Proper Methods for Steam Trap Sizing

Steam Trap Sizing

Proper steam trap sizing is a critical factor in obtaining efficient and reliable steam trap operation. Incorrect steam trap sizing can negate proper trap design, installation, and can cause condensate backup, steam loss or both.

Steam trap sizing is sometimes mistaken for selection of the steam trap connection size. Rather it is the proper sizing of the internal discharge orifice. (For low pressure steam heating systems, manufacturers produce steam traps with connection sizes that relate directly to capacity, orifice size). However, an industrial steam trap must be sized by selecting the proper discharge orifice. A two-inch steam trap can have the same condensate capacity as a steam trap with a half-inch connection. Once the condensate capacity is determined and the proper orifice size is calculated, the steam trap connection size can then be determined to meet the installation requirements.

Steam trap connection size is dictated by installation criteria—it has no effect on condensate capacity.

To determine the correct orifice size, the following data is required:

- Maximum steam pressure (steam trap body rating)
- Maximum steam temperature (steam trap body rating)
- Operating pressure (psig)
- Inlet steam pressure to the steam trap
- Minimum differential pressure (delta P) (P1 –P2)
- Maximum steam temperature (steam trap body rating)
- Maximum condensate capacity (lbs./hour)
- Minimum condensate capacity (lbs./hour)
- Steam trap discharge pressure or condensate return line pressure (P2)
- Condensate flow condition = Modulating or on/off condensate flow vs. continuous operation.

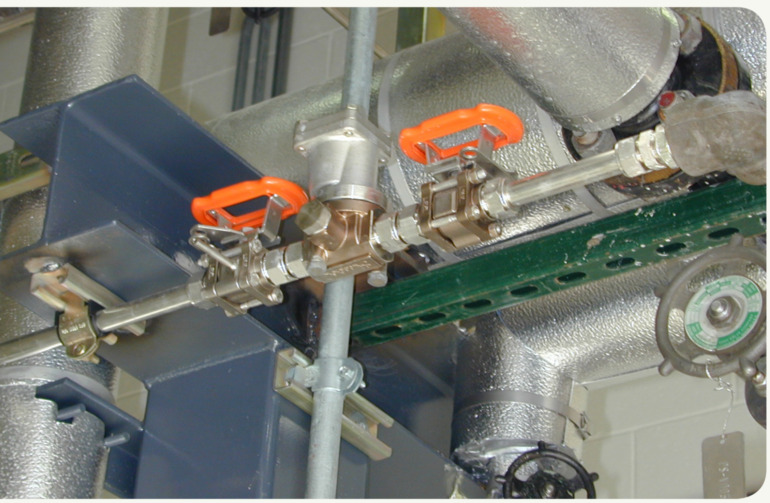
The maximum steam pressure is determined by either the design specification of the system or by the pressure setting of the safety valve which protects the steam system. Operating steam pressure can be obtained from an installed pressure gauge.

The condensate capacity requirements can be more difficult to obtain. Condensate capacities may be documented in either the design specifications or on equipment nameplates. If the condensate capacity is not shown, it will be necessary to calculate the condensate capacity by using a heat transfer formula. One basic item to remember is that one pound of steam condenses to one pound of water. If pounds/hour of steam is known, the condensate capacity is the same. If equipment is rated in BTU/hour, the capacity in pounds/hour can be approximated by dividing by the latent energy of the steam pressure at the equipment.

If a steam control valve is installed to control the flow of steam to the process, the rated capacity of the valve, in terms of (x) pounds per hour of steam, would generate an equivalent amount of condensate.

Back Pressure—Steam Trap Capacity

A high percentage of steam trap applications will have back pressures above atmospheric at the discharge side of the steam trap caused by the condensate return system. The back pressure may be unintentional or deliberately produced by the design or the operation of the condensate return system.



