Technology Assisted Steam Trap Diagnostic Program

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Collect, record and do further spectral analysis of the different types of steam traps with acoustic ultrasound

A portion of all the generated steam produced at the boiler house is commonly lost in the distribution system. Failing steam traps largely contribute to this energy loss as well as other safety issues. The implementation of acoustic ultrasound as a diagnostic tool will highly improve your system reliability and supply real information about the system behavior leading to facilities betterment.

Technology Assisted Steam Trap Diagnostic Program

COLLECT, RECORD AND DO FURTHER SPECTRAL ANALYSIS OF THE DIFFERENT TYPES OF STEAM TRAPS WITH ACOUSTIC ULTRASOUND

Background

Facilities around the world utilize steam as an integral utility for their manufacturing and heating processes. Steam, the pure gaseous state of water, as an industrial fluid, has many benefits and uses. It is clean, easily controlled and efficient. Common uses include heat transfer for space heating, humidification and sterilization for the manufacturing industries, hospitals, universities, and many more.

An important steam system component is a steam trap. Unfortunately, some steam traps fail-open at some point in their life cycle, leaking dry steam, costing thousands of dollars per year.

According to the US Department of Energy (DOE), 15-20% of the steam produced by a central boiler plant is lost via leaking steam traps, in a typical space heating system without a proactive trap assessment program.

Implementing a ***technology assisted steam trap diagnostic program*** not only will provide dollar savings, but will also improve the safety of the facility and the quality of the steam delivered to steam utilizing components. Steam conservation yields energy savings as well as water conservation and reduced boiler emissions.

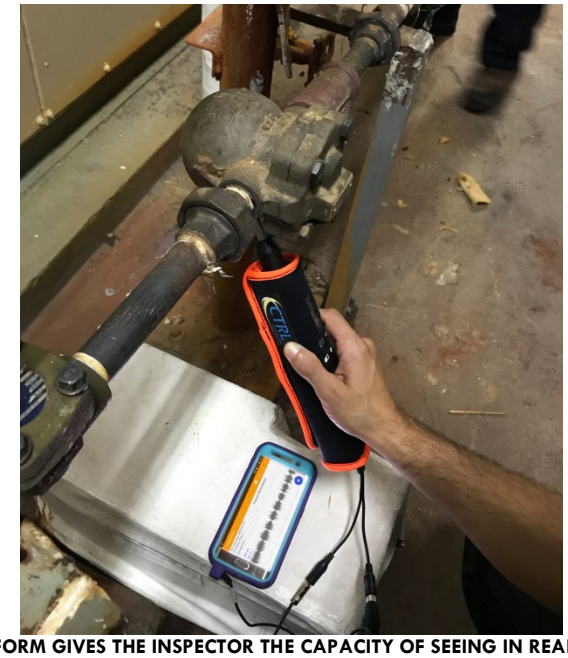

FIGURE 1: THE UL101 AND INCTRL PLATFORM GIVES THE INSPECTOR THE CAPACITY OF SEEING IN REAL TIME THE GRAPHIC REPRESENTATION OF THE BEHAVIOR OF EVERY TYPE OF STEAM TRAP

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What is a Steam Trap and why are they essential?

A steam trap is an automatic valve that differentiates between steam and condensate, closing in the presence of steam and opening in presence of condensate. A steam trap should remove air and uncondensable gases as well as handle fluctuating loads.

When steam comes in contact with a heat transfer surface, this fluid(steam) will no longer be able to remain in a gas phase and will become condensate (liquid phase). This is where the critical role of the steam trap comes into play, allowing the removal of condensate for the proper distribution and utilization of the steam. A steam system will not be able to operate adequately without a steam trap, the system will either flood if condensate accumulates, or not reach the desired pressure (losses) if the valve is open. Common locations for these devices include drip legs in the steam distribution header and heat transfer components like water heaters, kettles and autoclaves.

FIGURE 2: STEAM TRAPS ARE FUNDAMENTAL FOR A RELIABLE OPERATION OF THE STEAM SYSTEMS, PREVENTING ENERGY LOSSES, FLOODING, AND WATER HAMMER

- **Energy Savings**

Most steam trap technologies discharge through an internal orifice meant to regulate the condensate removal function. When a steam trap fails-open, steam will leak out, pressurizing the condensate recovery system or vent to atmosphere resulting in significant energy losses. In either scenario, leaky traps will adversely affect the steam system pressure, causing the fuel and electricity consuming boiler to operate at higher firing rates than needed. The steam boiler will need to compensate for the steam leaks while attempting to provide end users with their steam flow needs.

