Fire Protection Hydraulics and Water Supply Analysis

FPST 2483 Unit 05a

Hazen-Williams Equation

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The Hazen-Williams Formula

- The fire protection industry uses the Hazen-Williams formula more commonly than the Darcy-Weisbach formula.
- Since the early 1900's, fire protection codes and standards have required that friction loss be calculated using the Hazen-Williams formula
- ***NFPA 13 and 24*** require the use of the Hazen-Williams formula in hydraulic friction loss calculations.

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Friction Loss

- **First Principle of Friction Loss:** 10-0 100-0
- Given that all other conditions are the same, the amount of friction loss is directly proportional to the length of the hose or pipe. L Pf
- **Second Principle of Friction Loss:**
- When hoses or pipes are the same size, friction loss varies approximately with the square of the increase in the velocity of the flow. (*If flow doubles, friction loss quadruples.*) Pf Q

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Friction Loss

- **Third Principle of Friction Loss:** D
- Given the same discharge volume, friction loss varies inversely as *the fifth power of the diameter* of the hose. In basic terms, given the same flow, the larger the hose is, the less friction loss will occur.
- *2 ½ to 3 = 33%   2 ½ to 4 = 24%   2 ½ to 5 = 7%*
  100 33   100 24   7
- **Fourth Principle of Friction Loss:**
- For a given flow velocity, friction loss is approximately the same, regardless of the pressure on the water.

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HAZEN-WILLIAMS FORMULA

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

1→2

D↑ ↓Pf
C↑ ↓Pf

100 - 150

Where:

P_t = Friction loss in psi

Q = Flow rate in gpm

L = Pipe length in feet

C = Coefficient of roughness unitless 'C-factor'

D = Pipe diameter in inches

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HAZEN-WILLIAMS FORMULA

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

design values range 100-150

1. **Pipe diameters are usually actual internal diameters.** A.1, A.2
2. **C-factor depends upon piping material and age.**

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Role of Diameter

- See Table A.1 for Aboveground piping nominal and actual inside diameters
- See Table A.2 for Underground piping nominal and actual inside diameters

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Role of Diameter

- Any increase in pipe size will reduce friction loss if all other factors remain the same.
- If the diameter is doubled, the friction loss will be reduced by a factor close to 1/32.
- If the diameter is tripled, the friction loss will be about 1/243 of its original value.

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

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The Coefficient Of Roughness

The Coefficient Of Roughness (C) Is A Reflection Of The Interior Surface Condition Of The Pipe

Large values of C indicate smooth pipe and thus less friction loss.

Smaller values of C reflect rough or deteriorating pipe, which in turn will have greater friction loss.

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C-FACTORS

Material	C
Unlined Cast Iron	100
Lined Cast Iron & Ductile Iron	140
Black Steel Pipe - Wet	120
Black Steel Pipe - Dry	100
All Plastic	150
Copper	150

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Recommended values in NFPA 13

Table 22.4.4.7 Hazen–Williams *C* Values

Pipe or Tube	*C* Value*
Unlined cast or ductile iron	100
Black steel (dry systems including preaction)	100
Black steel (wet systems including deluge)	120
Galvanized (all)	120
Plastic (listed) all	150
Cement-lined cast or ductile iron	140
Copper tube or stainless steel	150
Asbestos cement	140
Concrete	140

*The authority having jurisdiction is permitted to consider other *C* values.

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If All Other Things Remain Constant

- When the flow rate is doubled, the friction loss will be about four times greater.
- If the flow triples, friction loss will be almost nine times greater.

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

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