GOLDER RANCH FIRE DISTRICT

Engineer Practical Check Sheets

Calculating Hydraulics (Field)

Standards:
NFPA 1010 Section 1002: 5.2.4, 5.2.4(B)

Task/Performance Outcome:
The candidate shall be given the objective of completing a Field Hydraulics test. This will verify the Candidate's abilities to determine common hydraulic questions that commonly pertain to the position of a driver operator with in the fire service.

Required Personal Protective Equipment (PPE):
Test with be administered through professional development.

Required Equipment:

Theoretical Equations	
Nozzle Reaction Smooth-Bore Nozzle	$NR = 1.57 \times d^2 \times NP$
Nozzle Reaction for Fog Nozzle	$NR = 0.0505 \times gpm \times \sqrt{NP}$
GPM Flow of Smooth Bore Nozzles	$gpm = 29.7 \times d^2 \times \sqrt{NP}$
Friction Loss	$FL = C\,Q^2\,L$
Elevation Pressure	EP = 5 psi × (number of stories – 1) or EP = 0.5 × Height

Friction Loss Coefficients	
Hose Diameter (inch)	Coefficient
1 ¾	15.5
2 ½	2
3 with 2 ½ couplings	0.8
5	0.08

Appliance Losses for High-Flow Devices (flows greater than 350 gpm)	
Device	Appliance Loss (psi)
Wye and Siamese	10
Ram XD	10
Standpipe and FDC	10
Elevated master stream and deck gun monitors	25
Dead Pump	25

Smooth Bore Tips GPM Flow Rates		
Size (inches)	GPM Handline/Master	
	50 psi	**80 psi**
1"	200	250
1 1/8"	250	350
1 1/4"	325	400
1 3/8"		500
1 1/2"		600
1 5/8"		700
1 3/4"		800
1 7/8"		900
2		1000

Smooth Bore Tips Decimal conversions	
Size (inches)	Decimal
1"	1
1 1/8"	1.125
1 1/4"	1.25
1 3/8"	1.375
1 1/2"	1.5
1 5/8"	1.625
1 3/4"	1.75
1 7/8"	1.875
2	2

Critical Fail Criteria:
Failure consists of the following:

- Glaring, gross errors, as documented by the evaluator
- An apparent lack of efficiency and comfort with the activity, as documented by the evaluator
- Less than 80% of available points scored

Evolution Details:
The will candidate will be administered a Field Hydraulics test via paper or electronic form. The individual will have a set amount of time to complete the test (time allotment will be notified prior to test being administered).

Calculating Hydraulics (Field)

Tasks
Using the hand Method Calculation for 1 ¾" Hose To perform the hand method calculation for 1¾" hose, follow these steps: 1. Start with the left hand open and the thumb on the left. 2. Assign the flow in gpm to the base of each finger, from left to right, in 25-gpm increments, designating the thumb as 100 gpm and then 125 gpm, 150 gpm, 175 gpm, and finally 200 gpm on the little finger. 3. Assign numbers to the tips of the fingers beginning with the thumb as 1 and then 2, 3, 4, and 5 on the little finger. 4. Assign the multiplier number of 12 to the base of the thumb and to the base of each of the other fingers. 5. To calculate the FL for a given flow through a 1¾-inch hose, find the gpm on the hand, and multiply the number at the tip times the number at the bottom of the finger. 6. The hand method calculates the FL per 100 ft of hose only. Multiply this value times the length, and add any AL loss, elevation gain/loss, and NP to find the correct PDP. **Example:** When flowing 150 gpm, note that 150 gpm is the middle finger and has the number 3 at the tip and the number 12 at the base. When multiplied, 3 × 12 = 36 psi FL in 100 ft of 1¾-inch hose. The exact FL would be 34.875 psi per 100 ft of 1¾-inch hose.
Performing the Hand Method Calculation for 2 ½" Hose To perform the hand method calculation for the 2½" hose, follow these steps: 1. Start with the left hand open and the thumb on the left. 2. Assign the flow in hundreds of gpm to the base of each finger, from left to right, in 100-gpm increments, designating the thumb as 100 gpm and then 200 gpm, 300 gpm, 400 gpm, and finally 500 gpm on the little finger. 3. Assign the spaces between fingers as the half-hundred figures (i.e., 150, 250, 350, and 450). In this way, the flow designations are assigned to the hand for 2½-inch hose. 4. Assign to the fingertips the multiplier numbers of 2 for the thumb and 4, 6, 8, and 10 across the hand to the fingertips. 5. Assign 3, 5, 7, and 9 to the spaces between the fingers. 6. The FL for 100 ft of 2½-inch hose is obtained by selecting the desired flow and multiplying the number at the tip of the finger by the first digit of the number at the base of the finger. Half-hundred flows such as 250 gpm may be translated as 2.5. **Example 1:** When flowing 250 gpm in 100 ft of 2½-inch hose, multiply the first digit of the flow, 250 gpm = 2.5 (found at the space between the index and middle fingers), by the corresponding multiplier of 5 = 12.5 psi FL for 100 ft of 2½-inch hose. **Example 2:** If flowing 300 gpm through 100 ft of 2½-inch hose, multiply the first digit of the flow, 300 gpm = 3 (found at the base of the middle finger), by the corresponding multiplier of 6 = 18 psi FL per 100 ft of 2½-inch hose.

