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Control Steam System Energy Costs

Steam system losses can silently drain profits

By Ven V. Venkatesan, Energy Columnist

OPERATING AND maintaining a reliable steam system is vital to chemical processing plants and can have significant cost impact on a plant's annual budget. Typical profit drainers in operating and maintaining a steam system include excessive fuel cost, inefficient steam generation, less-than-optimal steam utilization and poor condensate recovery. Ensuring adequate supply of steam often results in excessive capacity usage, expensive fuel choices or condensate draining to grade, leading to compromised efficiency levels and higher steam cost. Because steam system dependency is unavoidable, addressing those three issues is crucial to minimizing steam costs.

Optimize steam generation capacity. A chemical processing plant in upstate New York operated all six of its boilers to meet its frequently surging steam demand. After analyzing the normal and peak steam demands of its several processing buildings, engineers concluded that one boiler could be stopped during the day with the help of a steam

demand controller and another during the night shift. Successful results from multiple trials stopping one boiler during the night shift paved the way for operating personnel to stop the second boiler during the day.

The necessity to review steam demand may arise when a plant expands its capacity or adds another steam-dependent processing unit. In such cases, a new steam demand analysis combining the existing and additional steam demands may help optimize new boiler capacity to meet the increased demand. It even may be possible to avoid a new boiler addition.

Optimize fuel choice. Steam costs highly depend upon the cost of fuel fired in the boiler. Typically, fuel prices increase from low-grade fuels such as biomass, to medium-grade fuels like coal, to higher-grade petroleum fuels such as oil and LPG. Natural gas prices usually fall between medium- and higher-grade fuel costs. Most chemical processing plants in



the United States use natural gas to fuel their boilers. A few plants use coal-fired boilers to meet steam demand, while very few use biomass as their fuel and those that do must modify their boilers accordingly.

The project cost of installing boilers also increases as the fuel choice moves from gaseous fuels to liquids, solids and biomass fuels. In addition, steam generation cost significantly depends upon the plant's location and the availability, and market prices, of fuels. Predicting fuel supply price changes long term is very difficult, so, one way to optimize steam cost is to retrofit or modify the boilers' burners or combustion systems to fire multiple fuels.

Some plants generate rejects or unusable and unmarketable byproduct streams. Retrofitting boiler burners to fire those waste streams as fuel could help reduce steam costs. Hence, it's worth investing in multiple fuel-fired boiler systems in all medium- and large-sized chemical processing plants.

Improve condensate return systems. Processes critically dependent on steam heating must have reliable condensate removal. Condensate backing up inside the heat transfer equipment (due to stalling, excessive backpressure in the return piping or water hammer problems) should be drained to grade to avoid interruptions in steam heating. Properly sizing the condensate return piping and providing appropriate flash separation from steam condensate is an essential requirement of a condensate return system. However, properly sized return piping could become under-sized when more condensate sources are connected to it, or excessive flash steam generation occurs in the return piping due to operational changes of the steam-heated equipment.

Because the immediate option to maintain steam heating is to waste the condensate by draining it to grade, personnel should alert management to the monetary losses associated with condensate drain. If not addressed, steam cost will remain high and profits will drain silently.

Utilize waste heat for steam generation. Most plants have waste gas incinerators operating continuously to burn off toxic and other waste gases from the process. Because these waste gas stream flows occur occasionally and mostly in small quantities, fuel always is firing the incinerator beds to maintain the incineration temperature. In some plants, this fuel firing almost equals the consumption of a small- or medium-sized boiler. Hence, it's worth exploring waste-heat steam generation from incinerators or heaters that exhaust the flue gases to stacks at temperatures above 400°F.

PIPING MATTERS

More opportunities exist in other parts of the system, in particular, the large network of pipelines, valves and other fittings that are possible sources of heat energy loss. In addition, the steam distribution system requires devices to collect condensate, keep steam dry and control its flow and required pressure level. If these devices aren't designed and maintained properly, the energy loss could be substantial.