- **Safety**

Steam systems distribution headers rely on drip legs fitted with steam traps for the purpose of condensate removal. It is important to remove water from steam headers as quickly as possible to preserve steam quality and for safety reasons. A fail-closed steam trap renders the drip leg inoperable and will allow condensate to build up in that portion of the steam header. This scenario will cause the drip legs downstream, of the failed drip pocket, to accumulate excess condensate which can lead to dangerous water hammer, potentially leading to a safety threat to plant assets and personnel. Water hammer is caused by slugs of condensate traveling at high speeds inside the steam header piping. When these slugs come in contact with elbows, valves and other piping auxiliaries, the results can be destructive. Costly shutdowns and repairs are not uncommon if multiple fail-closed steam traps are allowed to accumulate on a main steam header.

- **Process Equipment Uptime and Longevity**

Steam quality is of utmost importance when evaluating the efficiency of a steam system. Effective use of steam traps will allow dry, saturated steam to reach its destination providing the highest available BTU content. Additionally, the buildup of condensate will reduce the efficiency of heat exchangers by creating a film (insulation effect) inside the heat transfer area. Another effect of excess water in steam headers, is a wire-drawing effect on control valves and pressure regulators which significantly reduces the performance and longevity of these plant assets.

Airborne/Structure borne Ultrasound

ISO 29821-1:2011 establish that Airborne/Structure Borne (A&SB) Ultrasound can be used to detect abnormal performance or machine anomalies. The anomalies which are detected are high-frequency acoustic events caused by turbulent flow, ionization events, and friction, which are caused, in turn, by incorrect machinery operation, leaks, improper lubrication, worn components or electrical discharges. A&SB ultrasound is based on measuring the high-frequency sound that is generated by turbulent flow, by friction or by the ionization created from the anomalies. Because of this statement the inspector therefore requires an understanding of ultrasound and how it propagates through the atmosphere and through structures as a prerequisite to the implementation of an A&SB ultrasound program.

So how do the fluid conditions in a steam trap generates ultrasound? The key word is “turbulence”, and to understand it we have to discuss fluid velocity. When there is a velocity gradient between two moving particles, in other words one moving faster than the other, frictional forces acting tangentially to the same are developed.

The friction forces try to introduce rotation between the moving particles, but simultaneously the viscosity tries to prevent that rotation. Depending on the relative value of these forces, different flow states may occur.

When the velocity gradient is low, the inertial force is greater than friction, the particles move but do not rotate, or do so but with very little energy, the end result is a movement in which the particles follow definite trajectories and all particles passing through a point in the field of flow follow the same path. This type of flow is called "laminar", meaning that the particles move in the form of layers or sheets.

As the velocity gradient increases, the friction between particles next to the fluid increases, and they acquire an appreciable rotational energy, the viscosity loses its effect, and because of the rotation the particles change trajectory. As they pass from one trajectory to another the particles collide with each other and change their course erratically. This type of flow is called "turbulent". Due to the valve/orifice operation of the steam traps turbulent flow is present and can be used to determine its health.

Three widely used categories of Steam Traps

Thermodynamic Steam Traps

The Thermodynamic "Disc" type trap operation is driven by the dynamic effect of flash steam. When sub-cooled condensate enters the steam trap cavity, the pressure lifts the disc of the seat and allows condensate (and air) to pass through and flow out of the steam trap. The pressure drop and increased velocity produced by the flow of condensate through the trap internals will cause some condensate to flash into steam. The higher velocity on the outlet port will draw the disc to snap close against the seating surface, while the flash steam pressure buildup inside the chamber on top of the disc will force it down against the incoming condensate. At some point, the trap upper chamber will cool and cause the flash steam to condense, lowering the pressure on top of the disc. The incoming condensate will now be able to lift the disc and repeat the cycle.

This trap's operation is quite repeatable, making diagnostics fairly simple in most cases, because the inspector expects to differentiate the opening – close operation of the trap. It is not uncommon for this type of steam trap to cycle up to ten times per minute. As the steam trap's internals begin to deteriorate, the device will begin to emanate a sound akin to an "automatic gun" (chattering) indicating a need for the device to be repaired or replaced as soon as possible.

