Understanding Reactive, Preventative and Predictive Approaches to Steam System Maintenance

White Paper

Contents

1. Executive Summary

Steam system maintenance has traditionally been conducted on a run it till it breaks basis. That approach reduces expenditures in the moment, but increases costs significantly over time as equipment is damaged, productivity is lost, and planning is made impossible. Efficient operators are incorporating a three-pronged approach to reliability programs that includes reactive, preventative, and predictive activities.

The reasons and benefits to using each type of reliability program are examined in relation to steam trap failures, and a closer look is taken at some of the modern technologies that operators are deploying in order to achieve savings in cost, time, and product.

2. The State of Steam System Maintenance

The chemical industry has been challenged by sporadic growth and lowered profitability over the past decade, driving businesses to seek strategic ways to control costs and increase production.[1] Maintenance staffs may be overextended due to the loss of employees with steam engineering knowledge while even brand new facilities are often plumbed incorrectly by plumbers who are not versed in the specialized methods required to install pipes in steam systems. For example, if a heat exchanger isn't draining properly, it may take longer to heat up or it may overheat and burn the product. Either malfunction results in losses for the operator.

Steam systems are typically quite reliable with proper maintenance, but they are complex systems, and even a small failure can result in an ongoing waste of energy or even a catastrophic shutdown.

Yet, while all operators agree that reducing costs and increasing uptime are critical concerns, many are not aware of how reliability programs can help them achieve these goals. Operators cite a lack of budget, expertise, and knowledge as reasons to avoid implementing these programs, but such concerns are unfounded. All systems will eventually fail, so a reliability program is an investment that is certain to provide returns in the forms of greater uptime, lower maintenance costs, increased efficiency, and better customer service.

Reliability programs can be reactive, preventative, or predictive. Most operators default to a reactive approach, letting failures determine their maintenance schedules, but a better practice is to institute a blend of programs so that a suitable and right-sized response is always ready when a failure arises.

Reactive Programs

A reactive program allows systems to run to failure. For some organizations, a reactive program is their only program; instead of taking a structured preventative or predictive approach, they simply respond as breakdowns occur. Allowing systems to fail without intervention keeps maintenance costs and staffing requirements low some of the time. However, when a failure occurs, the chance to control those costs is lost as workers are sidelined, overtime accrued, and parts rushed to the site in order to minimize downtime. Other costs associated with a run it till it breaks approach are damage to equipment and lost productivity.

However, even operators with preventative and predictive reliability programs in place need to have reactive programs as well; since not all failures can be prevented or predicted, a reactive reliability program can define an approved course of action when an urgent situation emerges.

Preventative Programs

A preventative program requires an ongoing effort. The tasks involved in this approach may seem to be unnecessary because they aren't critical at a particular moment, yet this is exactly why they are useful. A preventative program reduces both short-and long-term costs. Short-term costs are reduced when problems are caught before they become urgent, allowing corrections to be planned in a way that allows for better control of labor, parts, and downtime. Long-term costs are reduced because preventative maintenance ensures systems perform at optimal efficiency and fulfill longer working lives. A preventative program saves 12-18 percent over a reactive approach.[2]

Predictive Programs

A predictive program uses sophisticated technologies to monitor a system's state. While many companies take a preventative "annual and manual" approach to checking their steam traps, that practice can leave traps leaking or blocked for extended lengths of time, resulting in significant energy loss or downtime. Cumulative losses have a costly financial and environmental impact. Automation and secure wireless technology enable operators to quickly identify and respond to leaks and blockages before failures occur or equipment is damaged. The risk of catastrophic line failures is reduced, operating performance is maintained, and critical processes are hardened against unscheduled interruptions. Predictive reliability programs have been examined by NASA, which has found that these programs reduce costs by fifty percent.[3]

1 *Overview of the Specialty Chemicals Industry. (2016, August). Retrieved from IHS Markit: https://www.ihs.com/products/specialty-chemicals-industry-scup.html*
2 *Federal Energy Management Program. (2010, August). Operations and Maintenance Best Practices Guide. Retrieved from Office of Energy Efficiency and Renewable Energy: http://energy.gov/eere/femp/downloads/operations-and-maintenance-best-practices-guide*
3 *NASA. (n.d.). Predictive Maintenance-Facility, Ground Support Equipment. Retrieved from NASA: https://oce.jpl.nasa.gov/practices/ops13.pdf*

3. Managing System Reliability

Steam that leaves the boiler is nearly 100% steam. As the steam is distributed throughout the system, heat is lost and condensation collects in low points. Steam traps protect against these failures by discharging condensate and gases without discharging live steam.

All mechanical products fail over time. Even plants with regular maintenance programs experience between fifteen and thirty-five percent failure rates in their traps at any given time.[4] The higher rates are more common at aging plants, and are probably the result of unidentified or unrepaired legacy failures that have collected over time.

