



» HOW TO CORRECTLY SIZE CONDENSATE LINES

TO ENSURE PROPER SYSTEM OPERATION

1. SIZING CONDENSATE LINES

Sizing condensate lines is very different from sizing any other fluid-conveying pipes. A high percentage of the time, the condensate header or line contains a two-phase flow, which is the condensate (liquid) and steam (flash or blowthrough steam from failed steam traps). If the condensate line is operating with two-phase flow and the condensate line is sized just for the liquid flow, then the condensate line will be undersized. The condensate line undersizing has significant end results: poor process performance and operation, water hammer, and component failures.

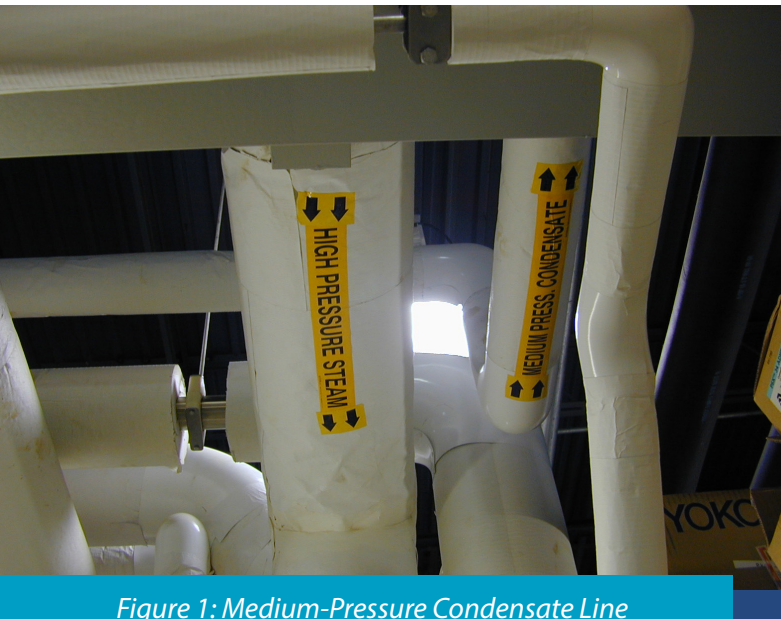


Figure 1: Medium-Pressure Condensate Line

2. CONDENSATE LINES: SINGLE-PHASE FLOW

Sizing condensate lines for just a liquid flow is simple. There are many different reference charts for water flow in piping systems that are very accurate and easy to use

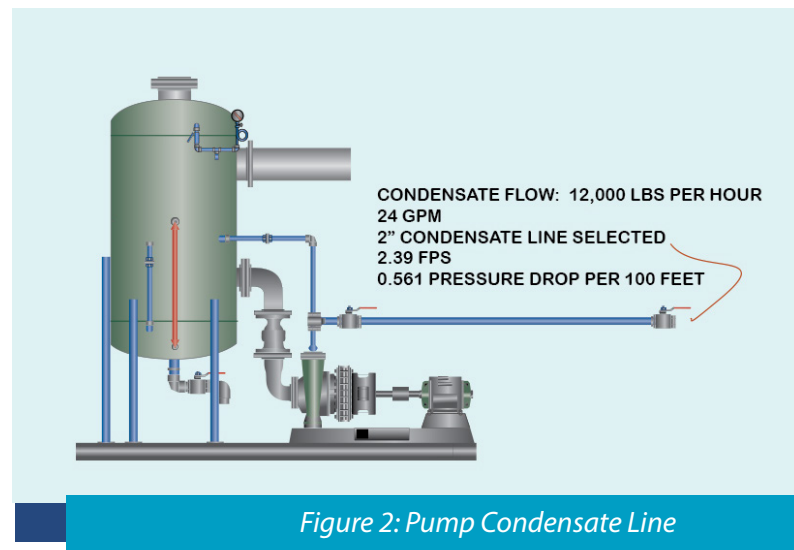


Figure 2: Pump Condensate Line

for condensate line sizing. The condensate line with only a liquid (condensate) flow should have velocities below 7 feet per second (fps).

Example: Condensate line with 12,000 lbs. of condensate flow

- Divide 12,000 lbs. by 8.33, then divide by 60 to calculate gallons per minute (gpm)
 - 24 gpm
- Using a liquid piping flow chart, a selection of 2" condensate pipe would have the following factors:
 - 2.39 fps velocity
 - 0.561 pressure drop per 100 feet

Increasing the condensate line pipe diameter would reduce the velocity and pressure drop, but it would add to condensate line installation costs. But the pressure drop decrease from increasing the condensate pipe diameter would reduce the condensate pump horsepower.

