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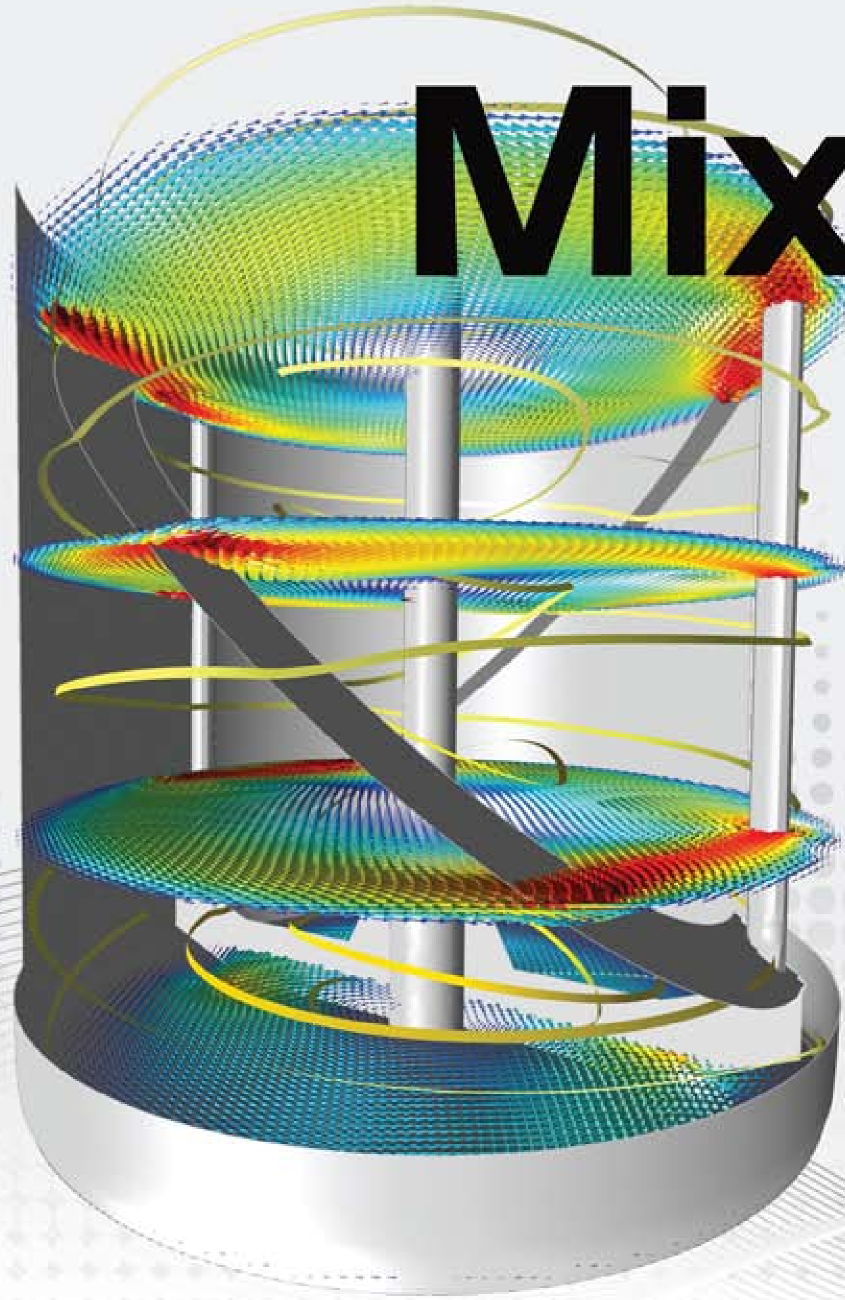

Implement a Sustainable Steam-Trap Management Program

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Steam trap management is important for the successful operation of a chemical processing plant. Follow these guidelines to realize the benefits of such a program.

Steam traps can significantly affect safety, reliability, and product quality in chemical process industries (CPI) plants. Their impact, though, is sometimes not fully understood. As a result, companies may neglect steam traps for long periods of time — which can be a costly mistake.

The key component of a steam-trap management program is the steam trap survey (Figure 1). However, it is much more than the survey itself. The survey identifies possible improvements; the trap-management program executes and sustains those improvements. An effective steam-trap management program focuses on three areas: pre-implementation strategic planning, onsite program implementation, and ongoing program oversight.