Open Failures

When traps fail in an open state, they leak live steam. Over time, even small leaks can result in hundreds or thousands of dollars of wasted steam per trap; a steam trap on a large high-pressure line can pass more than 600 lb per hour of steam, which can cost more than $30,000 per year.[5] Failures in open traps also lead to other inefficiencies, such as increased boiler loads. Older plants are particularly vulnerable to increases in loads known as phantom loads, which occur when aging systems accumulate leaks, degrading efficiency throughout the plant. As much as twenty percent of steam production[6] can be lost to phantom loads, mostly through failed steam traps. Some operators choose to bypass failed traps, which increases fuel expenses and consumes excess capacity.

To compensate for the loss, operators can make a large investment to increase the capacity of their existing boilers, add an additional boiler, or reduce the steam loss by repairing or replacing failed traps.

Closed Failures

When traps fail in a closed state, condensate can backup. Condensate can cover heat exchanger tubes, compromising heat transfer and slowing processes. Condensate can also travel through the system at high velocities, slamming into pipe walls when a change in direction, temperature, or terrain is encountered. That causes an effect called waterhammer, which can erode pipes, damage pipe supports, and cause the pipe to catastrophically implode. Unlike open failures, which can persist for years, closed failures will eventually cause processes to stop. The key is to identify them before they've caused great damage.

Safety

Steam leaks are not only costly, they are dangerous. In addition to their scalding heat, they can decrease visibility and limit hearing. Outdoors, leaks can freeze or cause mold, causing a slip hazard. Regulations around workplace safety and environmental protection require these risks to be managed. Beyond compliance concerns is the general need to protect the public; steam systems can lead to loss of property and life if a catastrophic failure occurs in a populated area.

4 *Ibid.*
5 *Gustafson, D. (2015, May). Process Control. Retrieved from BNP Media: http://digital.bnpmedia.com/article/Process+Control/1989660/0/article.html*
6 *Federal Energy Management Program. Steam Trap Performance Assessment.*

4. Trap Failure in a Reactive Maintenance Program

An operator taking a reactive approach to maintenance will only learn that a trap has failed when a check-up is performed or the fault has become obvious. Most steam traps are checked once a year, which means that a trap could have failed the day after the previous year's check or the day before the current check. There is no way to know, but an operator can assume the average failure time to be six months. The life of failures can be reduced by increasing the frequency of checks.

A reactive approach should not be the only approach, but every operator needs a reactive program to set in motion when an unexpected failure occurs. By having a structured response plan, proper training, and an appropriate stock of spare replacements on hand, unexpected failures can be rectified with minimal disruption and expense.

5. Trap Failure in a Preventative Maintenance Program

A time-based preventative program can be tailored to an operator's environment. Some facilities inspect monthly and replace yearly, while others are on a three- or six-year schedule. Regardless of frequency, however, all preventative programs should start with an assessment to establish and plan the scope of work required to bring the system to optimal performance.

An assessment exposes problems, but it also identifies areas in which improvements can be made. Top priorities should address failed open steam traps and steam leaks that are wasting energy and failed closed steam traps that present operational and safety risks due to waterhammer. However, an assessment does more than target areas for repair and replacement; it can also expose opportunities for overall system improvement.

As a preventative program advances and regular maintenance is performed, the number of failed traps decreases and efficiency improves. The result is better reliability, performance, and cost-effectiveness. For example, one operator implementing a Spirax Sarco preventative reliability program saw open trap failures rates decrease from 7 percent to 3.6 percent in four years, while closed trap failure rates dropped from 8.3 percent to only 0.6 percent. A program like this reduces the potential for waterhammer and associated system failure and also reduces the consumption of steam, compressed air, and nitrogen. These greater efficiencies result in significant savings; the operator mentioned above has saved $9.3 million annually for a cumulative savings of $23.4 million to date.

6. Trap Failures in a Predictive Maintenance Program

Predictive reliability programs use sophisticated diagnostic systems to determine equipment status before a failure occurs, allowing operators to target components in need of maintenance and avoid wasting resources to check or replace traps in good condition. This focused approach has greater upfront costs, but they are recouped by savings on materials, labor, and downtime. According to the Federal Energy Management Program,[7] a steam trap with a .25 inch orifice that fails in an open position will lead to losses that cost about $7,800 annually. At a failure rate of twenty percent, an operator with one hundred traps will lose over $156,000 in steam, product, and fuel. A predictive reliability program pays for itself in one year or less, on average.[8]

The predictive computer systems can be programmed to compare the pressure level and orifice sizes of each trap. When a trap is leaking, the technology can also calculate the total cost of lost steam. By monitoring the performance

7 NASA. (n.d.). Predictive Maintenance-Facility, Ground Support Equipment. Retrieved from NASA: https://oce.jpl.nasa.gov/practices/ops13.pdf
8 Ibid.

of steam traps over time, a predictive reliability program creates a deterioration map that can be used to forecast and prepare for maintenance during scheduled downtimes. This condition-based maintenance minimizes disruptions of critical processes and enables operators to integrate their steam trap maintenance into their existing asset management systems.

