Traps Impact Performance of Steam Systems

Selecting the right steam trap for the application, having it installed properly, and regularly testing it for functionality can increase boiler plant reliability

By Scott A. French, Armstrong International, Inc.

Boiler plant reliability and efficiency depend on the reliability and efficiency of each component of the steam generation, distribution, and condensate return system. Maintaining a boiler plant means paying close attention to components including langes, elbows, valves, unions, and steam traps since each component has the potential of wasting steam.

The cost of replacing the wasted steam can be enormous in terms of system efficiency, lost production, fuel consumption, makeup water treatment cost, and maintenance. These additional costs must be factored into the bottom line of every organization.

In addition to reducing the reliability and efficiency of the boiler, a steam leak impacts the reliability of other equipment as well. For example, leaking steam will increase humidity which can contribute to electrical controls malfunctioning and equipment failures.

A steam leak is costly in terms of out-of-pocket cash to replace the lost steam whether it comes from piping, connections, or steam traps blowing live steam. Table 1 shows that even a small steam leak, allowed to go undetected and unrepaired, can cost several thousand dollars. Multiple leaks can compound the financial requirements.

As shown in the figure, steam mov-.ng through distribution pipes is hotter than the surrounding air. This temperature difference causes heat to flow from the steam through the pipe walls to the air. The resulting heat loss causes some steam to condense back to water.

Even a small steam leak, allowed to go undetected and unrepaired, can cost several thousand dollars.

When steam reaches the heat exchanger, heat passes from the steam to the substance to be heated such as air, water, food, or chemicals. Maximum heat transfer in the heat exchanger is highly desirable.

Getting rid of condensate

Condensate forms in steam lines as a result of unavoidable radiation and in heat transfer equipment where it releases energy for production. To achieve maximum efficiency of the energy transfer, hot condensate should be removed from steam lines and heat transfer equipment as fast as it forms and returned to the boiler for regeneration into steam. It costs far less to raise the temperature of hot condensate to the boiling point than to elevate cool makeup water to the boiling point.

Steam moves rapidly in mains and supply lines-ften at speeds greater than 90 mph. A buildup of condensate in these lines can be pushed along by fast-moving steam. At minimum, water hammer will produce an annoying sound. Severe water hammer can damage pipes, fittings, and regulating valves. It is essential that condensate be removed from lines while it is a "heavy dew" before it can grow into a dangerous slug.

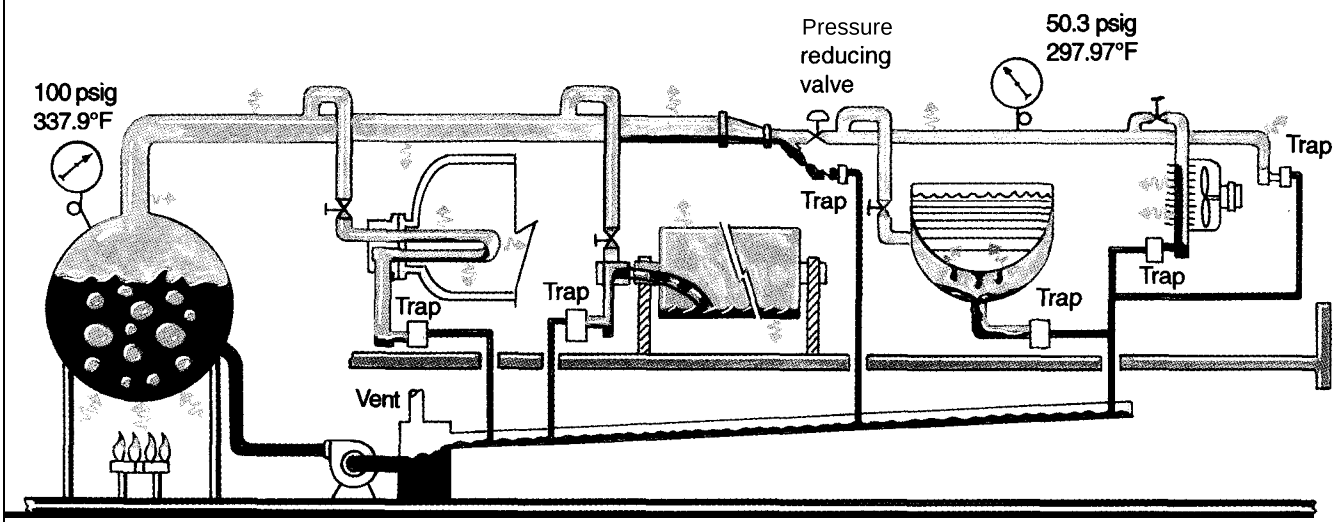
The heat contained in a pound of condensate is negligible when compared with the heat contained in a pound of steam. Condensate in the heat transfer unit takes up space and reduces the unit's capacity. It also forms an insulating film inside the unit, decreasing heat transfer efficiency. In order for the unit to be kept full of steam and operating at maximum efficiency, condensate must be removed promptly.