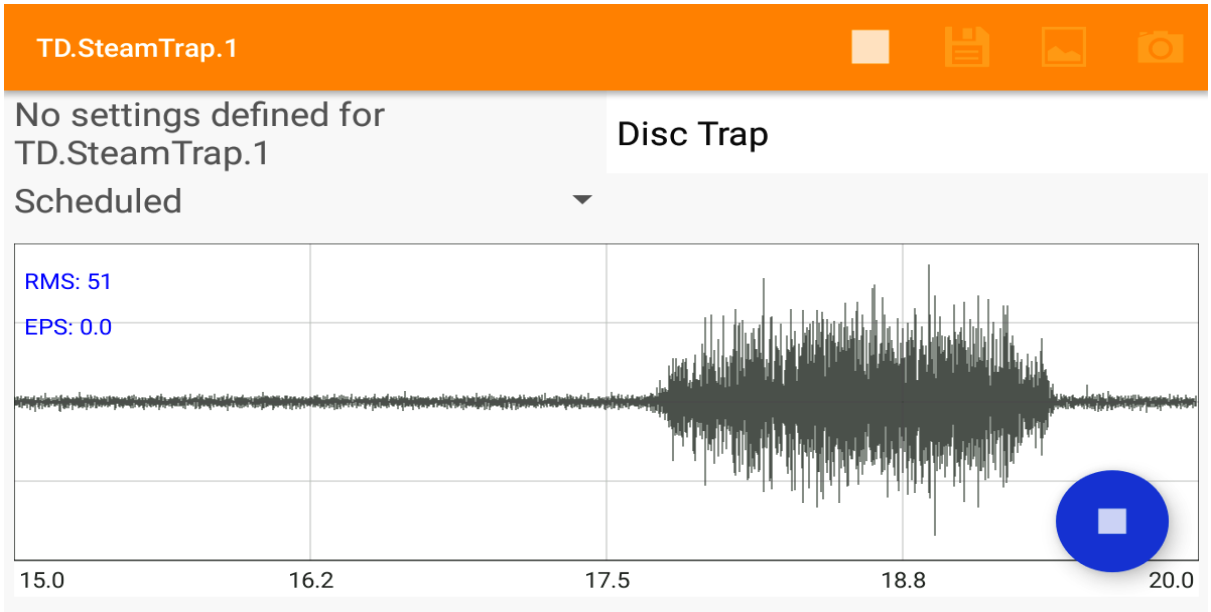

FIGURE 3: FOR DIAGNOSING A GOOD DISC STEAM TRAP THE INSPECTOR SHOULD CLEARLY SEE THE CLOSED – DISCHARGE – CLOSED CYCLE, IS A GOOD IDEA TO MONITOR THE AMPLITUDE OF THE ULTRASONIC SIGNAL IN THE CLOSED POSITION FOR DETERMINING ITS TIGHTNESS LEVEL

Mechanical - Float and Thermostatic Trap (F&T):

With the use of a float assisted mechanism, this trap technology modulates the condensate discharge, providing a continual flow equal to the condensing rate. This feature is advantageous to avoid condensate accumulation and makes this trap technology the trap of choice for steam utilization applications such as heat exchangers.

The continuous discharge characteristic however, creates a challenge for diagnostic purposes to a surveyor. If condensate is being discharged at the same rate it is being produced, this means the outlet temperature will be very similar to the saturated steam temperature, thus, from a temperature analysis perspective, the surveyor will not be able diagnose a fail-opened steam trap with accuracy. Furthermore, from an acoustic-ultrasound diagnostics perspective, the steam trap discharge (a mixture of condensate and flash steam) will generate a continuous sound very similar to a fail-opened steam trap.

If any modulation at all is heard or visualized using InCTRL, this indicates that the trap is operating properly. In the event continuous rushing sound is heard, the steam trap most likely has fail-opened. Since an F&T steam trap is composed of a float assisted orifice mechanism and a thermostatic air vent, it is important to consider the operation of each of these devices when surveying the steam trap. For example, the float mechanism typically will fail in a closed position while the thermostatic element will fail in an open position. It is imperative for the surveyor to differentiate between flash steam and live steam and their corresponding operation acoustics.