This article discusses each of these elements of a steam-trap management program. It also explains why a company might struggle with implementing a program to manage steam traps, as well as ways to justify such a program.

▲ **Figure 1.** The steam-trap survey is the key component of a steam-trap management program. However, a plant should not jump into performing the survey without proper planning and preparation.

Why are trap-management programs difficult to implement?

Sites may struggle to implement a steam-trap management program for several reasons:

• insufficient resources

• lack of engagement or focus by employees

• inadequate understanding of the potential benefits and challenges of steam trap maintenance

• insufficient knowledge of how to implement a trap-management program or improve steam trapping problems

• focus on other activities that are either easier to accomplish or perceived to have a higher priority

• unwillingness to do extra work, such as preparing management of change (MOC) documents for new trap technology

• reluctance to spend a limited maintenance budget on steam system improvements due to a perceived higher return on investment for other projects

• difficulty in estimating the financial gains needed to justify the costs of continuing the program.

Motivations

Before a steam-trap management program can be implemented, the facility's management and associated personnel must be sufficiently motivated. Several factors illustrate the benefits of such a program and can serve as motivators:

• *leaking steam costs*. Leaking steam traps can be expensive due to steam energy loss *(1)* and to other overhead costs related to the leaking traps *(2)*, such as running a standby boiler or water-treatment facilities.

• *production impacts*. Failed steam traps, especially cold traps *(3, 4)*, can affect production (*e.g.*, turbine trips, freezing process lines, unnecessary process unit shutdowns due to freezing instrumentation).

• *maintenance costs*. Costs associated with repairing and ensuring the reliability of steam equipment are often significant.

• *personnel safety*. Steam traps that are not operating properly can cause personnel injury (*e.g.*, burns by leaking steam that is not visible, slips on pooled or frozen condensate).

• *environmental impacts*. Leaking steam traps result in higher energy consumption, which increases emissions of greenhouse gases and other pollutants.

The magnitude of these impacts and their associated costs increase dramatically with the length of time the plant has not consistently managed its steam trap population. To illustrate this cost, consider a facility that includes 1,000 traps with a failure rate of 20%/yr (Table 1). As shown in Table 2, for every year that the facility waits to implement a steam-trap management program, 20% more of the traps fail, resulting in losses that accumulate over time. The unrecoverable losses are the costs that accumulate throughout the year as more traps fail at a rate of \$800/yr for each trap. (This assumes that the trap failure rate by month is linear such that on average the traps are in failed operation for half of the year.) Forward-looking recoverable losses are the losses that will start to accumulate over the next year assuming no more traps fail. The total cost shown in Table 2 is the investment required to undertake a survey of all traps (\$12/trap for 1,000 traps) and to take corrective maintenance action for failed traps (replacement steam trap cost and maintenance labor). If the plant makes this investment, then the forward-looking recoverable losses can be avoided. These savings can be used to justify the costs associated with implementing a trap-management program.

Personnel must be sufficiently motivated to implement a steam-trap management program.

Getting widespread involvement

For the successful implementation of a steam-trap management program, all levels and groups within the organization should be involved in developing the program, especially:

• corporate-level management, such as the company's board of directors (including directors who drive initiatives related to energy and environmental issues as well as plant reliability initiatives), who can support and fund the program, as well as hold other employees accountable for the program's implementation

• senior site managers, such as plant managers and business unit managers, who are responsible for what happens at the plant level (rather than across all plants within the company)

Table 1. A plant has 1,000 steam traps that have an average failure rate of 20% per year.

Steam Trap Population	1,000
Failure Rate of Steam Trap Population	20%/yr
Cost Impact of Failed Traps	\$800/trap
Trap Survey Cost	\$12/trap
Steam Trap Purchase Cost	\$300/trap
Steam Trap Installation Cost	\$100/trap

Table 2. For the trap population described in Table 1, the cost of delaying steam trap maintenance rapidly accumulates with time.

Survey and Follow-Up Delay, yr	Trap Population Failed, %	Total Accumulated Trap Failures	Unrecoverable Accumulated Losses, \$	Forward-Looking Recoverable Losses, \$/yr	Total Cost, \$
1	20%	200	\$80,000	\$160,000	\$92,000
2	40%	400	\$320,000	\$320,000	\$172,000
3	60%	600	\$720,000	\$480,000	\$252,000
4	80%	800	\$1,280,000	\$640,000	\$332,000
5	100%	1,000	\$2,000,000	\$800,000	\$412,000

• maintenance managers and technicians, who have the time and budget to undertake the hands-on work, and for whom steam trap management is a priority

• operation managers, operations supervisors, and operators, to support testing and steam trap commissioning.

