Fire Protection Hydraulics and Water Supply Analysis

FPST 2483 Chapter 8

Testing and analysis of water supply system

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Outline

- Upon completing this module, the student should be able to:
  - Understand various flow measuring devices
    - Pitot tube
    - Flow pressure gage
  - Understand the test procedures
  - Graphically present the water supply information
- Reading material
  - Brock's book, chapter 8

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Water Supplies

- Elevated Water Storage Tank
- Ground Level Storage tank and Horizontal Centrifugal Fire Pump
- Reservoir, Lake, River, Pond, etc. and Vertical Turbine Fire Pump
- City Supply and Booster Pump

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The necessity for Testing

- The water supply available from point to point on a system will vary due to:
  - Elevation
  - Friction loss
  - Domestic and commercial consumption
- Available water at a particular location may change from year to year due to:
  - Changes in consumption
  - Deterioration of piping
  - Changes in the system

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Purpose of flow test

- The Purpose of a flow test is to establish the water supply available at a particular location.
  - Note: The location of the water supply will be at the gauged hydrant. (One location, two parameters)

Test Equipment Needed:

1. Water distribution drawings
2. Pitot tube and gauge
3. Tapped hydrant cap and gauge
4. Ruler
5. Hydrant and spanner wrenches
6. *Elbow
7. Smooth bore nozzle or play pipe
8. Note Pad & PENCIL

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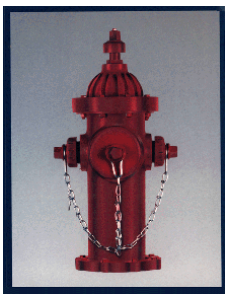
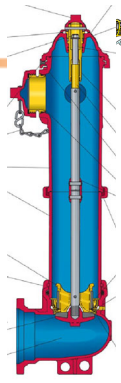
Dry Barrel Fire Hydrant





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Pitot Tube

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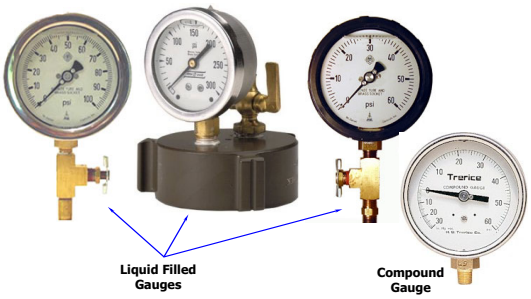
Cap Gauge & Gauges



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Taking a Pitot Reading

- Make sure the water has been drained out of the pitot tube prior to taking a measurement.
- When taking a pitot reading, hold the pitot tube one-half the diameter of the nozzle opening away from the nozzle. This is the point where the stream is the smallest and the velocity is the greatest.
- Hold the tube so the air chamber is elevated. This will help with needle vibration.
- Use the 2½-inch outlet.

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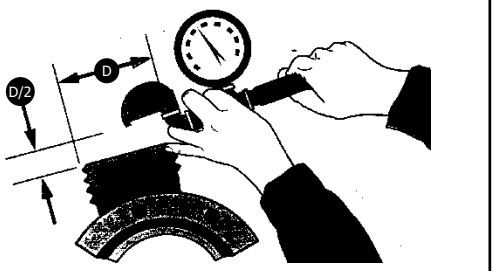
Taking a Pitot Reading



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Hand-on measurement

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Taking a Static & Residual Reading

- Look at the gauge straight on (if possible).
- Read the static pressure before flowing water and after closing the flowing hydrant.
- Take the residual pressure when the pitot reading is being taken.

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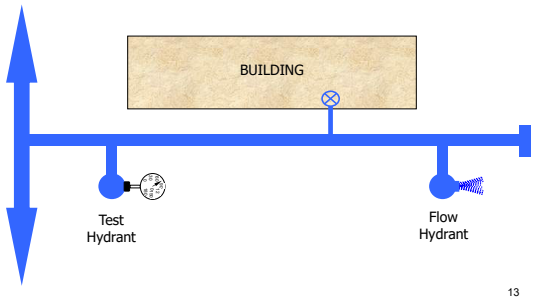
Water Flow Testing



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Flow Test Must Yield:

- Static Pressure
- Residual Pressure
- Flow During Test (i.e., pitot pressure)

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Water Flow Testing

$$Q = 29.83 C_d D^2 \sqrt{P}$$

- Where
  - C_d is the discharge coefficient
  - D is the nozzle or orifice diameter in inches
  - P is the pitot pressure in psi
  - Q is the flow in gallons per minute

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Water Flow Testing - Example

- Static Pressure = 86 psi
- Residual Pressure = 42 psi
- Pitot Pressure = 28 psi

- If D = 2½ and C_d = .8, then

$$Q = 29.83(.8)(2\tfrac{1}{2})^2(\sqrt{28}) = 789gpm$$

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Flow Characteristics in Pipe

- Head loss varies directly as the length of the pipe
- Head loss varies almost as the square of the velocity
- Head loss varies almost inversely as the diameter
- Head loss depends upon the surface roughness of the pipe wall
- Head loss depends upon the fluid's density and viscosity
- Head loss is independent of the pressure

