STEAM LINE SIZING:
WHY IT IS IMPORTANT AND HOW TO CORRECTLY SIZE

Steam Best Practices

HOW TO CORRECTLY SIZE

Selecting the correct size for a steam line is one of the most important items in a properly operating steam system. Steam lines are designed for 200 years of operation, and the plant should not experience premature failure with a properly designed and operated steam line.

One important factor to remember about steam system design is that a steam system must be viewed as a complete system rather than its component parts; therefore, all aspects need to be reviewed to ensure proper operation. For example, undersized steam lines will lead to steam starvation and steam pressure loss at the steam end user. This pressure loss is often mistakenly assumed to result from heat transfer problems or control valve issues.

Providing the correct steam pressure and steam quality to the end user is the goal of the steam distribution lines. Steam lines always will have a steam pressure drop with all the restrictions to steam flow, such as valves, elbows, pipe internal roughness, flow meters, expansion devices, and other items. The plant needs to determine the acceptable steam pressure drop for the steam distribution system and deliver the correct steam pressure to the end user.

When designing steam headers, branch lines, and condensate lines, there are general rules regarding velocities in the piping. Oversizing a steam or condensate line is never a problem except for the additional cost at installation, and it will add a very small additional energy loss through the insulation. However, the benefits of oversizing far outweigh the negatives of undersizing.
UNDERSIZING STEAM LINE NEGATIVES

Undersizing steam lines will increase the steam velocities, which, in turn, will increase the noise (dBA level) and pressure drops in the steam system. Higher velocities of 10,000 fpm or more will present four additional problems in the system:

- **Steam Quality**

  High velocities in the steam line will entrain the condensate that forms from thermal losses through the insulation. The end result will be lower steam quality. The design of the steam distribution system should provide at least steam quality of at least 98% to the end user.

- **Higher Steam Line Pressure Drops**

  The steam line pressure drops will increase with higher steam line velocities.

- **Premature Steam Line Component Failures**

  Poor steam quality in the steam line will cause erosion in the steam line elbows, flow meters, isolation valves, and other items.

- **WATER HAMMER**

  In severe cases, the result could be water hammer in the system.

WHAT ARE THE CORRECT VELOCITIES?

- Steam heating system velocities: 6,000 feet per minute
- Process steam velocities: 10,000 feet per minute
- Condensate piping velocities (two-phase flow/flash steam): 4,500 feet per minute
- Condensate piping velocities (liquid only): 420 feet per minute

SIZING STEAM LINES FOR VELOCITY

**Formula for velocity in steam piping:**

\[
\text{Velocity} = \frac{2.4 \times \text{flow} \times \text{specific volume}}{\text{cross-sectional area}}
\]

- Flow = lbs. per hour
- Specific volume (typically at the end of the steam line) cubic ft. per lb.
- Cross-sectional area of the pipe

\[
\text{Internal area in square inches}
\]

Example:

Steam Flow: 110,000 lbs.hr
Steam Pressure: 215 psig
10” Sch. 40 pipe: 78.9 (cross-sectional area)

\[
\text{Line A} = \frac{2.4 \times 110,000 \times 2.002}{78.9 \ (\text{Area})} = 6698 \text{ FPM}
\]

CALCULATING THE STEAM LINE PRESSURE DROP

When calculating the pressure drop for steam lines of any length, it is not sufficient to depend upon calculations based on velocity alone. Velocity is only one part of the solution.

**Formula:**

\[
P_d = \frac{P_1 - P_2}{0.0484 \cdot f \cdot L \cdot G^2} \cdot D^5 \cdot W
\]

- \(P_d\) = Pressure drop in lbs. per square in.
- \(P_1\) = Initial pressure in lbs. per square in. absolute
- \(P_2\) = Final pressure in lbs. per square in. absolute
- \(f\) = Friction factor
- \(G\) = Lbs. of steam per minute
- \(D\) = Internal diameter (inches)
- \(L\) = Length of pipe
- \(W\) = \[\frac{1}{V_5}\] = weight of steam per cubic feet of pressure \(P_1\)
EXAMPLE

$P_1 = 234$ psia
Steam flow = 90,000 lbs. per hour
Pipe size = 10"
Pipe schedule = 40
Length = 1,000 ft.

Step 1.

$W = \frac{1}{V_5}$ = weight of steam per cubic feet of pressure $P_1$

$V_5 = 1.960$ ft.$^3$/lb., $W = \frac{1}{1.96} = 0.509$ lbs./ft.$^3$

Pressure Drop = 

\[
\frac{(0.0484)(0.0053)(1,000)(90,000/60 \text{ steam flow mins.})^2}{(10.02)^5 (0.509 \text{ lbs. ft.}^3)}
\]

Pressure Drop = $234$ psig - $P_2 = \frac{577,170}{51,411}$

Pressure Drop = $234$ psia - $P_2 = 11.23$

$P_2 = 222.8$ psia
## General Tables

**Grinnell - Piping Design and Engineering**

### Properties of Pipe

<table>
<thead>
<tr>
<th>nominal pipe size outside diameter, in.</th>
<th>schedule number</th>
<th>wall thickness, in.</th>
<th>inside area, sq. in.</th>
<th>inside area, % of outside</th>
<th>inside area, surface, per ft</th>
<th>sq ft inside surface, per ft</th>
<th>wall thickness, in.</th>
<th>weight, lb</th>
<th>moment of inertia, in.</th>
<th>section modulus, in.²</th>
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## Properties of Pipe

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<tr>
<th>Nominal pipe size</th>
<th>Schedule number</th>
<th>Wall thickness, in.</th>
<th>Inside diameter, in.</th>
<th>Inside area, sq. in.</th>
<th>Metal area, sq. in.</th>
<th>Sq ft inside area, per ft</th>
<th>Sq ft outside area, per ft</th>
<th>Weight inside metal, lb</th>
<th>Weight of water, lb</th>
<th>Moment of inertia, lb-in²</th>
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### GENERAL TABLES
GRINNELL - PIPING DESIGN AND ENGINEERING

#### PROPERTIES OF PIPE

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<th>nominal pipe size</th>
<th>schedule number*</th>
<th>wall thickness, in.</th>
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*For more information, visit [thermdex.com](http://www.thermdex.com) for full details on the properties of pipe.
ABOUT US

Thermdex personnel are experts in the field of steam and condensate systems engineering with vast real-world experience and highly recognized professionals in the industrial arena. Our services include design, engineering, requests for quotations, standard operating procedures, root cause analysis, system optimization, steam balancing and project management. Thermdex can review your entire steam and condensate system from steam generation to distribution to end user processes and condensate recovery.