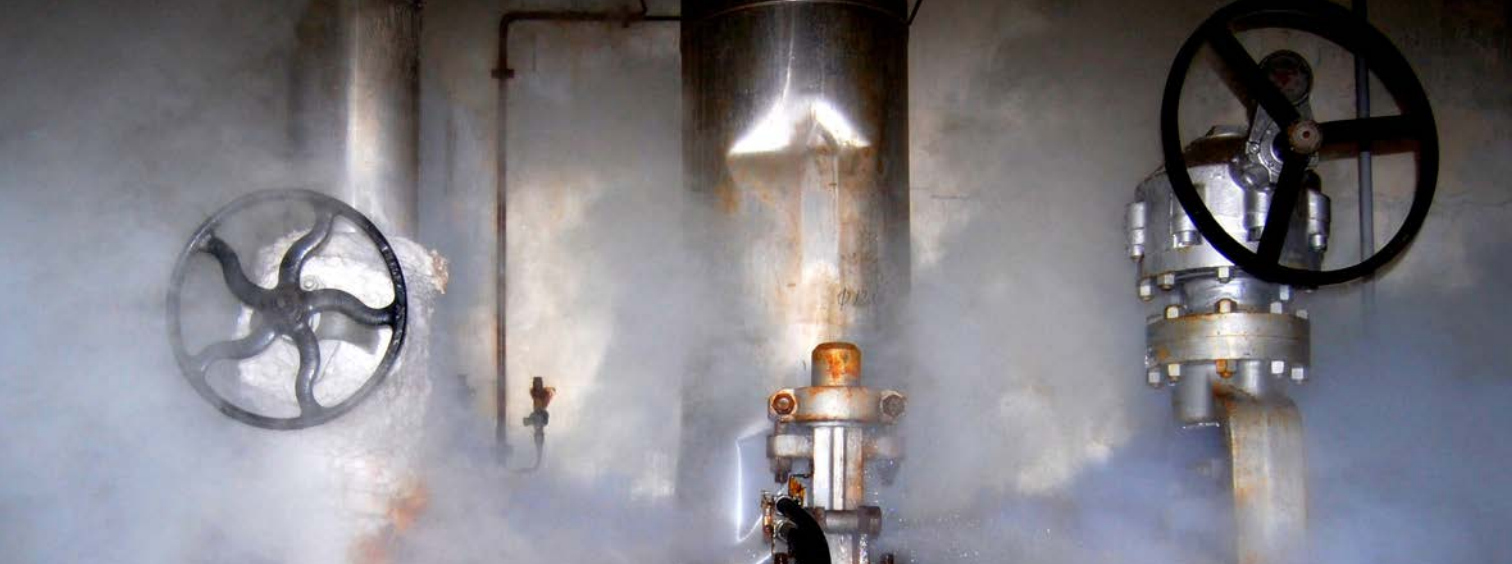
A steam distribution system collects steam from boilers, waste heat boilers and steam turbine exhausts. In multiple-pressure-header steam systems, the lower-pressure-level headers automatically collect steam from the higher-pressure headers through letdown valves. As steam travels through various pressure-level pipelines to the point of use, it loses some of its heat and energy content, resulting in condensate formation.

For plants with sections of steam distribution piping outdoors, energy and process engineers can monitor



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steam demand change when it rains to quickly assess losses due to poor pipe insulation. One chemical processing complex in West Virginia with widely distributed steam distribution piping reported a 5,000-lb/hr steam surge whenever it rained. Losses likely occur even when it doesn't rain and go up during the winter months. Hence, it's worth conducting an insulation survey at least once every three years and fixing any damaged or exposed hot surfaces. Providing insulation blankets is preferable for pipe sections and fittings, especially those located outdoors, that require periodic removal for maintenance.

