APPLICATION NOTE

Repairing faulty steam traps can bring huge savings

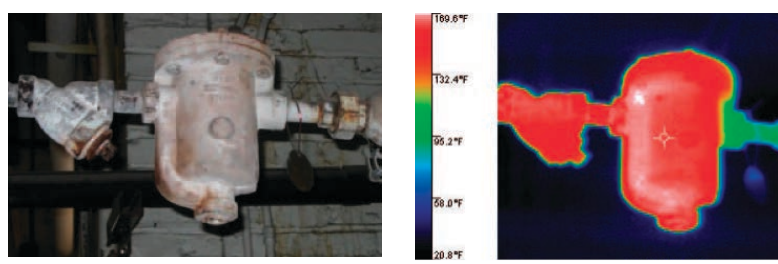
Steam loss from faulty steam traps can cost tens of thousands of dollars per year, and the only way to avoid that loss is to test them several times a year. The traps are often high up, and require the use of catwalks and ladders for access.

Thermal imagers make testing easy from a distance, they allow you to test from the machine room floor. You just point and shoot at your designated target to get an accurate temperature reading and that lets you diagnose whether it is operating properly or needs repair. Infrared cameras are a portable, non-invasive way of monitoring and troubleshooting steam traps and the complete steam system. Finding just one large faulty steam trap can cover the cost of the imager.

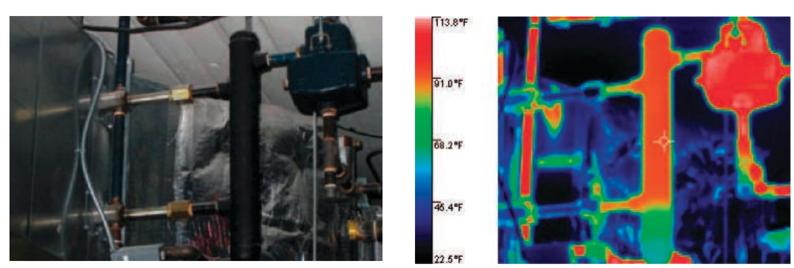
The cost of failure

With no maintenance for three to five years, you can expect 15 % to 30 % of your traps to have failed. So, "blow-by" losses for 60 medium-sized traps are likely to be between $26,100 and $52,200 a year.

In one particular application in the US, thermal imaging of steam lines reduced energy costs by $16,200/year. A Fluke thermal imager showed several problems including six traps not operating properly, steam leaks in plating tank coils and at plating lines, and opportunities for condensate recovery. The traps were replaced at a cost of $500 each, with consequent savings of $3,200 per trap. The energy log at the boiler supply panel was updated before and after the work to ensure the modifications were successful.



When operating correctly as here, steam trap thermal images should show an abrupt change in temperature.



This image shows the steam feed, into the HVAC duct. The feed tube shows condensation in the bottom of the vertical tube.

How steam traps work

Steam is used in a wide variety of applications – to heat raw materials and treat products, power equipment and supply space heating and generate electricity. The U. S. Department of Energy (DoE) estimates that over 45 % of all fuel burned by U.S. manufacturers goes to raise steam.

Steam transports heat efficiently because its latent heat is high, so it holds a large amount of energy, and is easily piped to where it is needed at low costs.

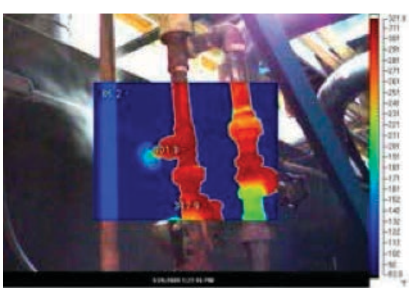
Ideally, the steam raised by the boiler is all transported to the load (the pressure of the saturated steam determines its temperature). There, it gives up its latent heat as it condenses onto the internal surface of the process heater (or heat exchanger). The dry steam can become wet steam, mixed in with condensate still at steam temperature. This is returned to the boiler for re-conversion to steam. The condensate can however collect in the system and cause waterlogging. That can reduce efficiencies and cause water hammer and thermal shocks that damage pipe lines and components.

Any air in the system (particularly at start-up)

Inverted bucket steam traps are often used on larger air handling systems.

also reduces efficiency and, together with any "non-condensable" gases like nitrogen and carbon dioxide, needs to be removed. Steam traps are valves that discharge condensate and air from a steam system without loss of steam. This condensate can be returned to the boiler feedwater tank through condensate headers and pumps, and the air is vented to the atmosphere.

Steam traps can be blocked by dirt in the system, and corroded because of the condensate. If a steam trap fails open it blows live steam, wasting energy and money. If it fails closed, condensate accumulates in the heat transfer equipment and pipelines. That may affect the processing characteristics, and in severe cases can lead to water hammer and mechanical damage to the equipment/pipeline.



Thermal imagers can show many sources of waste - here highlighting heat loss from non-insulated pipes.

A steam trap that is operating normally will have a specific temperature difference at the inlet and at the outlet of the steam trap when the trap is closed. The actual difference will depend on the temperature and pressure of the steam, and the type of trap (see "The different types of steam trap").