Finally, the program needs a champion to manage its implementation. This person is typically an energy manager with support from supervisors.

Planning and preparation

Once the plant has decided to implement a steam-trap management program, the next step is planning and preparation. At this point, people may be tempted to rush into the steam trap survey in the hopes of quickly identifying, and then replacing, failed traps. However, it is prudent to spend additional time in the planning phase. The planning activities that typically have the largest impact on the success of the program are:

• selecting and correctly installing the best steam traps for the site's conditions

• identifying the most-accurate diagnosis technology and testing resources

• defining the scope of the trap-management program.

Trap selection and installation

Many plants spend considerable effort testing steam traps and then repairing or replacing them, usually based on a replace-in-kind strategy. This approach will re-establish the plant's steam system to its original design, with no improvement over that design, which may be many years old. If the original design used inappropriate or suboptimal trap technology, the full benefits of a trap-management program may not be realized.

Therefore, before starting the survey, the plant should evaluate current steam trap practices and determine how they might be improved (Figure 2). Using this approach, higher-performance traps can be selected.

▲ **Figure 2.** Before starting the steam-trap management program, the plant should evaluate the current steam-trap practices and determine whether the optimal technologies are being used.

An effective method for assessing the existing steam trap technology involves a lifecycle cost model, which accounts for four basic cost components related to the four phases of the trap's lifecycle:

• purchase and installation costs of a new trap

• operational costs of a correctly operating trap related to functional steam loss (FSL), which can be estimated based on international standards *(5, 6)*

• operational costs associated with a failed trap (*e.g.*, leaking or cold trap) *(4)*

• repair or replacement costs.

Lifecycle costs should be evaluated for key applications (*i.e.*, those that have the largest impact on plant performance and energy efficiency), such as drip applications (including high-pressure drips), and tracing applications (including copper tracing). Each application has its own challenges and therefore requires a different type of trap. For example, high-pressure drip duty often deals with superheated steam, which typically causes traps to wear out quickly, whereas copper tracing traps may be susceptible to blockages caused by dissolved copper that precipitates and forms deposits within the trap internals when condensate flashes.

Trap selections should be documented to create a plant standard. This documentation should also include plant-specific installation guidelines and piping drawings to ensure that the steam traps are installed correctly. By selecting and documenting the optimal trap models in advance, corrective actions can be taken promptly.

The plant standards and installation drawings should be updated on a regular basis to take advantage of new trap technology as it becomes available. This helps with maintenance and also with outsourced projects to ensure traps are supplied and installed to the plant's best-practice requirements.

If the trap assessment identifies a better trap model, a management of change (MOC) procedure should be initiated and purchasing and inventory processes should be updated to reflect the new equipment. Thought needs to be given to the disposition of any existing inventory of old models and to preventing the automatic re-ordering of old traps that are no longer preferred.

Training on the trap standards and installation guidelines is invaluable, but may not be effective in the long term if the standards can only be reviewed from a company computer or library. Trap selection and installation requirements need to remain visible to, and easily accessed by, the maintenance technicians undertaking installation or repairs in the field. This can be done by summarizing the content of the standards on a wall chart or in a plastic pocket-size flip-book. All of this material should be prepared before the survey starts to ensure that any new and improved best practices for trap selection and installation supercede past practices.

Diagnosis accuracy

Correctly diagnosing the operational status of the steam trap has a significant impact on the profitability of the trap-management program (Figure 3). Four potential scenarios can occur:

1. Correct diagnosis of trap condition. A correct diagnosis does not add extra costs to the program.

2. Incorrect diagnosis of a good trap as either leaking or blocked. The site may then needlessly spend money (typically $400/trap) purchasing and installing a replacement trap. This situation not only results in unnecessary expenditures but could also take resources away from other, more-valuable, improvement projects.

3. Incorrect diagnosis of a leaking trap as good. Steam leakage from such a trap that is left in place can translate to an average annual energy loss of up to $800 per trap.

4. Incorrect diagnosis of a blocked trap as good. A blocked trap that is missed and left in place could have a potential impact of $800 per trap *(3)*.