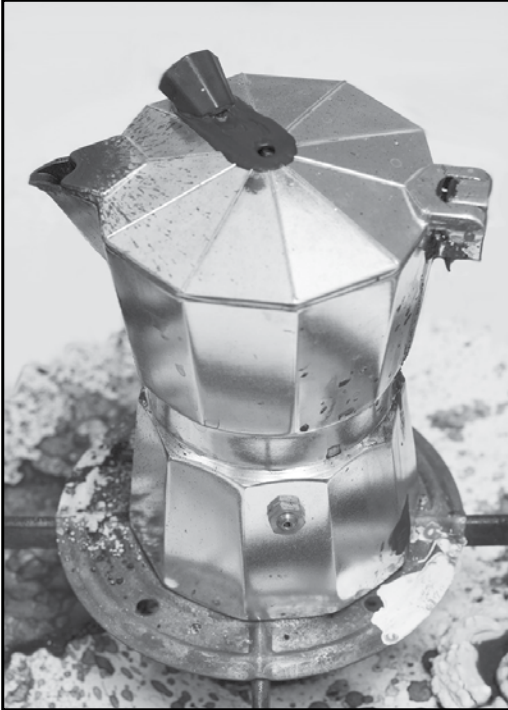
Steam's thermodynamic properties offer some design challenges in transporting heat to multiple locations. Because heat loss can quickly transform steam into a bi-phase fluid, it's important to take extra care when designing the steam distribution piping. To ensure dry steam supply and steam flow free from water hammer, the condensate formed in steam lines should be removed at appropriate sections of the steam distribution piping. Piping should slope downward in the flow direction and include drip legs at sufficient distances and before each rising section of pipe. Each drip leg should include a steam trap to drain out the collected condensate, ensuring dry steam delivery. Typically, these requirements should be addressed during the design stage. However, I find missing drip legs, inadequately sized drip legs and drip legs without steam traps in more than 90% of the plants I visit. Both wet steam supply and water hammer — resulting from an absence of steam traps or cold-plugged steam traps — lead to condensate accumulation that can slow down the heating of the process and cause plant stoppages. Hence, plant engineers shouldn't think only leaking steam traps cause energy losses. An annual steam trap survey and fixing failed steam traps is an essential requirement that shouldn't be compromised when management trims budgets.

Steam leaks and condensate drains are visible profit drainers in a steam distribution system. Instead of accepting them as low-priority housekeeping issues, fix them as soon as they are noticed. High-pressure superheated steam leaks generally aren't visible and pose a safety risk to personnel. They might be worth fixing, even if "on-line" leak repair is the only option. If plant engineers have the option to review the design of new or extended steam distribution systems, they should consider providing enough isolation valves, by identifying and classifying critical maintenance-prone sections.

Periodic steam system audits should be a routine part of the plant engineer's cost optimization plan. Audits typically focus on finding any steam, condensate or heat losses and verifying the correct operation of the steam-heated equipment. Because of the higher temperature of steam and condensate, steam distribution systems are ideal subjects for inspection with infrared (IR) test instruments. Thermal imaging IR cameras are now available at affordable prices and provide temperature information across a wide field of view. Even if a steam leak occurs inside an enclosed object, such as a steam trap, it can be detected easily by an IR camera. Thermal imagers also can be used to identify hot spots on steam handling equipment with broken or damaged insulation. (For more on thermal imagers, see: "Use Thermal Imagery for Process Problems," www.ChemicalProcessing.com/articles/2009/202/.)

According to a U.S. Department of Energy survey, steam accounts for one-third of all the energy used in process plants. Monitoring and optimizing the cost of your steam system can yield big rewards. Ignoring inefficient operation easily could drain profits. ●

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Unidentified condensate in steam systems can result in a range of issues from process inefficiencies to equipment failure and safety issues. If only I had more visibility into the health of my steam traps.

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Real-time Monitoring Picks Up Steam

Wireless devices help cut energy losses by detecting failed steam traps

By Seán Ottewell, Editor at Large

IN THE face of rising energy costs, steam waste is becoming even more of an issue for chemical plants. Traditional manual surveys are time consuming and expensive. Even when audits are carried out annually, up to 15% of steam traps will fail between surveys, says Emerson Process Management. A two- or three-year gap between inspections can push this figure up to 30%.