Unintentional Back Pressure

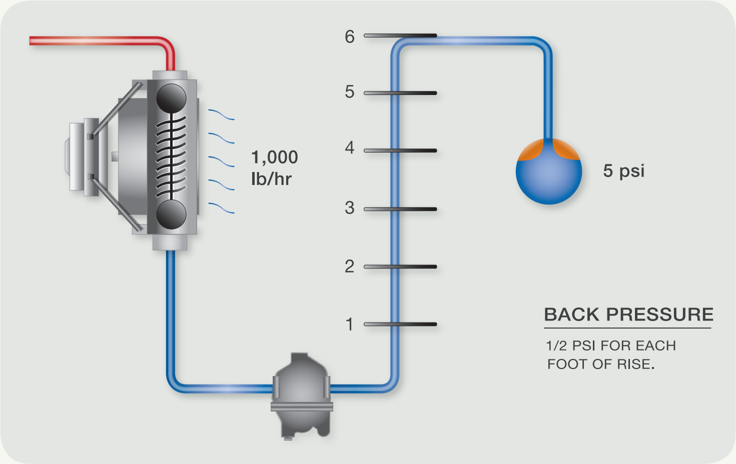
Unintentional back pressure is caused by static pressure created by a vertical rise in the condensate piping after the steam trap. Main condensate return lines are typically installed at elevations above the steam traps; therefore, it is necessary to pipe the condensate from the steam trap location up to the higher located condensate mains. A rule of thumb, every foot of rise in the condensate line after the steam trap equals ½ psig back pressure on the steam trap discharge. Undersized condensate lines can also cause back pressure on the steam trap that must be considered when sizing steam traps. Condensate lines need to be sized for two-phase flow (condensate and flash steam).

Intentional Back Pressure

Deliberate back pressure results from a condensate return system design that intentionally creates pressure in the condensate line to increase thermal cycle efficiency. See "Best Practice" No. 8 for more information on high pressure condensate systems.

Sizing Factor

Steam trap tables provide the condensate capacity (pounds/hour) of various discharge orifices at various operating pressures (maximum differential pressure). The condensate capacities listed indicate maximum continuous discharge. The calculations assume the discharge orifice never closes but rather remains open at all times. Since steam traps are designed to either cycle on and off, or to modulate, we must apply a sizing factor to these tables in order to obtain a steam trap with a condensate capacity sufficient for the application or process requirement. A sizing factor is added in the condensate capacity to determine the correct steam trap capacity selection for effective operation.



Unit Heater Application

Typical Sizing Factors

- Inverted bucket: 3 to 1
- Float and thermostatic: 2 to 1
- Thermostatic: 3 to 1
- Thermodynamic: 3 to 1

If start-up loads are heavy or fast, heat up is required. A sizing factor of 4 to 1 is more appropriate.

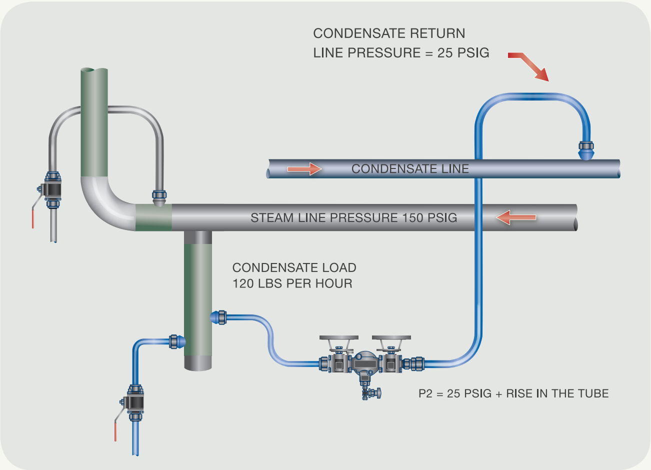
The selection of sizing factors is different for each operational steam trap design. Follow manufacturer's instructions when selecting the sizing factors.

Sizing example:

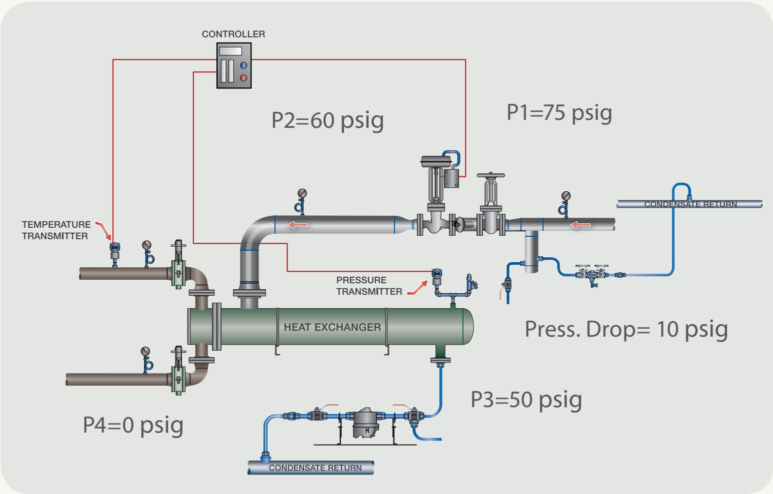
1. Delivery pressure to the unit heater = 15 psig
2. Pressure drop across the unit heater = 5 psig
3. P1 = 10 psig (inlet to steam trap)
4. Back pressure in the condensate line = 5 psig
5. Rise in condensate piping after the steam trap (distance of six feet) = 3 psig
    - ½ in. psig for each foot rise
6. P2 = 5 psig + 3 psig
    - Back pressure in condensate line + rise in the piping after the steam trap
7. Capacity: 1000 lbs. per hour
8. Float and thermostatic steam trap – capacity x 2 (sizing factor) = 2000 lbs. per hour
9. Steam orifice will have a maximum pressure rating of 15 psig
10. Steam trap capacity will be 2000 lbs per hour at a 2 psig differential pressure across the orifice. Two psig pressure drop is P1 – P2 = DP

