Remote steam trap monitoring techniques: A technical note

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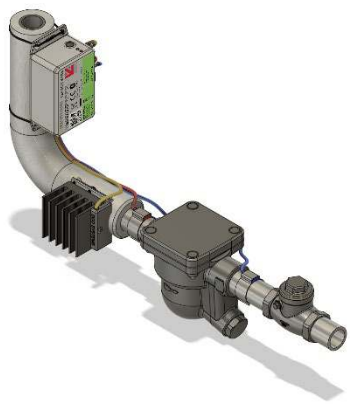
Most sites using steam have a mix of different types of steam trap onsite. Whether from a single manufacturer or several this will often include a mix of different mechanical trap types onsite. Mechanical traps are naturally subject to wear usually leading to one of several distinct failure types; up to 10% of the mechanical traps on a site may fail each year. This introduces obvious issues related to steam loss, safety, operational efficiency, environmental impact and operational costs.



DCO has introduced a remotely accessible, self-contained, steam trap monitoring solution to ensure that steam trap performance data is collected round the clock. Manual on-site monitoring is greatly reduced, and common routine test and measurement tasks are automated. Performance data is analysed in real-time to identify current and historical issues and that analysis is used to schedule maintenance and repair activity in a targeted resource-efficient manner. Costs are reduced through reduction of faults, improve of efficiency and automation of manual monitoring work.

The techniques used to assess steam trap performance are well understand and have be in common use for decades. This technical note will describe those techniques and how they are utilised in the DCO solution.

Monitoring and test requirements

A steam using site needs to know that the system is operating safely and efficiently. Steam traps are vital to that operation, providing for the removal of condensate and non-condensable gases from the steam system. Regular monitoring of their performance is required to ensure that steam traps remain operational, that there are no steam leaks and that no "cold" traps are present that could lead to excessive condensate build-up.

Avoiding leaks in the steam system is important to ensure that the system runs efficiently and effectively. Lost steam represents wasted fuel and money, with many sites still using non-renewable fuels it is also a source of excessive and unnecessary CO^2 emissions.

If condensate (stream that has condensed back to liquid water) is not drained correctly from steam pipework it can impact on equipment operation and lead to water hammer. Excessive condensate building up near steam consuming equipment can prevent it working properly by restricting the supply of steam. Water hammer (condensate being driven at high speed by the flow of steam) and has the potential to seriously damage pipes and equipment attached to the steam supply, even at low levels it can be a significant source of long-term reliability problems.

The traditional approach

The traditional approach to assessing steam trap performance is well established but is labour intensive and requires considerable time to undertake on a large scale.

In most environments the monitoring of steam traps is still undertaken as a manual process. It is most common for engineers to assess pipework using a temperature probe or thermal imaging which can be used to determine some types of faults. Where sites undertake a survey of steam trap condition, they will generally utilise an ultrasound probe that can be used to detect the presence of steam and condensate in pipework. Ultrasound probes generally translate the ultrasound present in pipework into a visual display or reduce the frequency of the audio signal to something in the range of human hearing. In both cases the use of ultrasound probes generally requires a trained operator who can recognise the signature of different types of traps, of different failure conditions and of a correctly operating trap.

An updated approach

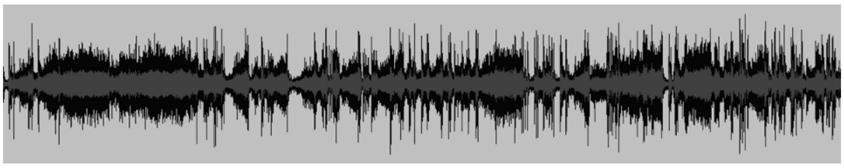
DCO has used its autonomous energy harvesting sensor technology to create a solution that is highly targeted at the requirements of steam trap monitoring. Providing a remotely accessible, self-contained, steam trap monitoring solution that collects and analyses trap performance data around the clock. Enabling the remote monitoring of steam trap performance with real-time notifications and alerts for performance and safety issues.