Failed steam traps can do more than waste steam. For example, a trap failing closed, instead of open, can lead to water hammer and physical damage to a facility — with potentially catastrophic results.

However, many steam traps are in hard-to-access or potentially dangerous locations that make surveying them hazardous.

Fortunately, wireless monitoring systems can ease the checking of steam traps at chemical plants. Vendors offering such systems include Spirax Sarco, Cheltenham, U.K.; Cypress Envirosystems, San Jose, Calif.; Emerson Process Management, Round Rock, Texas; and Armstrong International, Three Rivers, Mich.

NOW ATEX APPROVED

Spirax Sarco's new STAPS wireless steam-trap monitoring system, which was developed at the company's global R&D center in Cheltenham, currently is undergoing beta testing at the company's own sites around the world and with a major food manufacturer. Beta testing at chemical plants was hampered by lack of ATEX approval. However, this approval came in the last week of February. "We can now offer two versions, the standard one and the ATEX-approved one, and we anticipate trial sites in the chemical industry will be forthcoming," explains Simon Geuley, group product manager for condensate management.

The main driver for investment in steam trap monitoring is heat loss, says Geuley. The numbers associated with such losses can be dramatic. For instance, if roughly 10% of the steam traps fail annually at a process plant with 200 traps and the plant has an average trap size of DN20, steam pressure of

14 barg and operates 24/7 for 50 weeks/year, the cost of ignoring the failures would be £89,000 (about \$150,000), he notes. This is equivalent to well over one million liters of fuel oil plus 3,000 metric tons of carbon dioxide released to the environment, he adds.

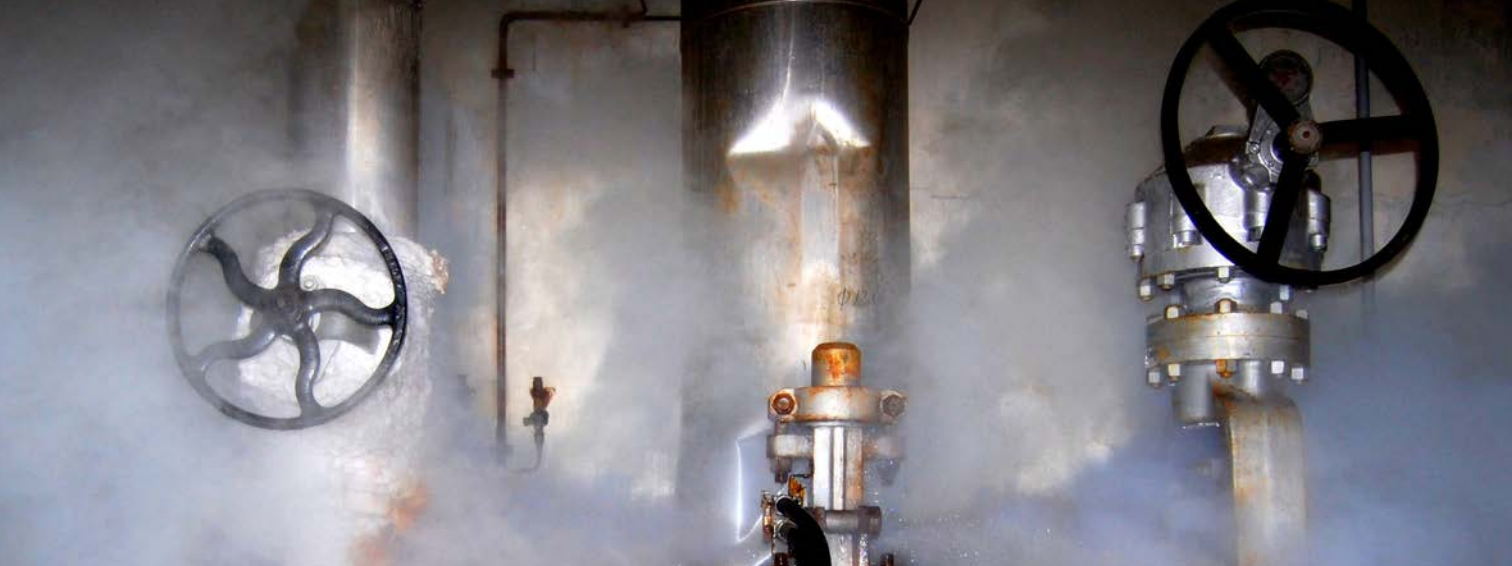
Wired monitoring systems are an option but can be expensive to install and maintain. "There are issues with intrinsic safety, particularly within the chemical industry. So, there has been a huge move to wireless solutions, particularly in the field of condition monitoring," Geuley explains.