Air and carbon dioxide (CO_2) gas also must be removed from the steam system as quickly as they form. Air is always present during equipment startup and in boiler feedwater. This feedwater may contain carbonates that dissolve and release CO_2.

Air is an excellent insulator and can greatly reduce heat transfer efficiency by forming an insulator film on heat transfer surfaces. Under certain conditions, as little as one half of 1 percent by volume of air in steam can reduce heat transfer efficiency by 50 percent. Its pressure also robs steam of its temperature.

Carbon dioxide can dissolve in condensate that has cooled below steam temperature and form carbonic acid. This acid is highly corrosive and even-

STEAM DISTRIBUTION SYSTEM



Heat radiation from the distribution system causes condensate to form. Steam traps, at natural low points or ahead of control valves, remove the condensate before it becomes a barrier to heat transfer. Hot condensate is returned through the traps to the boiler for reuse.

TABLE 1. COST OF STEAM LEAKS AT 100 PSI (ASSUMING STEAM COST OF $5/1000 LBS)

Size of orifice (in.)	Lbs steam wasted per month	Total cost per month	Total cost per year
1/2	835,000	$4175	$50,100
7/16	637,000	3185	38,220
3/8	470,000	2350	28,200
5/16	325,000	1625	19,500
1/4	210,000	1050	12,600
3/16	117,000	585	7,020
1/8	52,500	263	3,150

The steam loss values assume clean, dry steam flowing through a sharp-edged orifice to atmospheric pressure with no condensate present. Condensate will normally reduce these losses due to the flashing effect when a pressure drop is experienced.

tually will eat through pipes and heat-transfer equipment.

Which steam trap

The right steam trap removes condensate, air, and CO_2 from the system as fast as they form. The steam trap enhances the system's overall efficiency and reliability and results in substantial energy savings.

The right steam trap prevents the loss of live steam, handles dirt and scale that may form within the system, and operates satisfactorily against back pressure. Selecting the right trap size depends largely on the amount of condensate that must be removed.

If the trap installed is too small to handle the condensate that reaches it, the condensate will back up and eventually block the flow of live steam to the heat exchange device. A trap that is too large will wear out prematurely. In both instances, the trap performs at less than maximum efficiency. Computer software programs are available that will help maintenance personnel properly size and specify the most appropriate steam trap for the application.

Not all steam traps are created equal and to make the appropriate selection, one must understand the operating characteristics of each type of trap. Table 2 compares how types of steam traps meet specific operating requirements.

Although the steam traps vary in design, they all use one or more of three basic operating principles relating to velocity, temperature, or density.

There are four basic types of steam traps-the inverted bucket trap, the

Many of the problems associated with steam trap operation are actually in the system rather than the trap. When a trap fails to operate and the reason is not readily apparent, the discharge from the trap should be observed closely.

If the trap is installed with a test outlet, the task will be simple; otherwise, it will be necessary to break the discharge connection. The following conditions and observations will be helpful in determining the exact nature of steam trap operating problems.

Cold trap-no discharge

A. Pressure may be too high.

- Wrong pressure originally specified.
- Pressure raised without installing properly rated orifice.
- Pressure relief valve out of order.
- Pressure gauge in boiler reads low.
- Orifice enlarged by normal wear.
- High vacuum in return line increases pressure differential beyond which trap may operate.

B. No condensate or steam coming to trap.

- Stopped by plugged strainer ahead of trap.
- Broken valve in line to trap.
- Pipeline or elbows plugged.

C. Worn or defective mechanism.

- Repair or replace as required.

D. Trap body filled with dirt.

- Install strainer or remove dirt at source.

E. For inverted bucket, bucket vent filled with dirt. Prevent by:

- Installing strainer.
- Enlarging vent slightly.
- Using bucket vent scrubbing wire.

F. For float and thermostatic traps, if air vent is not functioning properly, trap will likely air bind.

G. For thermostatic traps, the bellows element may rupture from hydraulic shock, causing the trap to fail closed.

H. For disc traps, trap may be installed backward.

Hot trap-no discharge from trap

A. No condensate coming to trap.

- Trap installed above leaking bypass valve.
- Broken or damaged syphon pipe in syphon drained cylinder.
- Vacuum in water heater coils may prevent drainage. Install a vacuum breaker between the heat exchanger and the trap.

Steam loss

If the trap blows live steam, the trouble may be due to any of the following causes:

A. Valve may fail to seat.

- Piece of scale lodged in orifice.
- Worn parts.

B. Inverted bucket trap may lose its prime.

- If the trap is blowing live steam, close the inlet valve for a few minutes. Then gradually open. If the trap catches its prime, the chances are that the trap is all right.
- Prime loss is usually due to sudden or frequent drops in steam pressure. On such jobs, the installation of a check valve is called for. If possible, locate trap well below drip point.
- For thermostatic and float and thermostatic traps, thermostatic elements may fail to close.

Continuous flow

If an inverted bucket or disc trap discharges continuously, or a thermostatic or float and thermostatic trap discharges at full capacity, check the following:

A. Trap too small.

- A larger trap, or additional traps, should be installed in parallel.
- High-pressure traps may have been used for a low-pressure job. Install right size of internal mechanism.
- Abnormal water conditions. Boiler may foam or prime, throwing large quantities of water into steam lines. A separator should be installed or the feedwater conditions should be remedied.

