Fire Protection Hydraulics and Water Supply Analysis

FPST 2483 Unit 05

Darcy-Weisbach Formula

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Module objective

- Upon completing this module, the student should be able to:
  - Understand the laminar and turbulent flow;
  - Understand the principles of friction loss.
  - Use the Darcy-Weisbach Formula for simple problems

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Friction Loss

- **Definition: the total pressure lost while flowing water through pipe, fittings, fire hose, and adapters.**
- Friction loss is caused by movement of water molecules against:
  - Each other
  - The linings in fire hose or the inside of a pipe
  - Couplings
  - Sharp bends
  - Changes in hose, pipe, or orifice size by adapters
  - Improperly sized gaskets

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FRICTION LOSS IN PIPING SYSTEMS

I. Friction loss in simple lines.

A. Most fundamentally sound method of computing friction loss uses Darcy-Weisbach Equation.

B. Flow in conduits is either "laminar" or "turbulent".

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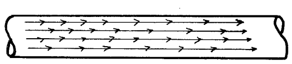
LAMINAR VERSUS TURBULENT FLOW

1. In laminar flow the fluid moves in parallel layers.
2. Laminar flow involves low stream velocities.



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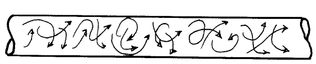
LAMINAR VERSUS TURBULENT FLOW

3. As stream velocities increase, stream breaks up into "turbulent flow:



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FRICTION LOSS IN PIPING SYSTEMS

C. An important concept is that swirling turbulent flow results in increased losses and to accurately predict friction loss, different relationships necessarily apply to laminar and turbulent flow.

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FRICTION LOSS IN PIPING SYSTEMS

D. Experiments have revealed a characteristic of fluid flow known as the Reynolds Number.

The Reynolds Number is as follows:

$$R_E = (VD)/\gamma$$

Where:

R_E is the dimensionless Reynolds Number.

V is the water velocity in ft/sec.

D is the pipe diameter in feet.

γ is the kinematic viscosity of the fluid in ft^2/sec.

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FOR WATER:

Temp °F	γ
32	1.931×10^{-5}
40	1.664×10^{-5}
50	1.410×10^{-5}
60	1.217×10^{-5}
68	1.084×10^{-5}
70	1.059×10^{-5}
80	0.93×10^{-5}

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FRICTION LOSS IN PIPING SYSTEMS

The Reynolds Number indicates if a flow is laminar or turbulent:

$R_E \leq 2100 \Rightarrow$ **Laminar**

$R_E > 2100 \Rightarrow$ **Turbulent**

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FRICTION LOSS IN PIPING SYSTEMS

E. Darcy-Weisbach Equation

$$h_f = fv^2L/2gD$$

Where:

- f = friction factor
- v = water velocity, fps
- L = pipe length, ft.
- g = acceleration due to gravity
- D = pipe diameter, ft.

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FRICTION LOSS IN PIPING SYSTEMS

For laminar flow: $f = 64/R_E$

For turbulent flow (Colebrook Equation):

$$\frac{1}{\sqrt{f}} = (-2)\left[\log\left(\frac{e}{(3.7)(D)} + \frac{2.51}{R_E\sqrt{f}}\right)\right]$$

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FRICTION LOSS IN PIPING SYSTEMS

- The Colebrook Equation cannot be solved directly for f.
- Must use trial and error or graphs called "Moody Diagrams".
- To use Moody Diagrams the Reynolds Number must be known and the value of e/D from the Colebrook Equation must be known.
- The value of e reflects the roughness of the pipe and depends on pipe material; see figure 5.2 in the text.
- D is pipe diameter in feet.

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FRICTION LOSS IN PIPING SYSTEMS

F. It should be noted that all flows sufficient for fire protection applications will be turbulent.

G. Fortunately, modern computer programs make use of Moody Diagrams unnecessary.

Steps:

1. Solve for Reynolds Number
2. Solve for e/D
3. Using the Moody Diagram, determine f
4. Solve for Hf
5. Convert to Pf

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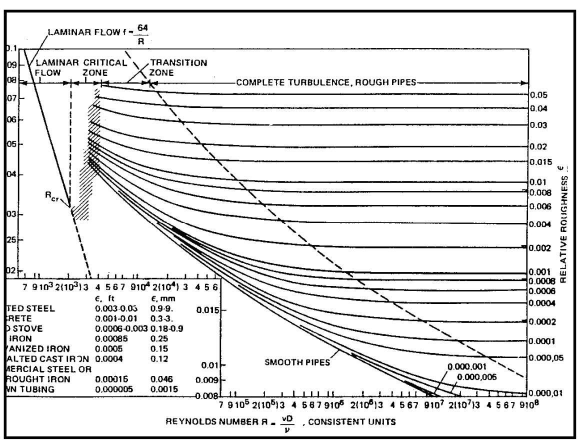

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The Darcy-Weisbach Formula

- The more accurate of the two formulas
- The most widely used by the engineering profession in general, but not in fire protection
- Recommended for testing foam proportioning systems, according to ***NFPA 11***, Standard for Low-Expansion Foam or Anti-freeze systems

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Summary

- Pressure loss is caused by fluid flow.
- Turbulent state is critical on determining pressure losses.
- Darcy-Weisbach equation is more precise with various conditions.
- Hazen-Williams equation is favored in sprinkler industry.
- Calculation needs skills and exercises.

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