The heart of the system is a head unit assembly that is mounted on the pipe upstream of the trap to be monitored and that is powered by a lithium battery that can last for up to ten years. It features vibration and temperature sensors as well as an advanced processor to carry out calculations. The head unit "listens" to the sound signature of the trap (Figure 1). This sound signature is categorized and transmitted via a 2.4-GHz wireless network.

The system also includes a receiver that the head unit communicates with and a repeater. These create a network and can



Figure 1. Monitoring system features built-in intelligence about a variety of traps. Source: Spirax Sarco.



communicate with each other and pass on the steam trap data to a supervisory PC that determines the trap condition and calculates any steam loss.

The monitoring is semi-continuous — occurring a minimum of every 15 minutes depending upon the customer's requirement. The information appears in a very simple format on the PC: green denotes “good,” amber is “caution” and red indicates a leak. Two other displays show battery condition and wireless signal strength. The latter also notes when the last successful communication took place in case there's a problem with the wireless network.

STAPS' leak-detection intelligence differentiates it from other wireless steam-trap monitoring systems, says Geuley. Using information from the tens of thousands of steam trap installations it has worldwide, the company has developed a device that can account for the operating principals of different types of steam traps — Spirax's offerings include bimetallic, fixed temperature discharge, ball float, inverted bucket, sealed thermostatic and thermodynamic traps — plus their respective loads and pressures. “So our algorithm is very difficult to replicate,” he claims.

PHARMACEUTICAL SUCCESSES

The wireless steam trap monitor (WSTM) from Cypress Envirosystems mounts non-invasively onto existing steam traps in minutes and uses a proven algorithm to detect trap failures, particularly expensive steam leaks. It has been designed to augment manual audits to detect failures in a timely manner.

One of its most successful applications has been at the main technology center of a major U.S. pharmaceutical company. The center includes a number of manufacturing buildings, each supplied with steam, chilled water and compressed air from a dedicated utility plant. Each building is responsible for its own energy consumption and is billed separately by the utility plant. Overall, the center houses more than 2,400 steam traps, many operating in hazardous locations where temperatures can reach up to 500°F.