The inspection routine

You need to scan every part of the steam system. Scan steam heat exchangers and transmission lines for blockages, underground steam lines for leaks, and boilers (especially their refractories and insulation) and process equipment for any anomalies.

The different types of steam trap

Steam systems can work at pressures between 0 to 1400 psi, and so there are several types to suit the varied pressures and system designs. Thermodynamic traps work based on the changes in fluid pressures as condensate flows through the trap, thermostatic traps on the difference in temperature between steam and its condensate, and mechanical traps using the difference in density between steam and condensate. The following is a greatly simplified explanation of the most common types:

- Conventional **thermodynamic** traps have a disc that is raised at start-up by incoming pressure to release cool condensate and air. Hot condensate flashes below the disc then fills the space above the disc, pushing it down on the seat to close the trap thus preventing loss of live steam.
- **Thermostatic balanced pressure** traps have a small capsule with a liquid/water mixture that boils a few degrees below the saturation temperature of the steam in the system, and expands to close the trap.
- **Thermostatic bi-metal** traps have bimetallic strip(s) that bend to open or close the valve a few degrees below the saturation temperature of the steam in the system, so preventing loss of live steam.
- **Mechanical ball float** traps have a ball float that rises to open the valve when condensate starts to fill a chamber.
- **Mechanical inverted bucket** traps have an inverted bucket that fills with steam as it enters the trap and then rises to close the valve, preventing steam loss. As condensate accumulates in the trap, the bucket drops and opens the valve, allowing the condensate to be discharged.

Many boiler plants distribute hot water to various building systems, and a vibration tester will indicate various pump problems and trend their severity over time.

Inspect traps and all other key steam-system components at least annually, and larger and critical traps more frequently. Comparing current images to previous images will show whether hot or cool spots are unusual, and whether repairs have been successful. Report forms should schedule a follow-up inspection shortly after the repairs, preferably with a date (some thermographers do this on the last Friday of the month).

High-pressure steam can be well above 100 °C (212 °F), so any potential safety risks should be repaired immediately, followed by those affecting production and product quality, and then by steam/energy loss. Document problems using the imager software, including thermal and digital images of the equipment since that is the best way to communicate problems found and to suggest repairs.

Other equipment in the system—particularly motors, fans and pumps—should also be regularly tested. Thermal imagers can help here, too, as can vibration meters.

Testing the traps

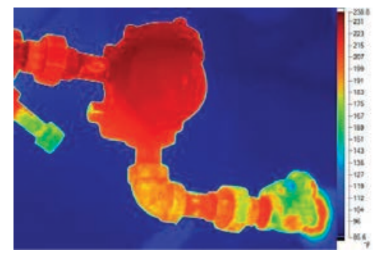
The US DoE program for Steam Trap Performance Assessment recommends "sight, sound and temperature" as the dominant techniques for inspecting steam traps. According to their data, implementing a basic annual inspection of the steam traps and associated equipment with infrared inspections will likely reduce steam losses by 50 % to 75 %.

Thermal imagers display surface temperatures (see "Thermal imagers—what you'll need"). They show how steam systems are operating, and where energy is being wasted. A high inlet temperature and a low outlet temperature (<100 °C or 212 °F) shows the trap is working correctly. If the inlet temperature is significantly lower than the system temperature, steam is not getting to the trap—the trap is not opening due to malfunction of the mechanism or is choked with dirt, or the problem could be upstream—a closed valve, pipe blockage, etc.

If inlet and outlet temperatures are equal, the trap probably failed open with steam being blown into the condensate line. If inlet and outlet temperatures are low, the trap probably failed closed, with condensate filling the trap and inlet line.

Conventionally, steam traps are tested by any one of the following methods:

- **Sound –** using an ultrasonic device that enables the operator to listen to the flow through the trap. The ultrasound receiver can detect leaking traps, or traps that have failed open and are blowing steam. Operators can hear the difference between steam and condensate in the system.
- **Sight –** visual examination—examining the discharge from the trap to see whether it is passing live steam. This can be done by looking at the open discharge from a trap or by using sight glasses upstream or downstream of a trap.
- **Conductivity –** by using conductivity sensors that indicate the presence of condensate held in a chamber upstream of the trap—the absence of condensate indicates that the trap is blowing.
- **Temperature –** by measuring and comparing the temperature at the inlet and outlet of the trap. While these methods are reasonably effective when used by experienced personnel, thermal imaging can be used effectively with a minimal reliance on experience or judgement. You can visit the Fluke website for more information and resources.


Another working steam trap.

Thermal imagers—what you'll need

Thermal imagers are often exposed to dust, dirt, water, chemicals and extreme heat or cold—and therefore need to be rugged or they will not last long. They need to detect a wide temperature range—higher than those used to examine heat loss in buildings.

High resolution is important when imaging across a distance, and will often repay the extra instrument cost in time saved by viewing from the ground. Sensitivity is particularly important when viewing steam traps because high-mass components do not change their temperature quickly when opening or closing.

Imagers should be easy to use with point-and-shoot, single-handed operation, easy focus, hand straps and wrist straps. Features like voice annotation are useful when gloves make data recording difficult.

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