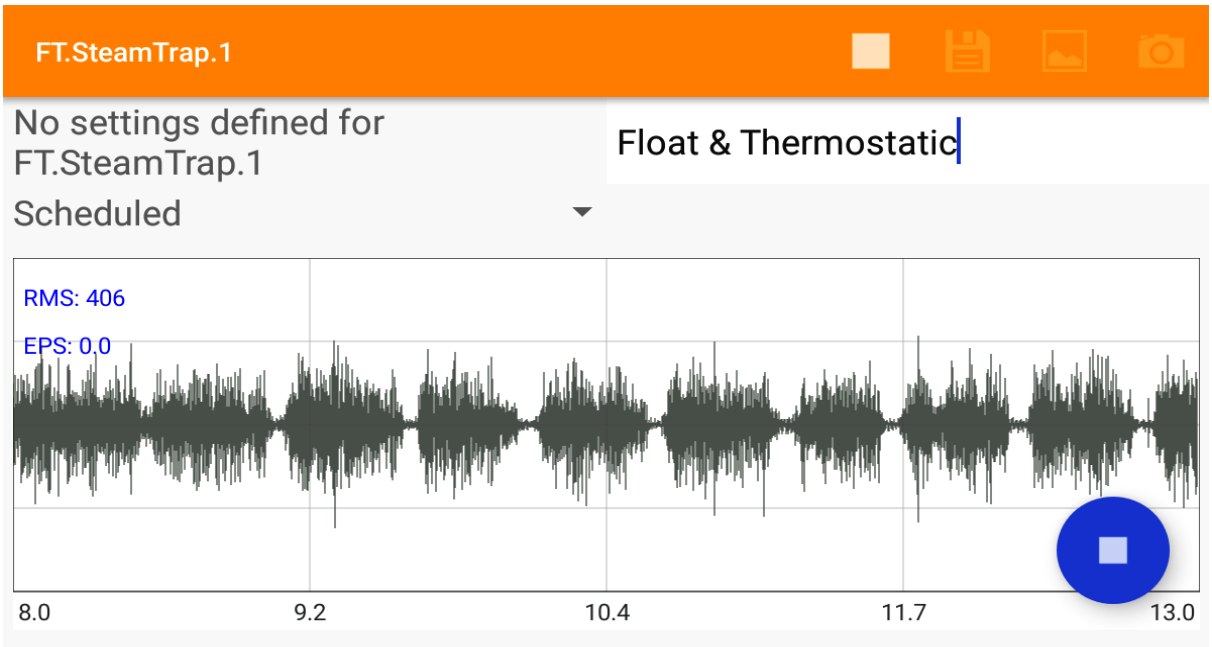

FIGURE 4: INCTRL CAN HELP THE INSPECTOR TO DETERMINE IF A F&T STEAM TRAP IS MODULATING OR NOT BY SHOWING THE CONTINUOUS EFFECT OF THE FLOAT ON THE FLOW, IF THE TRAP FAILS IN A CLOSED POSITION THE ISNPECTOR WILL SEE NO ACOUSTIC SIGNAL AND IF IT FAIL IN AN OPEN POSITION THE INSPECTOR WILL SEE A HIGH SUSTAINED AMPLITUDE SIGNAL DURING ALL THE SAMPLE

Mechanical – Inverted Bucket:

"Bucket Traps", as commonly referred, operate by using a bucket like device inside of the trap cavity. The cavity must be full of condensate for the trap to operate properly. Steam enters through the bottom of the bucket, causing it to lift upwards and seal the valve against the valve seat. As condensate flows into the bucket, the weight of the bucket will drive the valve down away from the valve seat, allowing the trap to discharge. The bucket has a small vent to discharge air and uncondensable gases. As the bucket's lifting or dropping movement opens and closes the valve, the ultrasonic inspector should expect to hear the turbulence to appear and disappear simultaneously.

Another thing to consider when inspecting this type of steam trap is the pivoting linkage between the bucket and the valve; this linkage can be worn out and is specifically weak against vibration. If the inspector hears a continuous rushing sound accompanied with metallic pounding, the inspector can conclude the trap is having a linkage problem.

