Pump Sizing Calculation Report

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System Summary

Total System Heat Load: **0 BTU/hr**
Total System Flow: **10.00 GPM**
Required Pump Head: **33.16 ft**
Critical Zone: **Zone 1**
Number of Zones: **1**

Fluid Type: **Water**
Fluid Temperature: **140°F**
Calculation Method: **Darcy-Weisbach**

Design Constants:

Heat Transfer Constant: **500 BTU/(hr·GPM·°F)**
(Specific heat of water × density × conversion factors)
Gravity Constant: **32.174 ft/s²**
Fluid Density: **62.400 lb/ft³**
Kinematic Viscosity: **5.060e-6 ft²/s**

Head Safety Factor: **10%**
Flow Safety Factor: **0%**

Zone 1: Zone 1

Inputs:

Zone Heat Load: **150,000 BTU/hr (manual)**
Emitter Type: **Baseboard**
Emitter Equivalent Length: **50.0 ft**
Temperature Difference (”T): **30.0°F (auto)**
Straight Pipe Length: **100.0 ft**
Pipe Material: **Copper**
Pipe Size: **3/4"**
Fittings:
90° Elbow: **1**
45° Elbow: **1**

Results:

Calculated Flow: **10.00 GPM**
Velocity: **6.63 ft/s**
Reynolds Number: **85702**
Total Effective Length: **153.0 ft**
Head Loss: **30.14 ft**

& WARNING: Flow Velocity Exceeds Recommended Limit

Proof of Math (Step-by-Step Calculations)

1. Heat Transfer Calculation (GPM from BTU/hr and ”T):

Formula: GPM = BTU/hr ÷ (500 × ”T)

Substituting values: GPM = 150,000 ÷ (500 × 30.0)

GPM = 150,000 ÷ 15000.0

GPM = 10.00

2. Velocity Calculation:

Formula: Velocity = Flow ÷ Pipe Cross-Sectional Area

Pipe Internal Diameter: 0.785 inches = 0.0654 ft

Cross-Sectional Area: À × (0.0654 / 2)^2 = 0.003361 ft^2

Flow: 10.00 GPM = 0.0223 ft^3/s

Velocity: 0.0223 ÷ 0.003361 ft^2

Velocity = 6.63 ft/s

3. Reynolds Number Calculation:

Formula: Re = (Velocity × Diameter) ÷ Kinematic Viscosity

Assumed Water Temperature: 140°F

Kinematic Viscosity: 5.060e-6 ft^2/s

Re = (6.63 × 0.0654) ÷ 5.060e-6

Reynolds Number = 85702

Flow Regime: Turbulent

4. Friction Factor Calculation (Swamee-Jain Approximation):

Absolute Roughness: 5.000e-6 ft

Relative Roughness: 5.000e-6 ÷ 0.0654 = 7.643e-5

Turbulent flow - Swamee-Jain formula:

f = 0.25 / [log•€(µ/3.7D + 5.74/Rep·y)]^2

Friction Factor (f) = 0.018871

5. Head Loss Calculation (Darcy-Weisbach Equation):

Formula: h = f × (L/D) × (V^2/2g)

Effective Length Breakdown:

- Straight pipe: 100.0 ft
- Fitting equivalent: 3.0 ft
- Emitter equivalent: 50.0 ft
- **Total effective length (L): 153.0 ft**

Gravity constant (g): 32.174 ft/s^2

h = 0.018871 × (153.0 / 0.0654) × (6.63^2 / (2 × 32.174))

h = 0.018871 × 2338.85 × 0.6829

Head Loss = 30.14 ft

Assumptions & Constraints

Fluid Assumptions:

Fluid:	**Water**
Temperature:	**140°F**
Density:	**62.400 lb/ft³**
Kinematic Viscosity:	**5.060e-6 ft²/s**

Calculation Method:

Method:	**Darcy-Weisbach**

Friction factor via Swamee-Jain approximation

Validity Domain:

- Turbulent flow regime (Re > 4000 typical for hydronic systems)
- Closed-loop hydronic heating systems
- Temperature range: 40°F to 180°F

Velocity Target Ranges:

- Recommended: 2-4 ft/s (quiet operation, minimal erosion)
- Absolute maximum: 8 ft/s for water, 6 ft/s for glycol
- Minimum: ~1 ft/s (below this, air separation may occur)

Data Sources:

- Pipe dimensions: ASTM standards
- Fluid properties: NIST, ASHRAE Handbook - Fundamentals
- Roughness values: Engineering reference tables
- Fitting equivalents: ASHRAE, crane technical papers

DISCLAIMER: This report is for preliminary sizing only. Professional engineering review is required for final design. All calculations are based on stated assumptions and design constants. Field conditions may vary. Verify all values before equipment procurement or installation.