To understand the magnitude of misdiagnosing steam trap health, assume an average financial penalty of $600 per misdiagnosis. If, on average, three condition-diagnosis errors are made for every 100 tests, then for a 1,000-trap population, the hidden misdiagnosis cost is $18,000; for a facility with 6,000 traps, the corresponding cost would be $108,000. The misdiagnosis cost can be allocated as a testing penalty of $18 per trap for each trap in the population ($18,000 divided by 1,000 traps). The significant costs associated with misdiagnosis may influence the choice of testing strategy, and persuade you to choose a more expensive, yet more accurate, method. This example also highlights the criticality of correctly diagnosing a trap before undertaking costly maintenance action.

Factors to consider when evaluating the accuracy of a testing methodology include:

• *technology type*. Typically, a combination of ultrasonic and contact temperature measurement is the most accurate method of steam trap testing.

• *objectivity*. Objective methods that diagnose a trap's operating condition based on empirical reference data or reference standards *(7)* specific to each trap model are more accurate than subjective methods (such as visual observation). The more specific the reference data to each particular model, the more accurate the diagnosis.

▲ **Figure 3.** The accuracy of the diagnosis method used during the trap survey is very important.

• *outside validation*. The diagnosis method should be validated by a recognized third-party verification agency to ensure that the diagnosis methodology and results obtained are accurate according to sufficient, in-depth, empirical confirmation testing.

• *survey speed*. A typical survey can accurately evaluate between 50 and 150 traps per day, depending on the type of facility and accessibility of the traps. By estimating an average time to find a trap, test it, and record the condition data, and comparing that to the time stated in the survey proposal, a plant can determine whether the testing prices quoted in contractors' bids are reasonable.

Certification, experience, and training of the people undertaking the trap survey are also important, although there are no industry standards defining certification and training requirements.

Survey scope

It is important to determine the scope of the survey, replacement models, installation improvements, and maintenance actions before starting the survey. The survey scope should include:

• safety training requirements

• plant areas to be surveyed and the numbers of traps to be tested

• steam trap diagnostic technology to be used

• the tagging with equipment numbers used to identify steam traps

• instructions for marking failed traps in the field (*e.g.*, red paper tags, orange spray paint, etc.)

• data to be collected on the steam trap location (*e.g.*, pipe connections, sizes, isolation valve locations, bypass valve details)

• accessibility and provisions to access traps (*e.g.*, personnel lifts, scaffolds, etc.)

• special requirements (*e.g.*, testing in confined spaces or hazardous areas)

• instructions for updating the plant's steam-trap database

• suggested replacement models for failed traps

• additional testing steps if traps are identified as cold (*i.e.*, not in service)

• additional testing for locations susceptible to vibration

• content of the survey report and format (*e.g.*, an Excel spreadsheet)

• survey report presentation requirements

• survey progress report requirements.

In defining the survey scope, pay special attention to: onsite data collection; special requirements for testing steam traps; and trap replacement philosophy.

Onsite data collection. During the survey, the testing team typically populates a database with such information as trap identification number, line pressure, trap model, connection type, and simple application notes such as drip or tracer. This application information should be expanded into as many different classes as the surveyor can reliably identify — for example, stainless steel tracing, copper tracing, sulfur line tracing, instrument tracing, turbines, and flare lines — because each of these applications may require a different type of trap. More detailed application classifications can also be valuable in identifying trends and root causes of failure, which is important for improving future trap selections and installations.

Another database field is priority. This may be as simple as differentiating among critical, important, and normal application significance, although additional classifications may be beneficial. Typically, site personnel will need to populate this field or provide onsite support to contract surveyors. The priority together with the type of application and other survey results can be used to prioritize maintenance responses beyond simply fixing the largest leaks. For example, a cold trap on critical instrument tracing or a critical turbine may warrant immediate attention to avoid an erroneous alarm and subsequent plant shutdown.

Special requirements for testing steam traps. It is crucial to determine the root cause of any cold trap's diagnosis in order to develop an appropriate maintenance response. A trap may be cold for several reasons — for instance, it might have failed closed or be blocked; it might have been valved out because it was leaking, on an abandoned line, or on a line that is temporarily out of service; it might have been mistakenly diagnosed as low-temperature based on an incorrect pressure assumption; or an upstream strainer might be blocked. While this work may accrue additional costs, it typically has a good return on investment. For example, the simple act of blowing down an upstream strainer and retesting the trap often eliminates the need to replace the trap, and may even prevent shutdowns due to catastrophic turbine damage or a turbine trip.