FIGURE 5: BECAUSE OF ULTRASOUND DIRECTIONALITY BY TOUCHING THE BODY OF THE INVERTED BUCKET STEAM TRAP THE INSPECTOR CAN DETERMINE IF THE CAUSE OF THE FAILURE IS A LINKAGE PROBLEM

Thermostatic Steam Traps

Thermostatic steam traps operate by sensing the difference in temperature between hot steam and colder sub-cooled condensate. Valve actuation occurs via the use of a bi-metallic element or liquid-filled bellow. The degree of sub-cooling must be considered to assure condensate is removed as needed.

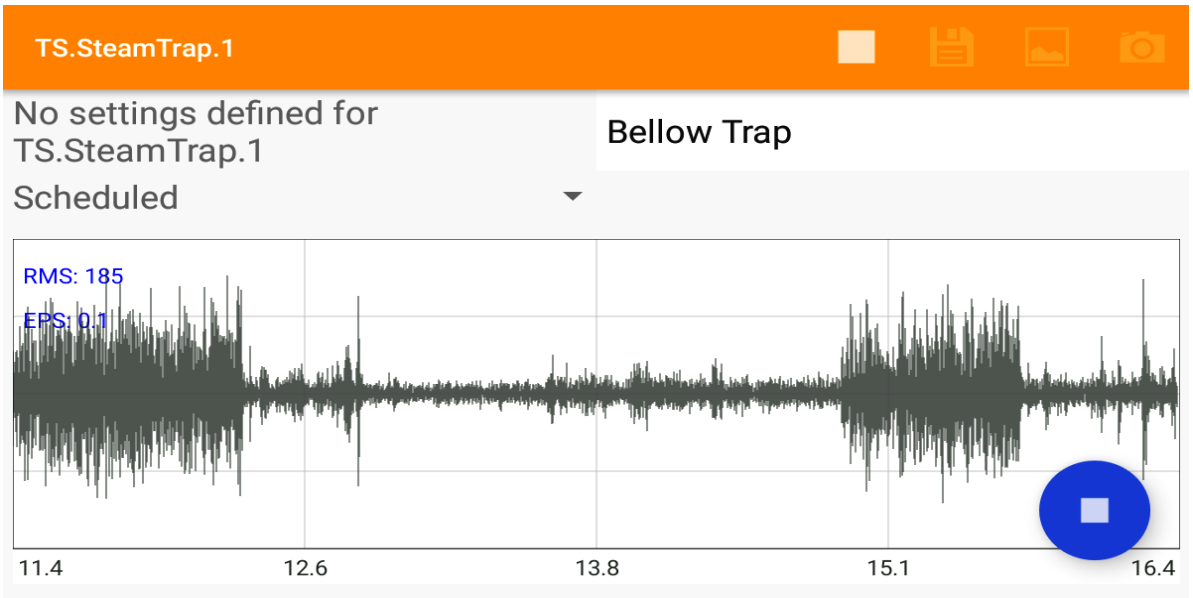

FIGURE 6: THERMOSTATIC STEAAM TRAP HAVE A CYCLING OPERATION AND TO DETERMINE IF THE ARE WORKING PROPERLY THE INSPECTOR SHOULD SEE IN THE SPECTRUM HAVE TO SHOW WHEN THE TRAP IS IN OPEN OR CLOSED POSITION

Conclusion

Steam trap surveys will indicate if the steam traps are operating as expected or diagnose if the trap failed in an open or closed position. Common diagnostic methods include Visual, Temperature, Acoustic and recently Continuous Monitoring. It is desirable that the inspector have experience in steam systems due to several operative considerations that require understanding the difference between live and flash steam, or knowing the different operation modes of each type of steam trap. The lack of this knowledge and expertise will lead to a weak survey with misdiagnosed assets.

The waveform analysis of the steam trap acoustic ultrasound is an excellent way of keeping evidence of the health status of the steam trap during the survey by way of giving the ability to hear again the inspected asset as many times as needed. If using InCTRL this can be done remotely, by contributing to have multisite assessment documented.

Assuring your steam utilities are as optimized as possible is paramount to the competitiveness most companies strive for these days, an effort that pays for itself.

CTRL Systems Inc. has more than 25 years supplying the civil and military industry with the lightest, sensitive, enduring and friendly Airborne Ultrasound Receivers, if you wish to receive more information about this and other applications do not hesitate in contacting us.

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