Using the Subtract 10 Method (gpm Flowing Method up to 350 gpm)

To use this method, follow these steps:

1. Assume a flow of 200 gpm in a 2½-inch line.
2. Subtract 10 from the first two digits of the flow to obtain the FL per 100 ft of hose: 200 gpm = 20 – 10 = 10 psi FL per 100 ft.
3. If flowing 250 gpm, subtract 10 from 25 = 15 psi FL per 100 ft.
4. If flowing 300 gpm, subtract 10 from 30 = 20 psi FL per 100 ft.
5. After obtaining the FL, multiply it times the number of 100-ft sections and add AL, EP (if any), and NP to arrive at the PDP.

Example 1: Calculate the PDP for 300 ft of 2½-inch hose with a 1-inch smooth-bore tip.

The 1-inch tip flows 200 gpm and has a NP of 50 psi. Subtract 10 from the first two digits of the flow:

For 200 gpm: 20 – 10 = 10 psi FL per 100 ft
300 ft of hose with 10 psi loss per 10 ft = 30 psi FL
PDP = NP + FL = 50 + 30 = 80 psi

Example 2: Do the same problem using the Q formula.

$$FL = C\,Q^2\,L \text{ or } 2 \times (2)^2 \times 3 = 24 \text{ psi FL}$$
$$PDP = 50 + 24 = 74 \text{ psi}$$

Using the Condensed Q Method

To use the condensed Q method, follow these steps:

1. Use the appropriate formula for the size of hose.

2. To calculate FL in 3-inch hose, use the formula $FL = Q^2$.

3. When flowing 300 gpm, $Q^2 = 3^2 = 9$ psi FL per 100 ft of hose.

4. To calculate FL in 3½-inch hose, use the formula $FL = Q^2/3$. For example, when flowing 300 gpm through 3½-inch hose, $Q^2/3 = 3^2/3$ or $9/3 = 3$ psi per 100 ft of 3½-inch hose.

5. To calculate FL in 4-inch hose, use the formula $FL = Q^2/5$. For example, when flowing 500 gpm, $Q^2/5 = 5^2/5 = 25/5 = 5$ psi per 100 ft of 4-inch hose.

6. To calculate FL in 5-inch hose, use the formula $Q^2/15$. For example, when flowing 700 gpm, $Q^2/15 = 7^2/15 = 49/15 = 3.2$ or 3 psi per 100 ft of 5-inch hose.

Quick Field Hydraulics

1 ¾" Hose – Rule of 4s:
GPM – FL
30 – 1
60 – 4
95 – 14
100 – 15
125 – 24
150 – 34
175 – 44
180 – 50
200 – 60

2 ½" Hose:
Even = $2Q^2$
Odd = 2(Q(Q+1)

3" Hose:
Even = Q(Q – 1)
Odd = Q^2

Slide Method for 2 ½" and 3" Hose:

Slide Method for 2 ½" and 3" Hose				
Slide Up	**2 1/2"**	**GPM**	**3"**	**Slide Down**
Max GPM through 2 ½" is 500		800	8 X 7	56
		750	7 X 7	49
		700	7 X 6	42
		650	6 X 6	36
		600	6 X 5	30
		550	5 X 5	25
50	2(5 X 5)	500	5 X 4	20
40	2(4 X 5)	450	4 X 4	16
32	2(4 X 4)	400	4 X 3	12
24	2(3 X 4)	350	3 X 3	9
18	2(3 X 3)	300	3 X 2	6
12	2(2 X 3)	250	2 X 2	4
8	2(2 X 2)	200	2 X 1	2
4	2(1 X 2)	150	1 X 1	1
2	2(1 X 1)	100	1 X 0	0

5" Hose:
Less than 1000 GPM = Q/2
Greater than or equal to 1000 GPM = Q

Calculating Available Water

1. Determine the static pressure from the hydrant on the master intake gauge (intake pressure from the hydrant when not flowing water).
2. Flow the first attack line(s), and determine the gpm flowing.
3. Determine the residual pressure from the hydrant on the master intake gauge (intake pressure left over after the first attack lines are flowing).
4. Subtract the residual pressure from the static pressure.
5. To determine the number of additional lines of equal flow that can be supported, multiply the first digit of the static pressure by 1, 2, or 3. If the first digit of the static pressure multiplied by 1 is equal to or less than the difference between the static and residual pressures, the hydrant will supply three times the gpm currently flowing. If the fist digit of the static pressure multiplied by 2 is equal to or less than the difference between the static and residual pressures, the hydrant will supply two times the gpm currently flowing. If the first digit of the static pressure multiplied by 3 is equal to or less than the difference between the static and residual pressures, the hydrant will supply one times the gpm currently flowing.

Example 1: Calculate the available water after flowing 250 gpm attack line(s).

The static pressure from the hydrant is 80 psi. Two attack lines are flwoing off the horizontal standpipe with a current flow rate of 250 gpm. The residual pressure on the master intake gauge is reading 70 psi. Subtract the residual pressure from the static pressure (80 – 70 = 10). The first digit of the static pressure (80) is 8. When this digit is multiplied b 1 (8 x 1 = 8), the result is less than or equal to the difference between the static and residual pressures (10). Therefore, the hydrant can safely flow three times the amount of water it is currently flowing.

Example 2:

Static Pressure = 70 psi
Residual pressure = 55 psi
GPM Flowing = 300

Static – Residual = 15
70 – 55 = 15

Fist digit multiplied by 1,2 & 3
7 x 1 = 7
7 x 2 = 14
7 x 3 = 21

14 is closest to but remains equal to or less than the Static – Residual drop of 15. This mean two times the current GPM of 300 can be supported.

300gpm x 2 = 600 gpm of additional flow can be supported