Traps on high-pressure (*e.g.*, >1,000 psi) steam lines can be difficult to diagnose with ultrasonic technology, so alternative methods, such as thermal imaging, may be necessary. Ultrasonic testing can also be affected by ultrasound propagating from local sources, such as flow through a nearby control valve or a leak through an adjacent bypass valve, as well as by vibration from turbines or rotating equipment. In these cases, additional testing may be required. This should be defined before the survey begins, so that testers understand the requirements and are technically able to carry them out.

Trap replacement philosophy. Maintenance programs to diagnose and repair unhealthy steam traps often focus on leaking traps, while ignoring or placing a lower priority on cold traps. Cold traps are often perceived as less critical than leaking traps. However, the impact of cold traps is much more serious. The philosophy and budget for replacing cold traps should be considered during the planning stage.

A survey of a large facility might identify a significant number of traps that have small leaks. The company may not have the resources to repair all of these leaking traps, and the costs associated with a small leak may not justify the expense of replacement. Consequently, the plant's philosophy may be to address traps only when the steam leak exceeds a specified quantity. If the trap is leaking even a small amount of steam on a continuous basis, the leak will get worse and likely justify replacement during the next survey.

Program implementation

If the trap-management program has been well planned, execution should go smoothly. The areas that are most critical to the success of the implementation phase are testing, maintenance response, and oversight.

The first decision that needs to be made at the outset of implementation is to identify the individuals who will perform hands-on trap testing and follow-up maintenance actions. This often involves determining whether onsite personnel will have sufficient time and training to properly diagnose trap operation, or whether it would be better to contract an external specialist to perform the survey. It may also be a challenge to keep general maintenance technicians focused on trap testing and repair/replacement due to other maintenance or process priorities.

In deciding who will perform testing and maintenance, consider the following credentials of the person or team:

• safety record and safety training

• experience using testing equipment that makes automatic and accurate trap condition judgments based on empirical reference data

• experience and training, particularly regarding the correct identification of steam trap models, principles of operation, and installation practices

• availability to undertake the work without being diverted to other issues

• references if an external testing service is being considered.

Most facilities either use an external specialist for testing and a dedicated in-house contractor for trap replacements, or form an in-house team (possibly including an embedded contractor) to perform the testing and to make any necessary trap repairs or replacements.

Before testing starts, a training session on trap selection and installation should be conducted for all technicians. This is essential, because the benefits of the program could be lost if a trap is not correctly diagnosed during testing, the proper replacement trap is not selected, or the replacement trap is not installed correctly. In addition, the trap installation drawings should be reviewed, modified as needed, and approved in advance of any installation. It is beneficial for the steam-trap vendor to review and validate several of the initial replacements to ensure they are properly installed according to the manufacturer's recommendations. This allows for early identification of deviations, minimizes ineffective expense allocation, and enables quick retraining of maintenance personnel before a problem becomes significant or difficult to correct.

Once the resources have been identified, other testing logistics, such as nondisclosure agreements, work contracts, site access, permits, and licensing, should be addressed according to the company's standard procedures.

Testing

Three aspects of testing are commonly overlooked and warrant special consideration:

Locating and identifying the trap to be tested. The first survey in a plant or production unit may require operations support to locate all of the traps. During the initial survey, specific trap-location information should be recorded so that future surveys can more easily locate the traps. This could be done by entering notes that describe trap locations into a field in the steam-trap database, or by marking trap locations on a map of the facility. The cost of plotting trap locations on a map without software specifically designed for this purpose can be significant, so the additional cost to collect and document trap location data should be weighed against the expected future economic savings.

Trap access. Some traps might require a ladder, scaffolding, special access permits, or lifts; some might be covered with insulation or screening that prevents testing. Provisions for testing these difficult-to-access traps should be included in the request for proposal given to contractors before they bid on the job.

Process operations support. Support from process operators can be extremely valuable. Because they are familiar with the unit, experienced operators can help to ensure that all traps are located. They can provide accurate data on trap operating conditions, as well as whether the trap is genuinely in service by locating and determining the flow status of isolation valves. And, they can blow down the strainers of cold traps and help facilitate the testing of traps that are valved-out but should be in service.

