Fundamentals of Hydronic Design

Healthy HEATING

Comforting your mind, body and soles

Radiant Based HVAC Systems

Fundamentals of Hydronic Design

Healthy
HEATING

Comforting your mind, body and *soles*

Fluid Velocity

Fundamentals of Hydronic Design

Some slides contained animations in the original .ppt format which have been eliminated in the conversions to Adobe's .pdf format.

Fundamentals of Hydronic Design

- Flow & Velocity
  - Fluid shear (separation) in flow is due to frictional velocity.
  - Rate of deformation is directly proportional to the shearing stress.
    - Laminar vs. Turbulent
  - Turbulence complicates fluid behavior.
    - Flow through fittings, valves, etc…vs. Straight lengths of pipe.
  - Viscosity influences the nature of the turbulent flow
    - Glycol, cold weather start ups.
  - Flow speed and characteristics influence heat transfer, circulator energy, capital costs for equipment, and general operation.

Fundamentals of Hydronic Design

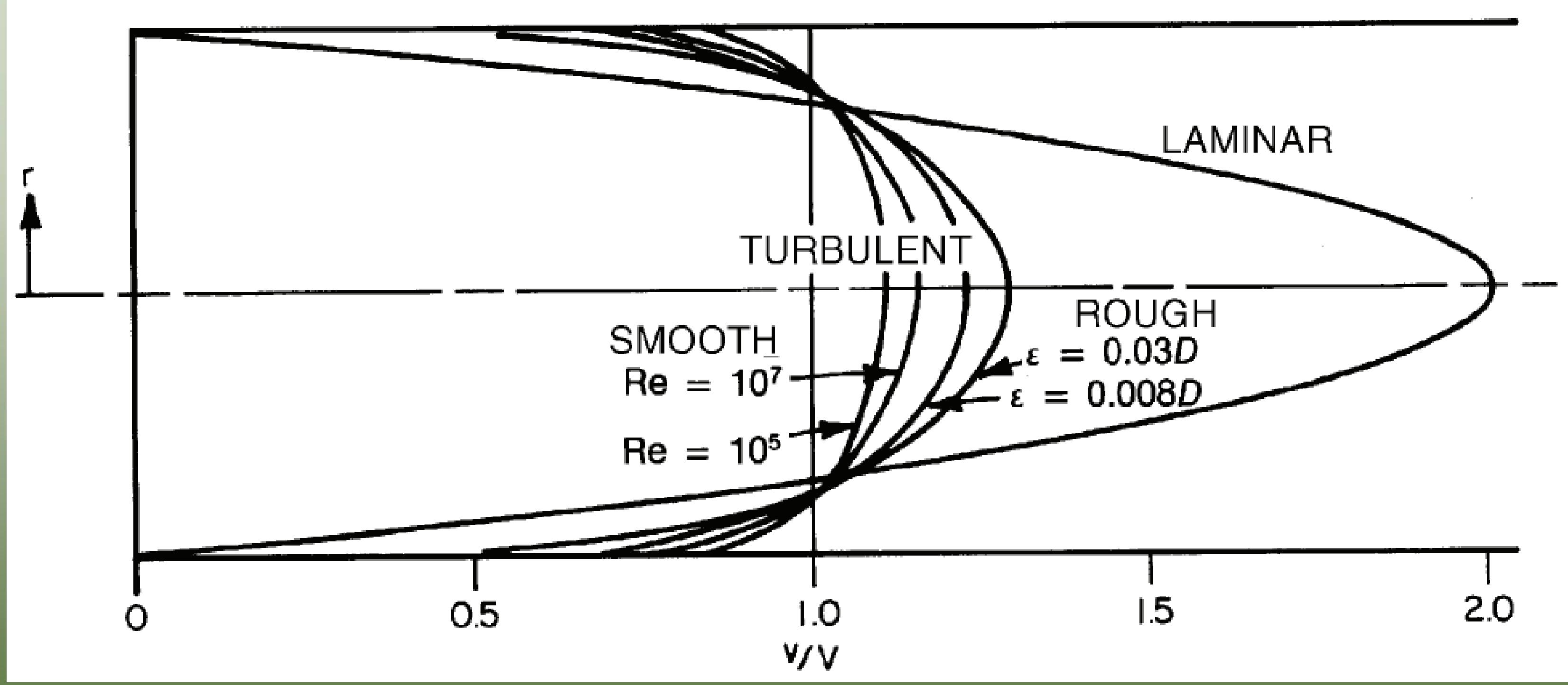
- Velocity
  - Reynolds number, Re, based on pipe diameter, dimensionless quantity, gives the relative ratio of inertial to viscous forces.
  - Laminar flow exists if the Re_D is < 2300.
  - Turbulent flow exists when $Re_D > 10{,}000$.
  - Between 2300 and 10,000, the flow is in a transition state and predictions are unreliable.

