Steam System Diagnostics

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When steam system troubles arise, the steam trap is often unfairly assumed to be the problem.

Other factors that should be reviewed include steam trap technologies, piping design (upstream and downstream of the trap), system needs (for efficient operations), and trap maintenance (for optimum performance).

This article identifies some of the more common situations that occur along with possible solutions.

Steam Trap Technologies

- ♦ Match trap technology to application needs.

The first thing to recognize is that the steam trap is one part of a sometimes complex network of equipment. If the trap is concentrated on exclusively, the correction will probably just serve as a band-aid that will not last as a permanent solution to the problem.

Table 1 provides key performance characteristics that should be considered to meet specific application needs.

Let's start by stating the prime role of a steam trap: to remove condensate, air and other non-condensible gases, while not losing any live steam. If a strap fails, it should fail open to ensure that condensate will continue to be removed from the system.

The information in Table 1 makes it clear that application needs should be matched to the correct trap technology. Each trap type has its strengths and weaknesses and will give poor results if it is applied incorrectly.

There is no perfrect trap technology for every application in every plant. Most major manufacturers have computerized trap sizing programs available to help the user optimize selection and prevent basic mistakes.

- ♦ Ensure that the steam being supplied is as dry as possible and contains the optimum Btu per lb. of latent heat for heat transfer.

Figure 1 readily displays the latent and sensible heat values in saturated steam at 100 psig. At this condition, it containes 309 Btu per lb. sensible heat and 881 Btu per lb. latent heat, all at a saturated temperature of 338° F.

As latent heat is used for heat transfer, it is best to be as close to the dry saturated point as possible, so as to use all the available Btu.

Many plants have less than ideal steam quality, often referred to as "wet steam." This means they are not as close to the dry saturated condition as possible.

This steam does not contain the maximum Btu available for optimum heat transfer.

For example, if a plant has steam with only 440 Btu per lb. of latent heat, it stands to reason that about twice as much of this steam will be needed to effect the same heat transfer.

This, in turn, creates a problem in that the trap must discharge twice the amount of condensate into what is often an undersized return line.

- ♦ Ensure that the piping allows the condensate to be removed effectively (Remember, water runs downhill.)

Figure 1. Total Heat in 100 psig Saturated Steam

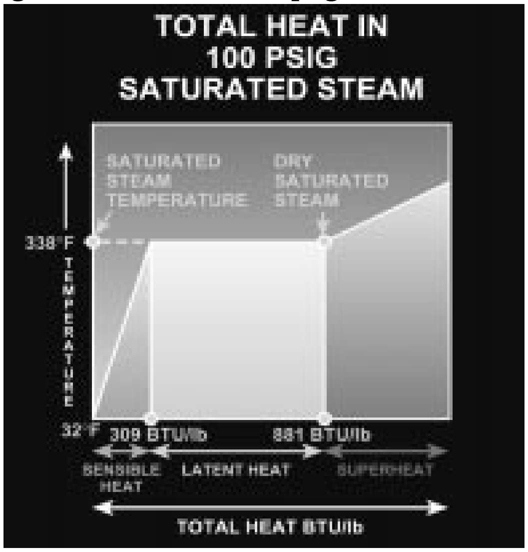
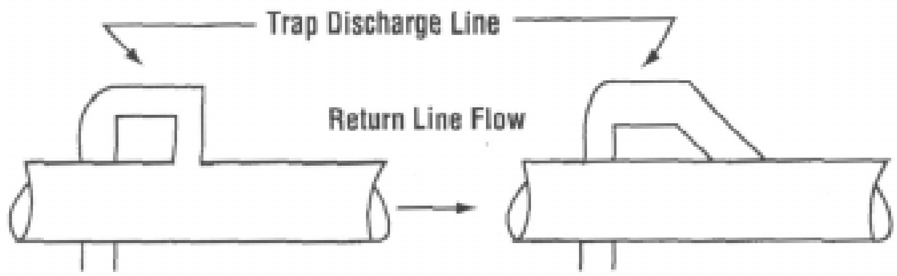


Figure 2. Trap Discharge Arrangements



Many plants have water hammer, and people become complacent about it, not realizing the damage it can cause to pipe work and associated equipment. It can also create a personnel safety hazard by leading to pipe breakage and possible escape of live steam.

