



# 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
- Given that all other conditions are the same, the amount of friction loss is directly proportional to the length of the hose or pipe.
- 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.)

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#### **Friction Loss**



- Third Principle of Friction Loss:
- 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 faction loss will occur.
- 2½ to 3 = 33% 2½ to 4 = 24% 2½ to 5 = 7%
- Fourth Principle of Friction Loss:
- For a given flow velocity, friction loss is approximately the same, regardless of the pressure on the water.

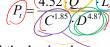
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#### HAZEN-WILLIAMS FORMULA



Where:



100-10-

- $P_t$  = Friction loss in psi
- 100-150
- Q = Flow rate in gpm
- L = Pipe length in feet
- C = Coefficient of roughness
- D = Pipe diameter in inches

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#### HAZEN-WILLIAMS FORMULA



$$P_f = \underbrace{\frac{4.52 \cdot Q^{1.85} \cdot L}{\left(C^{1.83}\right) \cdot D^{4.87}}}_{\left(C^{1.83}\right) \cdot \left(D^{4.87}\right)} \underbrace{Q^{1.85} \cdot L}_{\left(C^{1.83}\right) \cdot \left(D^{4.87}\right)}$$

- 1. Pipe diameters are usually actual internal diameters. A. A. Z.
- 2. C-<u>factor</u> 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

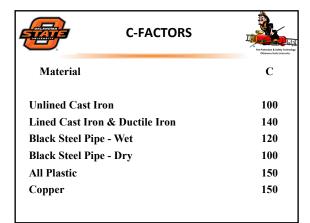


The Coefficient Of Roughness (C) Is A Reflection Of The Interior Surface Condition Of The Pipe

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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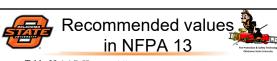


Table 22.4.4.7 Hazen-Williams C Values

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

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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.

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