Hydraulics Review Module

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. Currently, the MFRI Pump Operator Manual, 1998 edition is what is used for MCFRTA Pumps and Hydraulics Course.

The main difference with the MFRI Pump Operator Manual and previous manuals is the formula for calculating friction loss of attack lines. The other formulas that we have provided for calculating friction loss in attack lines are intended to expand your knowledge of the various methods that are available.

Friction Loss and Formula Review

The "Q" Formula

ATTACK HOSE LINES

$2Q^2$ = 2 ½" Hose
$6Q^2$ = 2" Hose
$12Q^2$ = 1 ¾" Hose
$24Q^2$ = 1 ½" Hose

SUPPLY HOSE LINES

Q^2 = 3" Hose
$Q^2 \div 3$ = 3 ½" Hose
$Q^2 \div 5$ = 4" Hose
$Q^2 \div 15$ = 5" Hose

$1100Q^2$ = ¾" Booster Hose
$150Q^2$ = 1" Forestry Hose

MFRI Friction Loss for Attack Lines
30 psi Friction Loss per 100 foot Section

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

MCFRS Matrix for Hand Lines Friction Loss per 100' Hose

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

Formula Review

EP = NP + FL + D + (-) EL
Engine Pressure = Nozzle Pressure + Friction Loss + Device +(-) Elevation

NR = 1.57 x D^2 x NP
Nozzle Reaction = 1.57 x (Diameter of Nozzle Tip)² x Nozzle Pressure

GPM = 29.7 x D^2 x √NP
Gallons per minute = 29.7 x (diameter)² x √ nozzle pressure

Nozzle Pressures

Standard Fog Nozzles = 100 PSI Smooth Bore Master Stream Nozzles = 80 PSI

Smooth Bore Hand Held Nozzles = 50 PSI Low Pressure Fog Nozzles 75 PSI

RULE OF EIGHT'S FOR SMOOTH BORE NOZZLE TIPS

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.

Example: 1" Tip = 0/8 + 2 = 200 GPM (A 1" tip has zero eighths associated with it so it is zero eighths (0/8) plus 2 to equal 200 gallons per minute flow)

1" Tip = 0/8 + 2	0 + 2 = 200 GPM
1 ⅛" Tip = 1/8 + 2	1 + 2 = 300 GPM
1 ¼" Tip = 2/8 + 2	2 + 2 = 400 GPM
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

Pump Pressure Calculations for Different Devices and Apparatus

Standpipe and Sprinkler Connections: 150 PSI at Base and 5 PSI per Floor unless otherwise specified on the connection.

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

Ladder Company Aerial Apparatus: Hose in ladder bed 3" or 3.5" and 100 feet long. Calculate the friction loss in the hose for the flow + 10 PSI for the Siamese and 10 PSI for the nozzle.

Aerial Towers: Pump per the specifications of the apparatus. If not specified use 120 PSI at the base of the tower plus the elevation. Check the gauge on the nozzle for proper pressure - 80 PSI Smooth Bore or 100 PSI Fog.

Relay Pressure: 50 PSI for 3" Hose
20 PSI for LDH

Metro Standpipe: Fill with hydrant pressure until your Master Intake and Discharge Gauge read the same pressure. Remember that the pressure down is 5 positive pounds per 10 feet of drop. You may not need to pressurize the system with your pump. Hydrant pressure may need to be gated back to compensate for the pressure.

Estimating Hydrant Capacity Formula

$$\frac{\text{Static - Residual}}{\text{Static}}$$

10% used ⅓ used 2x water available
25% used ½ used 1x water available

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