Water hammer is caused by:

1. Slugs of water traveling down the pipeline at high speed. Steam has an average velocity of 8,800 ft per min. (100 mph).
2. Thermal shock created by mixing of cold and hot discharges.
3. Hydraulic shock (solenoid valves).

The first two are the most common causes and can be minimized by installing the correct drip pocket design/location and return line designs.

- ♦ Verify that the return line sizing is correct and ensure all line direction changes are taken into account when designing your piping.

After reviewing upstream piping, it is important to ensure that downstream design does not contain any restriction or introduce water hammer.

This is an increasing problem because more condensate is being returned to the boiler either because of EPA rules or for cost effectiveness.

How often do people take the time to check that the line is large enough to handle the condensate load? Correct sizing provides a return line that operates only partially full, creating a soft system.

Undersizing is like squeezing a quart of liquid into a pint container. This creates a higher return pressure, as well as water hammer, and leads to less efficient handling of condensate.

Also, the return line must never run uphill.

It is sometimes forgotten in piping design that raising the trap discharge by, say, 20 ft. to connect to pipework creates an energy drain.

Figure 3. Steam Line Drains

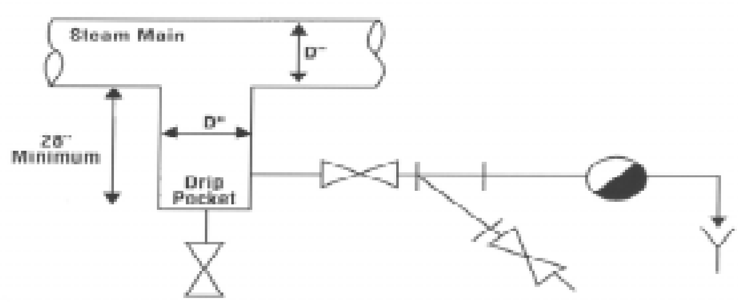


Table 1. Characteristics of Various Steam Trap Technologies

	Thermodynamic			Thermostatic			Mechanical	
	Disc	**Piston**	**Lever**	**Bellows**	**Bimetallic**	**Pilot**	**Inverted Bucket**	**Float & Thermostatic**
Discharge	cyclic	cyclic	cyclic	cyclic/ modulating	cyclic/ modulating	cyclic	cyclic/ modulating	modulating
Discharge Temperature	hot	hot	hot	hot/ subcooled	hot/ subcooled	hot	hot	hot
Air Venting	fair	good	excellent	excellent	excellent	excellent	poor	good
Dirt Handling	good	good	excellent	good/fair	fair	good	good	good
Superheat	excellent	excellent	excellent	good/fair	good	good	poor	poor
Water Hammer	excellent	excellent	excellent	good/fair	good	good	good	poor
Response	good	excellent	excellent	excellent	fair	good	good	excellent
Fail Mode	Open	open	open	open/close	open	open	open/close	closed
Freezing Susceptibility	no	no	no	no	no	no	yes	yes
Position Sensitive	no	no	yes	no	no	no	yes	yes
Back Pressure Sensitive	yes	yes	yes	no	yes	no	no	no

Back pressure is approximately 1/2 psi for each foot (e.g. 20 ft. is equal to 10 psi). This also lowers the differential pressure across the trap, thus reducing the volume of condensate it can pass.

Figure 2 demonstrates the correct positioning of trap discharges into the main condensate return line. They should always enter at the top, otherwise there will be mixing of hot and cold liquids, causing water hammer.