$$Re = VL/\nu$$

V = Velocity

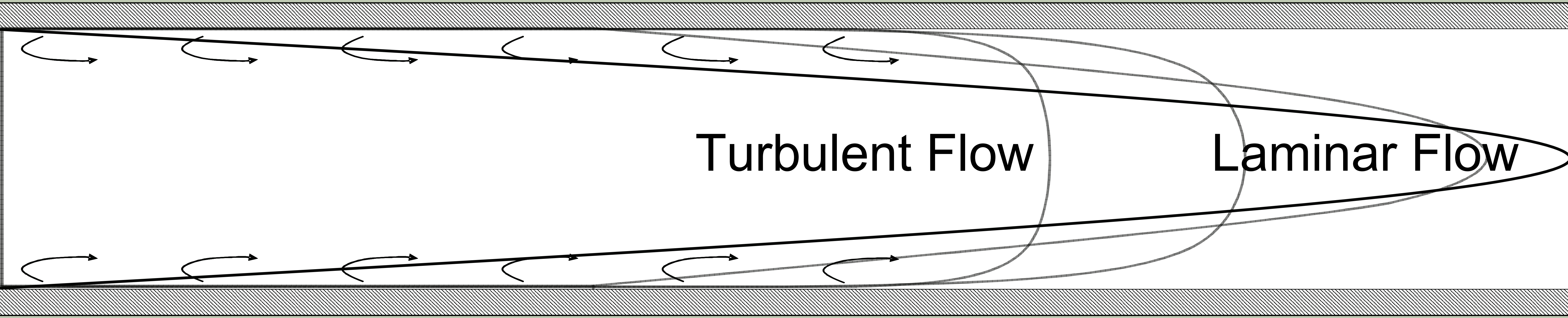
L = characteristic length, dia. θ

ν = kinematic viscosity



Fundamentals of Hydronic Design

- Laminar vs Turbulent



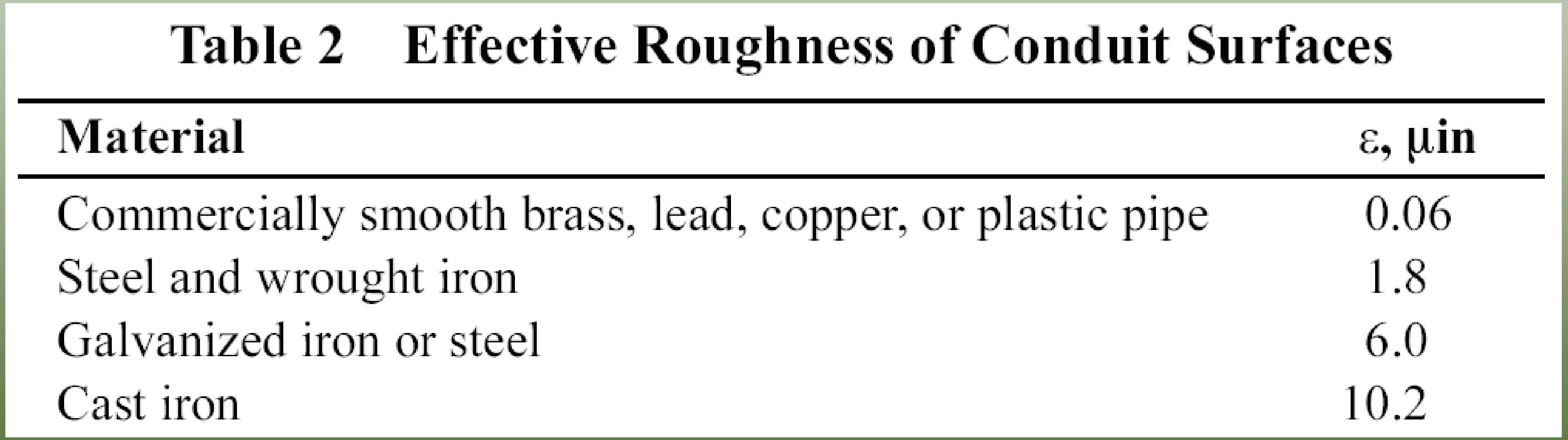


Table 2 Effective Roughness of Conduit Surfaces

Material	ε, μin
Commercially smooth brass, lead, copper, or plastic pipe	0.06
Steel and wrought iron	1.8
Galvanized iron or steel	6.0
Cast iron	10.2