Once a trap has been located, identified, accessed, and confirmed to be in operation, data logging, testing, and tagging are straightforward. However, some people find it difficult to classify and judge traps that are not being tested or are not in service. Consequently, guidelines for classifying traps whose operating condition is unknown should be developed. Traps that are not operating at the time of testing, for example, those on winterization lines, lines that are used only occasionally, or abandoned lines, should be classified as not in service. Traps that were not tested because they could not be accessed should be classified as not checked.

At large plants with several thousand or more steam traps, the testing results should be handed over to the maintenance team at least once a week while the survey is underway so that failures can be addressed as soon as possible. Such quick communication minimizes the negative effects of failed traps. It also avoids overwhelming the maintenance department with a long action list.

Maintenance response

The maintenance planners who prioritize personnel time and ensure that materials are ordered and ready for scheduled jobs should get involved early in the program-planning phase. Once the survey starts, the planners will manage the purchase, inventory, and allotment of steam traps and repair parts, place work orders, arrange scaffold access, and facilitate maintenance work.

All maintenance actions (*i.e.*, trap repair or replacement) should be documented by recording the date, action, new trap model, and comments. The data should be logged in the database that contains the diagnosis of the failed trap's operating condition. This will enable the analysis of accurate and historical results to improve the trap-management program. This final step of connecting maintenance records to the steam-trap database is often not done, but it is necessary for the ongoing improvement of the trap-management program.

Oversight

Successful programs are often driven by the involvement of at least two enthusiastic individuals, one in a management oversight role and the other in a supervisory and/or execution role. It also helps if higher levels of management in both operations and engineering support the trap-management initiative. Companies that have been most successful also usually have senior executives watching over program implementation.

Accurate and timely reporting of activities is essential. Since the benefits of the trap-management program are not attained until a trap failure is corrected, it is more important to track maintenance response actions than to track survey findings. The program status report should include data on:

- number of leaking traps replaced, the amount of steam-loss prevented, and the monetary savings associated with preventing that steam loss
- number of leaking traps waiting for maintenance and the amount of steam being lost
- number of cold traps replaced
- number of cold traps still in place, especially those classified as critical or on turbines or instrument tracing
- classifications of traps of unknown status
- cost of the survey and repairs (including parts and labor).

Milestone replacement targets should be established, reports reviewed monthly or quarterly, and the site held accountable for repairing failed traps according to the corresponding schedule. The infrastructure, content, and procedures to create and circulate the performance reports should be carefully planned to ensure that the reports can be generated quickly and easily. For example, software that is designed for the effective management of a steam trap population and that provides detailed trap-condition analysis, as well as reports on failure rate and economics, is available.

It can also be very helpful to involve a knowledgeable steam-trap vendor representative in the program on an ongoing basis to provide expertise and to help make steam system and trap-management program improvements.

Sustaining and improving the program

After the survey is completed, the failure data should be analyzed to identify common failure modes, and the effectiveness of the maintenance response should be reviewed to identify areas for improvement.

Once a company has survey data for three to five years, it should analyze the historical data to identify: common failure modes; trends in failure rates; trends in the number of traps classified as not in service and untested; the number of failures being carried forward to the next survey without being addressed; failure trends by applications or types of traps; and the locations where traps have frequently failed after maintenance action has been taken. This analysis may indicate an application, piping, or trap selection problem. The root cause of frequent failure should be identified and addressed. It is not uncommon for a significant percentage of a site's failures to be repeat failures in certain locations.

Failure rates typically decrease rapidly soon after a program is initiated and then level off. At this point, the company must determine whether the steady-state failure rate can be further reduced by improving the management program or is already as good as it can be. The historical analysis may provide clues to help with this determination. For example, it is possible for annual failure rates to decrease (which looks good) while the number of not-in-service and not-tested traps increases — which may indicate that problems are being hidden.

Finally, the annual survey analysis should be documented, and the trap testing leader, site champion, and trap vendor representatives should hold a review meeting to discuss the analysis and lessons learned that year.

Final thoughts

If the trap-management program is well run, the annual savings will gradually decrease as new traps and better technology are deployed. However, there are still many other opportunities to improve the performance of the steam system, including initiatives to improve specific steam-using applications such as reboilers, heat exchangers, turbines, and air heaters, as well as to optimize the entire steam and condensate system balance. CEP

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