This calculation does not take into consideration valves, expansion devices, flow meters, pipe internal friction factors,

and other components that are added into the condensate line that will restrict flow. These restrictions must be part of the final sizing calculations.

3. SIZING CONDENSATE LINES: TWO-PHASE FLOW

A high percentage of the condensate lines will contain a two-phase flow, which is the condensate (liquid) and steam (flash and possible blowthrough steam). If the condensate line is designed and sized just for the liquid (condensate) flow, then the condensate line would be undersized if two-phase flow exists in the condensate line.

Condensate line velocities should never exceed 4,500 feet per minute (fpm) to ensure that no water hammer will occur in the condensate line. Also, the higher velocities will cause higher condensate line operating pressures.

When sizing the condensate line, take the following three steps:

1. Determine the rate of condensate flow (liquid).
2. Determine the amount of flash steam.
3. Calculate the neglect factor that will allow utility steam to flow freely into the condensate line from failed steam trap stations.
 - o The additional steam will cause significant condensate line operation problems if the condensate line is not designed for this condition.

3.1. Example: Condensate Line Operational Parameters

- Condensate flow: 16,200 lbs. per hour
- Flash steam flow: 3,654 lbs. per hour
- Condensate line pressure: 20 psig
 - o The line is designed for a cascade system providing condensate to a flash tank system.
- Condensate line length 900 feet

Size the condensate line based upon the following:

1. the size of the vapor flow (flash steam),
2. the liquid flow (condensate),
3. add the two cross-sectional areas of the resulting two pipe diameters to determine the correct condensate line.

The percentage of flash steam versus condensate (water) is usually on the order of 20:1, so the effect of the condensate liquid in the condensate system sizing is usually small compared to the vapor (steam) flow.

3.2. Step 1: Calculating the Condensate Liquid Flow

- Divide 16,200 by 8.33, then divide by 60 = 33 gpm
- 2" condensate line selected
 - o 3.35 fps
 - o 1.05 pressure drop per 100 feet, or 9.45 total pressure drop in the system

3.3. Step 2: Sizing Condensate Line (Steam Flow) Velocities

The first step is to select a condensate line size, which, for this example, is a 6" schedule 80 condensate line. Based on the velocities, the condensate line can be increased or decreased to achieve a velocity below 4,500 fpm.



Figure 3: Condensate Lines

- Flash steam flow: 3,654 lbs. per hour
- Calculate the velocity:
 - Velocity = $\frac{2.4 \times \text{flow} \times \text{specific volume}}{26.07}$
 - Cross-sectional area (based on 6" schedule 80)

$$\text{Velocity (4,029 fpm)} = \frac{2.4 \times 3,654 \times 11.998 \text{ (specific volume at 20 psig)}}{26.07}$$

** Velocities are below 4,500 fpm

3.4. Step 3: Sizing Condensate Line (Steam Flow) Pressure Drop

- Flash steam flow: 3,654 lbs. per hour

When calculating the pressure drop for steam in the condensate lines, use the following formula to

Pressure drop	0.2	psig
Initial pressure in absolute	34.7	psia
Final pressure in absolute	34.9	psia
Friction factor	0.00053	
Flow rate	3,654.0	lbs./hr.
Flow rate in minutes	60.9	lbs./min.
Internal diameter	5.8	in.
Length of pipe	900.0	ft.
Specific volume	11.9	ft. ³ /lb.
Weight of steam at initial pressure	0.1	lb./ft. ³
Pressure drop	0.2	psia
Final pressure	34.9	psia

calculate the pressure drop that will occur in the condensate line:

$$Pd = P1 - P2 = \frac{0.0484 f L G^2}{D^5 W}$$

Pd = Pressure drop in lbs. per square in.

P1 = Initial pressure in lbs. per square in. absolute
 P2 = 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 = $\frac{1}{V_s}$ = weight of steam per cubic feet at pressure P1

Pressure drop calculation equals a 0.2 psia pressure drop.

3.5. Correct Condensate Pipe Diameter

Adding the liquid flow pipe cross-section area (2.953) and the flash steam flow (26.023) will equal a total of 29.023 cross-sectional (square inches).

A 7" condensate line would be the correct selection; however, no 7" pipe is available. Therefore, the final answer would be an 8" diameter pipe (schedule 80).



Figure 4: Condensate Line Installation