Characterising trap failures automatically

As previously noted, most trap faults are diagnosed through a combination of temperature and ultrasound analysis. Automating the actions of the human operator in this process is non-trivial but possible with sufficient understanding of the characteristic behaviours of each type of trap. While the monitor can try and infer the type of steam trap from the behaviours it sees, the most reliable results are found when the monitor is explicitly configured with the type of trap in use. Configuration on deployment permits the unit to immediately implement the most effective profiling methods.

Float (or Float & Thermostatic)

Detection: Steady flow response of trap means the primary monitoring mechanism for failure modes (other than "cold trap") is ultrasound.



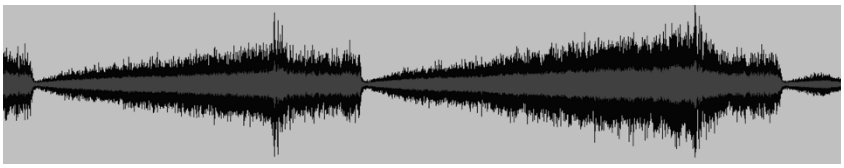
Normal operation: Usually a steady modulating flow of condensate as the float element of the trap reacts to condensate level. Usually these traps have a thermostatic element and periodic discharge from that can also be expected, often on start-up due to air or other non-condensable gases in the system.

Failed open: No modulation or variation is present, instead constant operation with non-stop discharge of steam to the condensate system.

Failed closed: No condensate or steam flow, see: *"Cold trap failures"*

Inverted bucket

Detection: Operational cycles detectable through temperature spikes but delayed temperature response of pipework means the primary monitoring mechanism is ultrasound.



Normal operation: A distinct open-close cycle. The interval between each cycle is dependent on the load on the trap. Measurement of time intervals allows the monitor to estimate the current condensate load if design parameters are known.

Failed open: The open-close cycle not present, instead constant operation with non-stop discharge of steam to the condensate system.

Failed closed: No condensate or steam flow, see: *"Cold trap failures"*

Staged orifice / Venturi traps

Detection: Trap has a steady flow response as the condensate load varies. Most installations specified to very specific temperature and pressure ranges so temperature effective monitoring technique. Ultrasound monitoring can verify normal operation in the condensate outflow.

Normal operation: Usually a steady flow of condensate as the trap reacts to changes in condensate flow, with the point at which condensate flashes into steam migrating between venturi stages as the load varies.

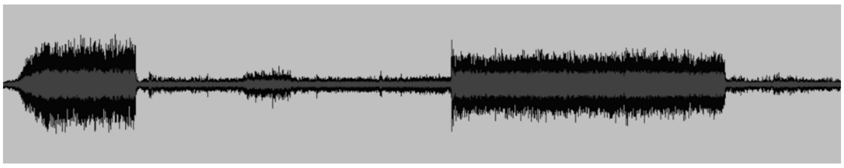
Failed open: These trap types have no moving parts so cannot fail open in normal operation. However, if incorrectly specified or installed they may show steam loss characteristics as the venturi stages will not be correctly matched to the condensate load.

Failed closed: No condensate or flash steam flow, see: *"Cold trap failures"*

Thermodynamic

Detection: Operational cycles and flow of condensate or steam detectable through temperature spikes and ultrasound but the distinctive operation of a thermodynamic trap means a key monitoring mechanism is sound.

Normal operation: Distinct clicks from the open-close cycle of the disc detectable both as sound and as temperature spikes on the condensate outlet.



Steam leakage: Distinct click cycle normally replaced by a more regular rattling as the disk no longer seats properly. Constant low flow of steam to condensate line.