Fundamentals of Hydronic Design

- Velocity
  - Low Velocity
    - Reduction in Heat Transfer, Differential Pressure Variations, Circulation Noise, & Circulation Energy
    - Contributes to Increased Capital Cost Of Piping & Accessories, Chance Of Clogging & Sediment Build Up, “Gurgling” i.e.: Air Separation

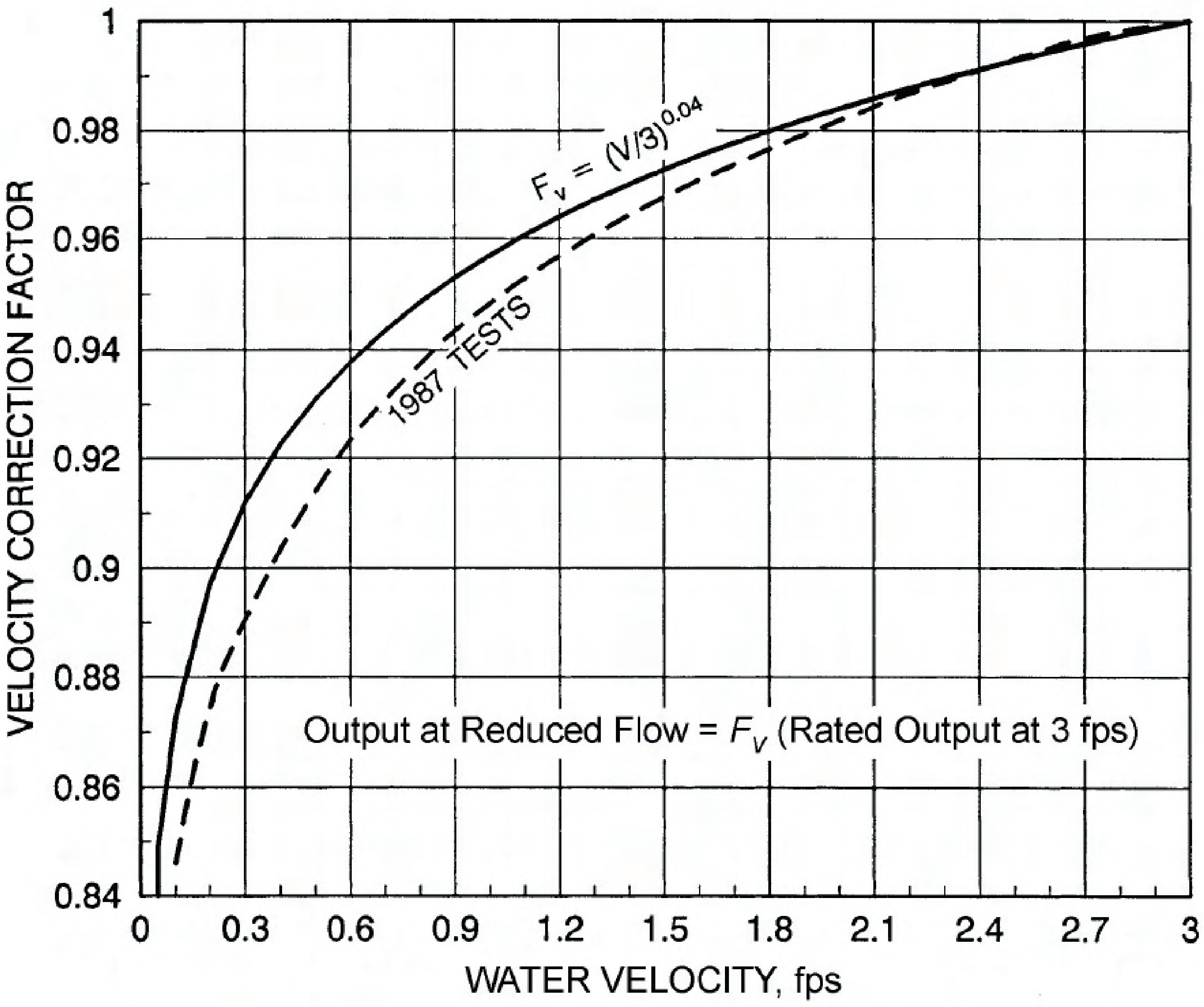


Fig. 3 **Water Velocity Correction Factor for Baseboard and Finned-Tube Radiators**