The utility plant installed WSTMs to continuously

ACOUSTIC TRANSMITTER



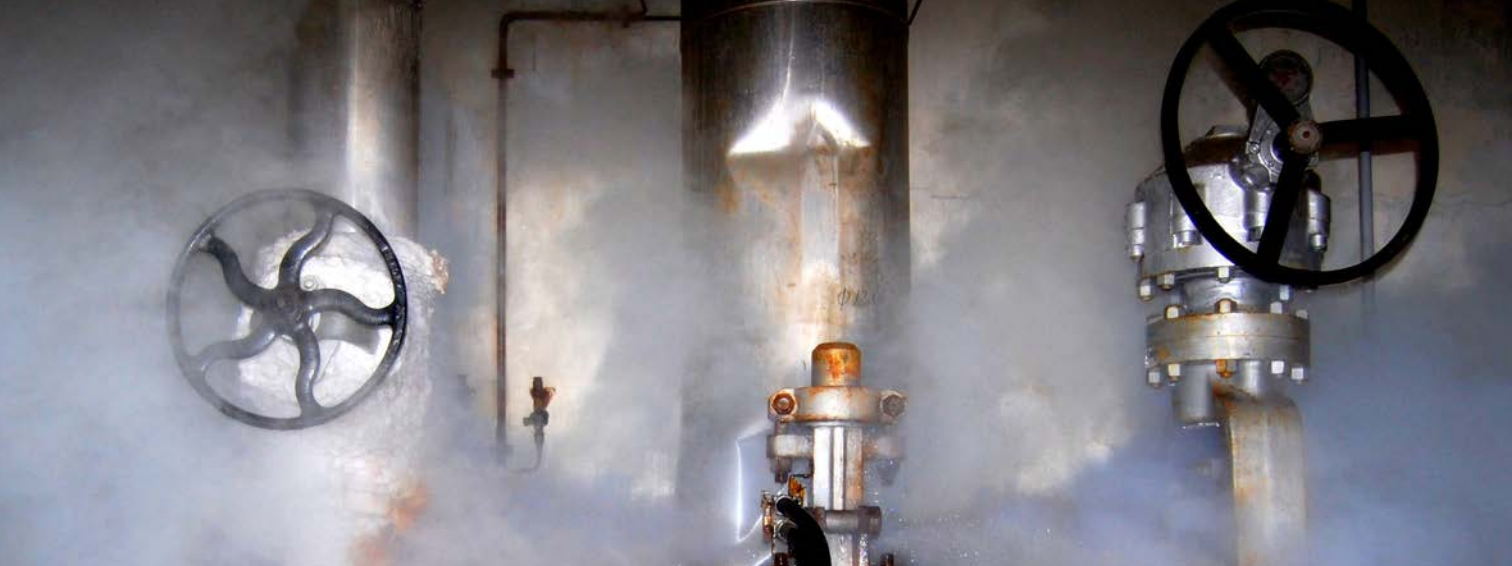
Figure 2. Plant easily added steam trap monitors to existing wireless network. Source: Emerson Process Management.

monitor the steam system — to provide transparent accountability for each building and close the loop on energy reduction goals for the company as a whole. The payback on this project was under 12 months.

The WSTMs perform monitoring and diagnostics, and transmit health status wirelessly to a central server for trending, graphing, alarming and historization. Installing each WSTM takes less than half an hour and doesn't involve breaking seals, leak checks, or production downtime. Whether traps fail open or closed, the WSTMs provide alarm notification, enabling timely maintenance to increase safety and reliability in addition to saving energy.

The WSTM has a built-in “zero footprint” web-based user interface that enables any user on the company Intranet to view historical trends, graphs and alarms/notifications. It also provides comprehensive reports with an energy summary that shows steam loss and its associated cost for analysis and auditing — no new software or operator training is required, says Cypress.

Existing automation systems easily can integrate the



WSTM data via open system interfaces. The pharmaceutical company uses OPC to bring the data into its Wonderware utilities management system; Cypress has a technology alliance with Invensys to ensure operability between its products and Wonderware software.

In a second application, a pharmaceutical company in New England has installed WSTMs on its 550 steam traps.

The company's traditional annual audit was taking about 140 man-hours, costing \$20,000 and requiring a calendar month to complete. The pharmaceutical firm replaced all failed steam traps uncovered during the audit. However, before the next audit, around 15% of the traps would fail and start to leak. On average, it took six months before the leaks were detected, at a cost of \$375,000 in lost steam.

Installation of the 550 WSTMs has reduced steam leakage by 95% and cut audit labor costs by 70%. Payback was achieved in less than a year.

"Although we are more focused on our healthcare market at the moment, we are absolutely considering the chemical in-

dustry and it's definitely a market that we want to grow into," says David Roberts, vice president of marketing.

FOOD FOR THOUGHT

A major food manufacturer based in the southeast U.S. also has benefited from wireless trap monitoring. The company had developed a preventive maintenance (PM) schedule for steam traps at a large plant that makes multiple product lines. It took a maintenance crew at least an hour to properly check each of the nearly 100 steam traps, which limited the PM to an annual exercise.

To meet its demand for automatic online monitoring of steam trap performance, together with real-time alerts to minimize the need for PM and energy losses, the company installed nine Rosemount 708 wireless acoustic transmitters from Emerson (Figure 2).