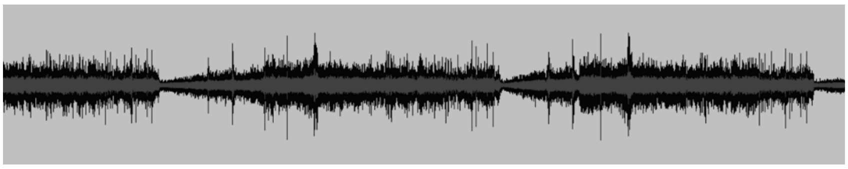
Failed open: The open-close cycle not present, instead constant operation with non-stop discharge of steam to the condensate system.

Failed closed: No condensate or steam flow, see: *"Cold trap failures"*

Notes: Thermodynamic traps are more susceptible to environmental effects on their operation (notably any significant cooling of the control chamber) so importance of accurate environmental data is raised.

Thermostatic

Detection: Operational cycles and flow of condensate or steam detectable through temperature spikes and ultrasound.



Normal operation: A distinct open-close cycle. The interval between each cycle is dependent on the load on the trap. Measurement of time intervals allows the monitor to estimate the current condensate load if design parameters are known. Time between discharges may vary widely between long intervals and short ones.

Failed open: The open-close cycle not present, instead constant operation with non-stop discharge of steam to the condensate system.

Failed closed: No condensate or steam flow, see: *"Cold trap failures"*

Cold trap failures

Cold trap failures are diagnosed initially through temperature monitoring in all trap types. In most failure scenarios the temperature of the steam side of the trap will fall below the operational temperature as condensate builds up in the trap and in the pipework ahead of it. In most scenarios the temperature on the condensate side of the trap will also drop as there is no condensate flowing to heat the pipework. There are variations in measurement that need to be catered for – e.g. if no non-return valve is installed (or it has failed) condensate from elsewhere can flow to the condensate side of the trap and raise the temperature at that point.

Temperature measurement is a particularly effective and rapid way of diagnosing traps that have failed shut. Traps that are leaking steam tend to attract more attention, but closed traps are a more significant source of safety and reliability issues. They prevent the effective removal of condensate from a system and allow it to build-up to levels that leads to water hammer with detrimental impact on equipment reliability and possibility of serious failure. A trap that is gradually failing shut will usually show a distinct and recognisable change in temperature profile over time that identifies impending failure and allows remedial action to be taken before it fails completely.

Failed closed traps are more easily missed in manual monitoring due to the long intervals between measurements and the possibility that assessment may not always align with the operational period of the trap. Drip leg traps are particularly prone to be being missed for such checks as they are often smaller and frequently hidden away or hard to access than larger process equipment traps.

Dealing with doubt

In the vast majority of cases automation can determine the operational status of traps with a high degree of confidence but there will always be "edge cases" where there is doubt over trap behaviour and symptoms. Where confidence is low the monitoring solution can flag areas of doubt. It can capture additional data and expose lower level data (e.g. ultrasound) as visualisations to an operator. In installations with high value traps (high loading, critical functions, etc.) monitors can be augmented with thermal and visual imaging capabilities to allow remote visual viewing by staff.

