specific to their apparatus.

Nozzle	Stream Type	Nozzle Pressure	Flow	Tip Size
TFT Metro 1	Fog	50psi	150gpm	
	Solid Stream	50psi	161gpm	⅞”
TFT Metro 2	Fog	50psi	250gpm	
	Solid Stream	50psi	266gpm	1⅛”
TFT – 2 ½”	Solid Stream	50psi	328gpm	1¼”
TFT Blitzfire	Fog	100psi	500gpm	
Elkhart XD – 1½”	Fog	50psi	150gpm	
	Solid Stream	50psi	161gpm	⅞”
Elkhart XD – 2”	Fog	50psi	250gpm	
	Solid Stream	50psi	266gpm	1⅛”
Elkhart XD – 2½”	Solid Stream	50psi	328gpm	1¼”
Elkhart Chief – 1”	Fog	100psi	45gpm	
Elkhart Chief – 1½”	Fog	100psi	95gpm	
Elkhart R.A.M.	Fog	75psi	500gpm	
	Solid Stream	50psi	473gpm 328gpm 210gpm	1½” 1¼” 1”