Sizing example:

1. P1 = 150 psig
2. P2 = 25 psig (back pressure in the condensate return line) + 2 psig (rise of condensate pipe)



Steam Line Drip Leg Application



3. Flow = 120 lbs. per hour
4. Thermostatic steam trap is selected.
5. Sizing factor is 3 x capacity or the steam trap will have to pass 360 lbs per hour
6. Differential pressure (P1 – P2 = DP) or 123 psig
7. Steam trap with a orifice rated for 150 psig with a capacity of 360 per hour at a differential pressure of 123 psig

Sizing example:

Steam to a modulating process requires the following information:

1. Determine the maximum pressure on the steam line supplying the process. The steam trap design and material have to be rated for the maximum steam pressure.
2. Select the steam trap orifice, which must be rated for the maximum steam pressure used in the process. The maximum pressure is especially critical in mechanical steam traps.
3. P1 (Inlet pressure to control valve) =
   - **a.** Some plants document steam pressure at the steam control valve inlet. Do not assume the steam line operating pressure will equal the steam pressure at the control valve. Pressure drops in the steam line have to be considered.
4. P2 (Outlet pressure from control valve to heat exchanger) =
   - **a.** There is a calculated pressure drop across the control valve. This information can be determined from the steam control valve performance information.
5. Pressure drop (heat exchanger).
   - **a.** All heat transfer components have a pressure drop. This information can be obtained from the transfer performance sheets.
6. P3 (Inlet pressure to steam trap)
   - **a.** Subtract the heat transfer pressure drop from P2 will result in P3.
7. P4 = Outlet pressure at the discharge of the steam trap
8. Condensate flow rate
9. Sizing factor = depending on steam trap design

Steam to a modulating process requires the following information.

1. Determine maximum pressure on the steam line supply. The process = 100 psig
   - **a.** Steam trap is rated for 250 psig @ 450°F.
   - **b.** Orifice in the steam trap will be rated for a pressure equal to or greater than 100 psig.

2. P1 (Inlet pressure to control valve) = 75 psig
3. P2 (Outlet pressure from control valve to heat exchanger) = 60 psig
4. Pressure drop (heat exchanger) = 10 psig from TEMA sheets
5. P3 (Inlet pressure to steam trap) = 50 psig
6. P4 = Outlet pressure from steam trap = 0 psig (atmospheric tank system – gravity drainage)
7. Flow rate = 3624
8. Sizing factor = minimum of 1.5 to 1, prefer 2 to 1 = 7248 lbs, per hour

Conclusion: The steam trap should have a capacity of 7248 lbs. per hour at a differential pressure of 50 psig and an orifice rating of 100 psig or more.

Steam trap sizing requires experience in the operating characteristics of many different pieces of equipment. The end result depends on the quality of the data.

The steam trap piping size can be selected after orifice sizing. The high condensate capacity steam traps will be available only in larger pipe sizes. If the heat transfer equipment has a two-inch piping outlet, don't select a half-inch steam trap, as condensate flow would be restricted. Always select a steam trap with a connection equal to or larger than the process outlet connection. 1.5 in. process outlet = 1.5 in. steam trap.

Many industries use ¾ in. steam trap piping as a minimum size to provide piping rigidity, and most important, standardization.

Roadmap:

1. Obtain accurate information.
2. Standardize on one or two steam trap manufacturers.
3. Have installation standards.
4. Obtain training on sizing procedures.