Trap Maintenance / Survey

Even with the correct type and size of steam trap installed, a maintenance program is essential to maintain optimum performance. Here are some pointers:

- Check traps at least annually.
- Verify trap operation by at least two of the accepted methods: visual, sound, temperature.
- Insulate lines but never the trap (you might not find an insulated trap and it could affect the trap's operation).
- Install the trap where it can be serviced easily (difficult loactions will not get checked).

If a steam trap is properly selected, sized, installed and maintained, it will provide many years of trouble-free service. However, it is important to remember tht the trap is only one part of the system, so careful attention should be paid to other equipment and conditions that could affect its performance.

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Steam Trap criteria / applications

While the main purpose of this article is to address the problems of steam systems, plant personnel also need to be aware of some steam trap specifics:

Sizing and selection

Steam trap sizing and selection criteria include the following:

- Technology.
- Operating pressure and discharge capacity.
- Ensuring that trap characteristics are suitable for the application discharge temperature.
- Venting ability.
- Suitability for drainage and pipe design.
- Freeze resistance.
- Ease of trap installation, checking and maintenance.

Applications

The three main applications for steam traps are listed below.

1. **Drip.** The purpose is to remove condensate from piping to prevent damage to the piping, control valves, strainers, etc., while assuring that production steam users receive dry steam. To achieve this, here are some check points (see Figure 3).

- Provide adequately sized drip pocket (28-in. minimum length) to match pipe size (e.g. on an 8-in. header, there should be an 8-in. diameter drain pocket).
- The trap connection should be on the side, about 6 in. from the bottom of the pocket to ensure that clean condensate is presented to the steam trap.
- Include a dirt blowdown valve at bottom of pocket to remove dirt or scale.
- Provide a trap every 300-400 ft.
- Locate drip pockets upstream of control valves, at all piping direction changes and, at the end of the line.

2. **Tracing.** This is the most maligned and least considered application, yet it is often vital and could be the subject of an article by itself.

A few applications include process line tracing, winterization, instrument protection and steam jacketing. All of these have the common purpose of ensuring that efficient steam is distributed. Some points to remember are:

- Match tracing loads to tube size.
- Limit the tube run to 100 ft.
- Have only one trap per system.
- Make sure the trap is located at low point.
- Adequately insulate the line, not the trap.

3. **Process.** Depending on the application, the steam trap will probably have to handle heavy start-up loads, often followed by smaller running loads. The trap's function is to drain the process equipment and thus ensure that effective heat transfer is achieved (through latent heat). A few guidelines for optimum results include:

- Provide an adequate size process connection from equipment.
- Locate trap below the equipment (water runs downhill).
- Use good piping practice to ensure that clean condensate is presented to the trap (same rules as drip pocket).
- Include air vents and vacuum breakers as necessary for effective equipment operation.

NOMOGRAPH FOR ESTIMATING CONDENSATE RETURN LINE SIZE

Case I—What size return line is needed?

Given:
Trap inlet pressure, P_1 = 50 psig
Flash tank pressure, P_2 = 10 psig
Measured run of return line = 715 ft
Total trap capacity into line = 10,000 lb/hr

Solution:

Connect	with	Read
P_1 = 50	P_2 = 10	X = 75
X = 75	W = 10,000	Y = 133
Y = 133	Le = 1,000	I.D. = 5-1/2 in.

Case II—What is the maximum condensate rate in lb/hr that can be discharged into a given return line?

Given:
Trap inlet pressure, P_1 = 600 psig
Flash tank pressure, P_2 = 75 psig
Return line I.D. = 4 inches
Equivalent pipe length, Le = 1,000 ft
(including allowance for fittings)

Solution:

Connect	with	Read
P_1 = 600	P_2 = 75	X = 175
I.D. = 4 in.	Le = 1,000	Y = 55
X = 175	Y = 55	W = 10,000