The plant already had a self-organizing wireless network for the Rosemount 3051S DP wireless flow meters it was using to monitor compressed air flow. Adding the non-intrusive wireless acoustic measurement devices was easy. "Wireless greatly reduces installation cost, and we use those savings to purchase more instrumentation to extend utility monitoring in our plant," notes the site's project engineer.

The nine transmitters were put on steam lines throughout the plant and integrated into the existing Smart Wireless Gateway, which communicates to a plant host. The acoustic transmitters monitor a variety of types of steam traps and work equally well on all of them, says Emerson; one transmitter even keeps tabs on a steam-driven pump to give early indication of problems. The network was easy to expand; the new transmitters just strengthened the mesh. There's a lot of concrete between the transmitters and the gateway and high EMF, but the wireless communications are strong and reliable, adds the company.

"Manual monitoring of temperature did not give us enough information to conclusively target a steam trap for replacement when we saw water-hammering," explains the project engineer. "But when we installed the wireless acoustic transmitter, we

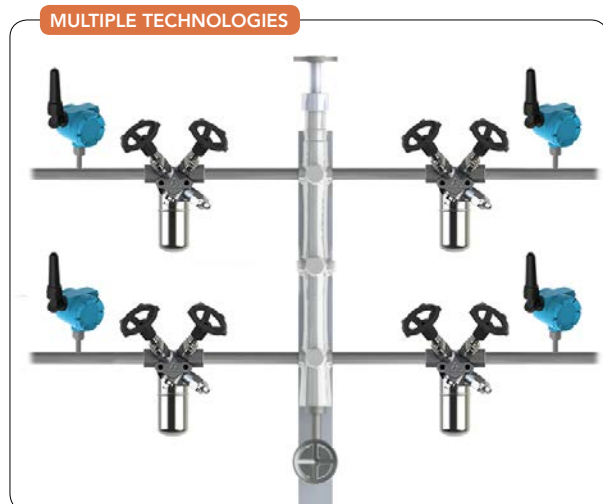
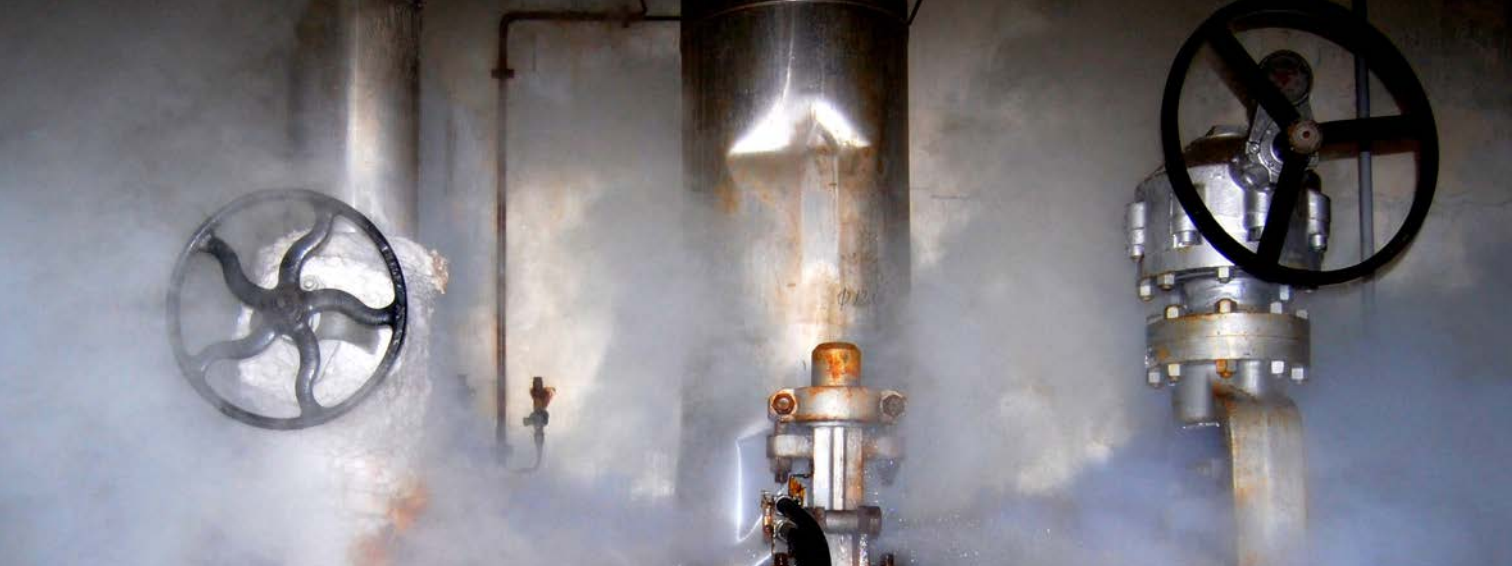