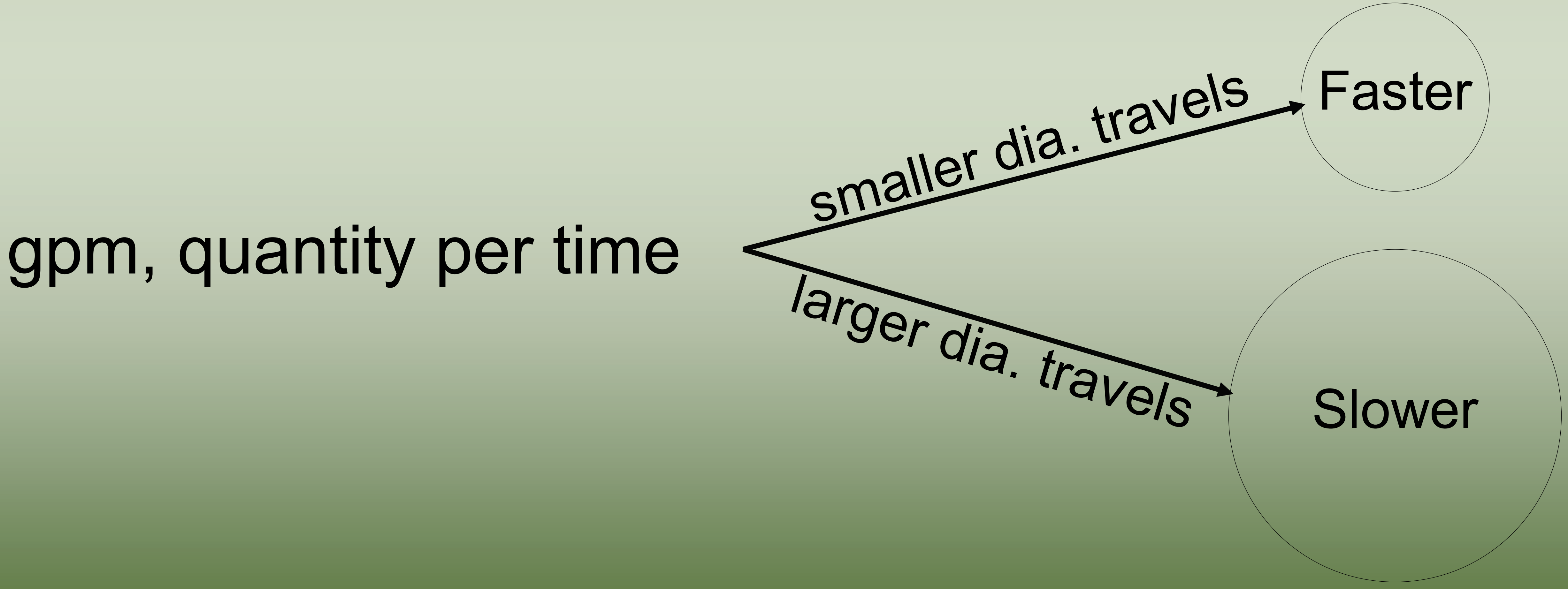
$$F_v = (V/3.0)^{0.04}$$

Fundamentals of Hydronic Design

- Velocity
  - High Velocity
    - Reduction in Capital Cost of Piping & Accessories, with less Air Separation & Sediment Build Up
    - Promotes Noise, Erosion, & Consumption of Circulation Energy But Improves Heat Transfer

Fundamentals of Hydronic Design

- Velocity
  - Determined by flow, time and pipe diameter
  - Balance Between Capital Cost and Operating Cost with System Performance.



gpm, quantity per time

smaller dia. travels

Faster

larger dia. travels

Slower

Fundamentals of Hydronic Design

- Velocity
  - How fast (fps) the fluid is flowing
  - Influences the differential pressure requirements for the circulator