Wireless Capabilities Offer Flexibility and Cost Savings

Predictive reliability programs use wireless monitoring to gain insight into processes while reducing engineering and other costs. The alternative, a wired system, is expensive to install, particularly in geographically-distributed environments and requires third-party personnel to be granted access to restricted areas. Once in place, a wired system places an additional burden on maintenance staff and is difficult to expand. A wireless system, on the other hand, can be expanded, shifted, or reduced at little or no cost, powered by batteries or energy harvesters, and monitored from remote locations. Because steam traps only require daily monitoring, battery longevity is excellent and batteries can be hot swapped without decommissioning the line if necessary. For these reasons, many operators capture substantial savings through the use of wireless technology.

Daily Monitoring Reduces Mean Time Between Failure (MTBF)

Reliability is measured by the duration of failure-free operation under specific conditions. This is called Mean Time Between Failure (MTBF), and the longer the MTBF, the greater the potential for profitability. In the early days of a system, the trap failure rate is high as imperfect traps break down due to application errors or material flaws. After those imperfect traps are repaired and replaced, the failure rate falls until failures only occur sporadically. At that point, the traps enter the stage known as useful life. After useful life, the traps enter wear-out mode and the failure rate increases again as the old units reach the end of their functionality. The duration of useful life depends on the materials and production processes used to manufacture the unit and the way it is applied, and the maintenance it receives in-line.

In a facility relying on reactive or preventative maintenance determining the true MTBF is only possible with broad assumptions because there is no way to tell how long a unit has been in failure mode. The operator only knows the date of the last maintenance, but the unit may have failed the day after that checkup or the day before the problem was observed. Because a year may have passed between those two occurrences, no insights can be gained from MTBF.

A predictive reliability program answers that need with technology-based daily monitoring. The data is used to identify patterns, create a deterioration map, and schedule maintenance far into the future. The results of these efforts are monitored and adjustments are made as needed, creating a cycle of improvement that reduces MBTF and extends useful life. When a unit in the stage of useful life does fail, predictive technologies can be used to help identify the root cause of failure, and that data can then be applied to prevent failures of other units in similar conditions.

Root Cause Analysis Data is Transformed into Actionable Intelligence

Root cause failure analysis in an environment relying on reactive or preventative maintenance usually involves the removal and visual inspection of failed parts and an assessment of its application. Predictive technology can be used to perform a detailed analysis based on technical specifications and then to make recommendations, such as changing steam trap technology or capacity. Implementation of the changes can be tracked and the trap in question can be monitored to see if the changes worked as expected.

Implementing a Predictive Reliability Program

Predictive technology is not recommended for in-house use because it requires specialized configuration, maintenance, and expertise to function properly. By outsourcing the program to a service provider, operators are relieved of the manpower and ongoing training requirements, as well as the cost of data acquisition and analysis equipment. In addition, other expenditures are lowered due to the economies of scale a vendor can provide.

7. Reliability Over Time

A reliability program must be implemented over the long term for operators to recognize gains. Sporadic efforts may deliver fleeting bumps in productivity or cost savings, but those results will subside when a program is curtailed and failures re-emerge, leaving operators wrangling with the same problems that existed before a program was attempted.

A reliability program that incorporates reactive, preventative and predictive approaches yields cost benefits quickly. Returns on investment can often be realized within a year from cost savings alone; an unmaintained high pressure steam trap costs $1450 annually, while that same steam trap costs $316 in a typical preventative program and only $192 in a predictive program.[9] In addition to direct cost benefits, operators of well-planned reliability programs will see fewer emergency shutdowns due to breakdowns, level workloads and stable manpower requirements, lower total maintenance man hours, reductions of spare parts inventories, and less unnecessary damage to equipment. When a system is reliable, a greater volume of work can be planned and productivity is increased.

8. Conclusion

The chemical industry depends heavily on steam for process applications, so pipes are as important as the equipment they tie together. At the same time, manufacturing facilities are complex systems, and operators have many machines and technologies competing for their resources. Establishing appropriate reliability programs requires specialized expertise and experience that may not be available in-house.

High levels of reliability are directly connected to high returns on investment. Spirax Sarco can help chemical plants optimize their product quality, energy costs, and plant productivity. With over 1300 qualified engineers, local manufacturing, and worldwide support, Spirax Sarco provides a single source of supply that helps operators achieve a stronger competitive position.

9 *Steam Trap Inspection vs. Monitoring. (2015, August 15). Retrieved from Thermaxx Jackets: http://www.thermaxxjackets.com/wp-content/uploads/2015/04/Steam-Trap-Inspection-vs-Monitoring.pdf*

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