Figure 3. Device uses a mix of methods, including acoustic and temperature monitoring. Source: Armstrong International.



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could tell immediately which steam trap was stuck.” It was quickly fixed, and a trend of the new trap showed normal acoustics and temperature.

“We found 22% of our traps needed to be replaced during our last PM check. By installing wireless acoustic transmitters, the plant will prevent steam loss with early detection of steam trap failure. Not only will this minimize energy loss, but it will free up maintenance to focus their time and attention on things that need to be fixed, to further improve our productivity,” the project engineer notes.

BUILDING UPON EXPERIENCE

The AIM system from Armstrong International provides intelligent wireless steam-trap monitoring that’s designed to tackle the three constant challenges faced by plant and maintenance engineers: identifying a failure, evaluating its scope and measuring its impact. AIM (Figure 3) relies on a mix of methods, including acoustic and temperature monitoring, integrated into a smart wireless device that can deliver immediate failure notifications and pinpoint their locations.

Armstrong’s biggest differentiator is the knowledge it has gained in over 100 years of steam system work, says Kerry Phillips, global manager, smart services group. “We’ve designed, tested, constructed and maintained more steam systems than any company. This gives us an advantage to not only know how to apply proper technology for maintaining steam traps, but also the ability to provide and execute the solution when problems are identified,” he notes.

The chemical industry only is at the early adopters’ stage when it comes to wireless steam-trap monitoring technology, says Phillips. “Based on experience, the industry’s biggest concerns appear to be with reliability and cyber security. Old behavior has been to manually survey the steam traps, but as

wireless technology becomes more accepted, the behaviors will change to automate steam trap testing. Wireless steam-trap monitoring is real-time, whereas manual surveys are typically done once per year. Real-time monitoring enables companies to identify the failure immediately so action can be taken. Most like to focus on the critical steam traps such as the high energy wasters and critical process.”

As a result, Armstrong’s successes so far in the chemical industry have mainly been in high-cost application areas. “For example, a chemical company with 2,000 steam traps will typically monitor the high-steam-pressure applications as well as any steam traps that are critical to their process. Armstrong is able to identify the worst offenders, to really focus down into the areas that are affecting efficiency and costing money.”

This, he says, is particularly important to process and maintenance engineers who these days are under pressure to achieve more with fewer resources. “However, as energy costs rise, so does the need to stay on top of steam leaks. One steam trap failing open can lose upwards of 500,000 lb/yr of steam. Depending on your cost of steam, this could be wasting up to \$8,000 per year — just for one steam trap! Typical chemical process facilities will have in excess of 1,000 steam traps, so the energy losses can add up quickly if they are not maintained regularly.”

Phillips cites examples at three customers to illustrate the point. The first boosted performance and profits after using the system to identify failed steam traps on high-pressure steam lines. The second had steam traps 105 ft off the ground in the middle of a pipe rack with no scaffolding support. AIM has enabled this customer to reduce downtime and reallocate valuable maintenance man-hours. The third experienced multiple steam-trap problems that caused condensate to back up into its steam turbine. Using wireless steam-trap monitoring decreased downtime and increased plant performance. ●