Sluggish heating

When trap operates satisfactorily, but unit fails to heat properly:

A. One or more units may be short-circuiting. The remedy is to install a trap on each unit.

B. Traps may be too small for job even though they may appear to be handling the condensate efficiently. Try next larger size trap.

C. Trap may have insufficient air-handling capacity, or the air may not be reaching trap. In either case, use auxiliary air vents.

Mysterious trouble

If trap operates satisfactorily when discharging to atmosphere, but trouble is encountered when connecting with return line, check the following:

A. Back pressure may reduce capacity of trap.

- Return line too small-trap hot.
- Other traps may be blowing steam-trap hot.
- Atmospheric vent in condensate receiver may be plugged-trap hot or cold.
- Obstruction in return line-trap hot.
- Excess vacuum in return line-trap cold.

Imaginary troubles

If it appears that steam escapes every time trap discharges, remember: Hot condensate forms flash steam when released to lower pressure, but it usually condenses quickly in the return line.

TABLE 2. HOW STEAM TRAPS MEET SPECIFIC OPERATING REQUIREMENTS

Characteristic	Inverted bucket	Float and thermostatic	Disc	Thermostatic
Method of operation	Intermittent'	Continuous	Intermittent	Intermittent*
Enerav conservation (time in service)	Excellent	Good	Poor	Fair
Resistance to wear	Excellent	Good	Poor	Fair
Corrosion resistance	Excellent	Good	Excellent	Good
Resistance to hydraulic shock	Excellent	Poor	Excellent	Poor[3]
Vents air and CO2 at steam temperature	Yes	No	No	No
Ability to vent air at very low pressure (1/4 psig)	Poor	Excellent	NR[4]	Good
Abilitv to handle startup air loads	Fair	Excellent	Poor	Excellent
Operation against back pressure	Excellent	Excellent	Poor	Excellent
Resistance to damage from freezing[5]	Good	Poor	Good	Good
Ability to purge system	Excellent	Fair	Excellent	Good
Performance on very light loads	Excellent	Excellent	Poor	Excellent
Resoonsiveness to sluas of condensate	Immediate	Immediate	Delaved	Delaved
Abilitv to handle dirt	Excellent	Poor	Poor	Fair
Comparative physical size	Large[6]	Large	Small	Small
Ability to handle "flash steam"	Fair	Poor	Poor	Poor
Mechanical failure (open-closed)	Open	Closed	Open[7]	Open/closed*

‘Drainage of condensate is continuous.
[2]Can be continuous on low load.
[3]Bimetallic and wafer traps-good.
[4]Not recommended for low pressure operations.
[5]Cast iron traps not recommended.
[6]In welded stainless steel construction-medium.
‘Can fail closed due to dirt.
[8]Can fail either open or closed depending on the design of the bellows.

disc trap, the thermostatic trap, and the float and thermostatic trap.

The inverted bucket trap's primary advantage is that it efficiently conserves energy far longer than any other trap type. The inverted bucket trap also offers excellent purging action and outstanding resistance to wear, corrosion, dirt, and hydraulic shock. It also operates effectively against back pressure.

The disc trap is small and light, making it a frequent choice when space is severely limited. It also offers purging action and is resistant to hydraulic shock. The disc trap, however, is not resistant to dirt and wear, resulting in more frequent replacement and substantial steam loss.

The thermostatic trap is most often used for applications having very light loads. It operates efficiently against high back pressure and can handle startup loads. The thermostatic trap is seldom used when dirt or hydraulic shock may be encountered, because it is susceptible to them.

The float and thermostatic trap is an excellent choice for applications where the steam system being drained operates on modulating steam pressure. Its float mechanism provides immediate drainage of condensate-even under zero-pressure conditions, when a vacuum breaker is also used-and its built-in thermostatic vent discharges air and CO_2. It also can vent large quantities of air and operate efficiently at startup and light load.

Maintaining the boiler plant

Maintaining the boiler plant is as important as specifying the most efficient and reliable components. A strong steam trap maintenance program can easily pay for itself in steam energy savings. Equipment is available that automatically tests steam traps on a regular basis and records their performance on a computer.

However, proper training for testing whether a steam trap is functioning properly also is a must. It takes a discerning ear to hear and know when a steam trap is properly discharging condensate. When testing a trap by a visual method such as opening a valve to allow the condensate to discharge to the atmosphere, it is critical to know the difference between the appearance of flash steam and live steam.

An early diagnosis of a potential trap problem is an advantage in reducing steam loss. Training a number of pipefitters on the proper techniques may cost far less than a wrong diagnosis that allows a steam trap to blow through. Understanding how the specific trap operates is the first step in troubleshooting steam trap problems. See the section "Troubleshooting Steam Traps" for tips and suggestions.

Scott A. French, P.E., is manager, application engineering, at Armstrong International, 816 Maple St., Three Rivers, MI 49093; (616) 273-1415 e-mail: scott@armstrong-intl.com.