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Factors on water supply

$$P_f = \frac{4.52 \cdot Q^{1.85}}{C^{1.85} \cdot D^{4.87}}$$

$$P_t = L \cdot P_f$$

p = psi/ft
p = psi/100' (some NFPA standards)
p = psi/1000' (NFPA,FM)
L = length of pipe

$$P_e = 0.433 \cdot H$$

$$H = 2.31 \cdot P_e$$

H = change in elevation (feet)
P_e = Pressure difference due to elevation (psi)

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Calculating Velocity in Pipes

- Formula $Q = AV$
  - *Q is flow in GPM*
  - *A is area of pipe in square inches*
  - *V is velocity of flow in feet per second*
  - *d is diameter of pipe in inches*

$$V = \frac{Q}{(60\text{sec})(7.58gal)} \div \frac{\frac{d^2\pi}{144}}{2} \Rightarrow V = \frac{0.4085(Q)}{d^2}$$

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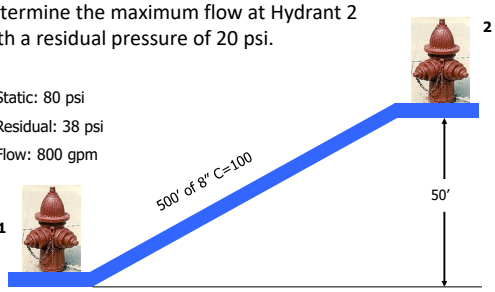
Example Problem

Determine the maximum flow at Hydrant 2 with a residual pressure of 20 psi.

Static: 80 psi

Residual: 38 psi

Flow: 800 gpm



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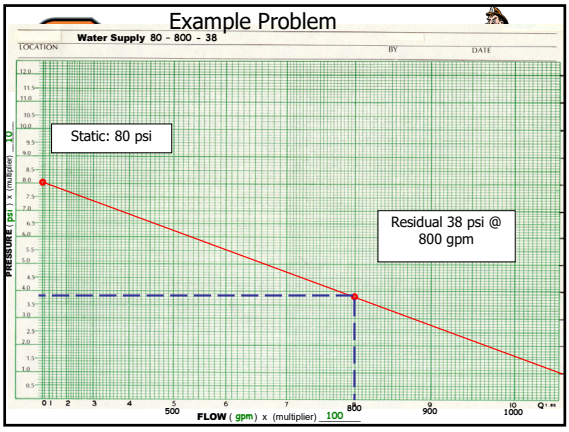
Example Problem



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Example Problem

$$p = \frac{(4.52)(Q^{1.85})}{(C^{1.85})(d^{4.87})} = \frac{(4.52)(800^{1.85})}{(100^{1.85})(8^{4.87})} = 0.008\frac{psi}{ft}$$

Friction Loss in Pipe

$$\Sigma p_{fl} = (0.008\frac{psi}{ft})(500')$$

$$\Sigma p_{fl} = 4.2psi \cong 4psi$$

Pressure Loss due to Elevation

$$p_{head} = (0.433\frac{psi}{ft})(50') = 21.6psi \cong 22psi$$

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Example Problem

Therefore, the characteristics found at Hydrant 2 are:

Static = 80 psi – 22 psi = 58 psi

Residual @ 800 gpm = 38 psi – 4 psi – 22 psi = 12 psi

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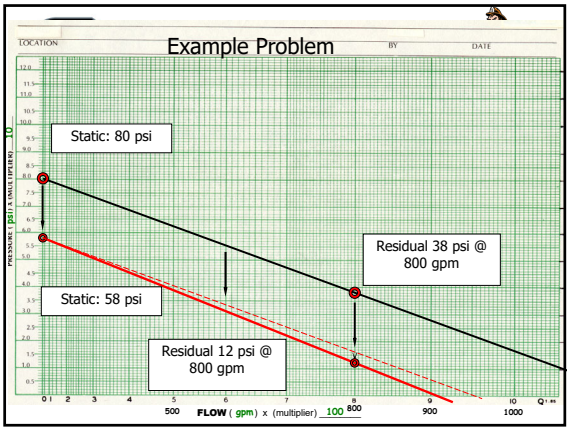

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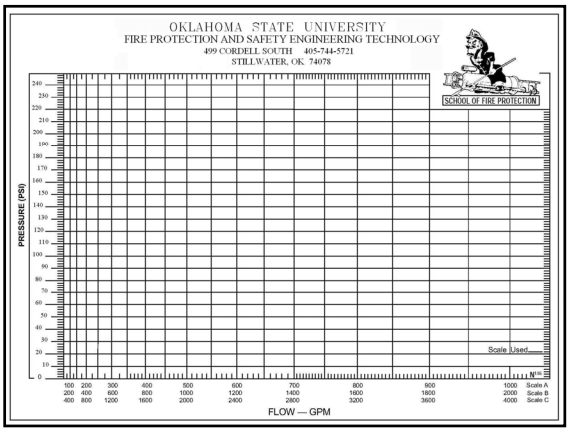

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Summary

- Hydrant flow test is necessary to determine the water supply of a certain system.
- The water supply is designated as a linear curve (Q^1.85 vs P)
- Manipulate the friction loss and elevation change in the diagram.

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