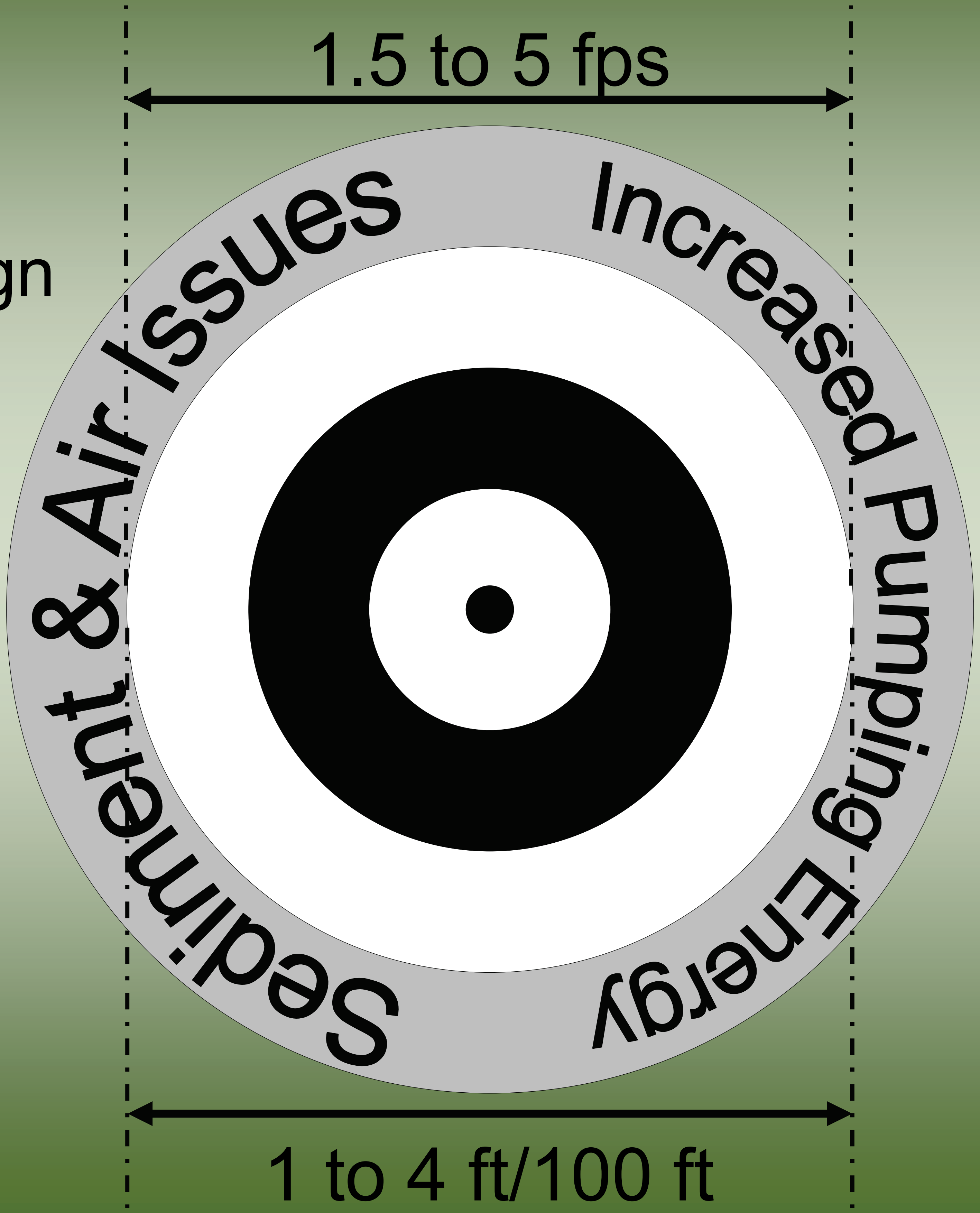
$$\frac{q_w\text{, Design Flow, USgpm}}{3.13 * \text{Area in}^2} = \text{Velocity ft/sec}$$

$$\frac{25 \text{ USgpm}}{3.13 * 3.17 \text{ in}^2} = 2.53 \text{ ft/sec}$$

WinCAPS | System Syzer

Fundamentals of Hydronic Design

- Velocity
  - Center Target Range
  - Magnitude of Aggressive Design
    - Possible with precautions
    - Remove Air & Sediment
    - Linear Piping, Bent vs Fittings
    - Use of Plastics



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This material is presented as an educational service and is supported by downloading the Guide to Indoor Comfort Quality and the Architectural Guide to Radiant Based HVAC Systems