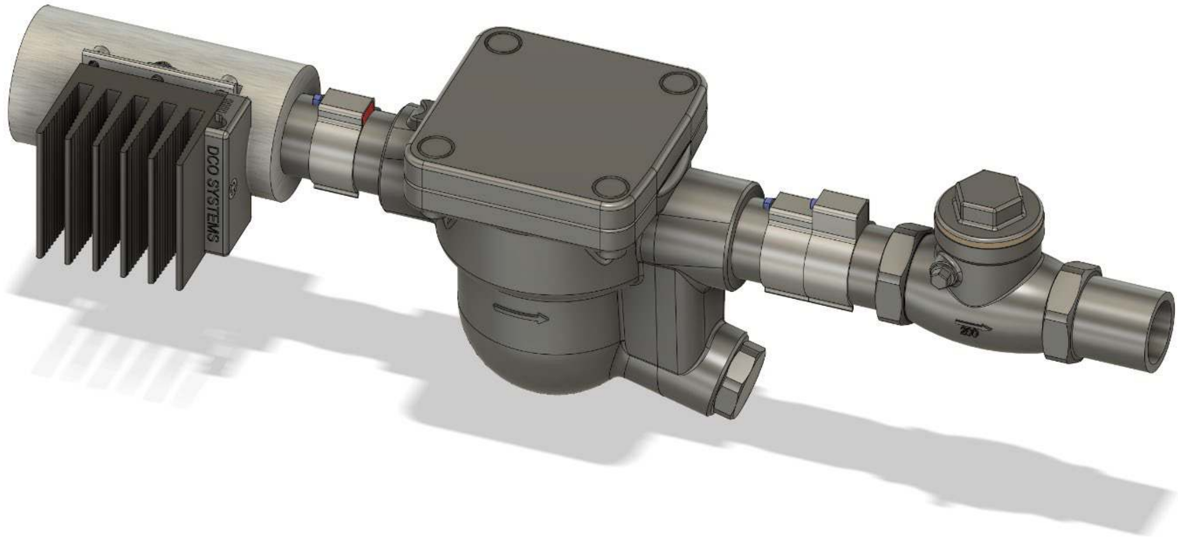
Integrating local knowledge

Engineering staff and maintenance personnel may have knowledge of plant conditions, changes, and upgrades unknown to the monitoring solution. This needs to be integrated into the monitoring framework to allow all system knowledge to be seen in context. Dashboard users can update and revise the parameters used for sensing, they can trigger measurement calibration when equipment and plant is changed, and they can annotate data and measurements with additional knowledge as and when needed.

Simplifying installation and management

Since traps are often found in difficult and inaccessible locations low maintenance is important. The updated monitoring solution achieves this by eliminating the requirements for communications/power cabling installation and for regular battery maintenance.

Each installed monitoring unit has a power harvesting module included that provides a local source of energy derived from high temperature pipework (condensate or steam). These power sources may be constant or intermittent and the monitoring unit adapts to fit available power. On-board control and analysis software allow the solution to dynamically assess the measurements currently required for each trap failure scenario. The unit can then balance the power demands of different sensors in real-time, while delivering the specific reporting requirements (e.g. duration between reports) configured. Each unit will also optimise its use of power dynamically to suit operational conditions – for example reducing sensing if the local steam system is off and less energy is available for harvesting.



Combining data for accuracy

To provide the most accurate, reliable, and repeatable information steam trap monitors will use multiple data points to determine current states. In-built monitoring intelligence allows anomalies in one area to trigger further monitoring and analysis by different types of physical sensing.

Measurements from around the trap are combined with measurements from other parts of the system to ensure that alerts and notifications accurately reflect trap status – upstream monitoring is used to determine steam mainline temperatures while monitoring adjacent to valves and control units provides indications of whether a trap is active or not.

Time is data

A key advantage of automated monitoring with many data points is that time itself becomes a usable data point. Identification of patterns over longer periods of time, than normally possible with manual measurement, aids delivering accurate notifications and alerts. Knowing system status over time helps prevent false warnings during transient events such as system start-up and shutdown. Patterns of behaviour over time become an aid to diagnosis – a significant benefit of automated monitoring is collecting data all the time. There is no possibility of missing a data point just because no manual monitoring was in place at that point in time.

Understand the monitoring environment

Measurement of the environment, particularly temperature and humidity at sufficient accuracy enables the detection of anomalies in the local environment – variations in the local environment of each sensing units, particularly in enclosed environments, can be used to determine the presence of leaks and variations in measurements between units can be used to localise the probable location of those leaks. DCO steam trap monitors include environmental monitoring features and data sets as standard.

Approach benefits

Manual on-site monitoring is greatly reduced and the need for personnel to routinely check traps in inaccessible and hazardous locations is eliminated. Performance data is analysed in real-time to identify current and historical issues and that analysis is used to schedule maintenance and repair activity in a targeted resource-efficient manner.

Further information

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