DESIGN GUIDE 13

“Use Available Data to Lower System Cost”

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(This article originally presented & published

May 2011

***IETC2011 33rd Industrial Energy Technology Conference* proceedings)**

STEAM BASICS: USE AVAILABLE DATA TO LOWER STEAM SYSTEM COST

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ABSTRACT

Industrial steam users recognize the need to reduce system cost in order to remain internationally competitive. Steam systems are a key utility that influence cost significantly, and represent a high value opportunity target. However, the quality of steam is often taken for granted, even overlooked at times. When the recent global recession challenged companies to remain profitable as a first priority, the result was that maintenance budgets were cut and long term cost reduction initiatives for steam systems set aside due to more pressing issues.

One of the regrettable results of such actions is that knowledgeable personnel are re-assigned, retired, or released when necessary steam system cost reduction programs are eliminated. When the time arrives to refocus on long term cost reduction by improving the steam system, some programs may have to start from the beginning and a clear path forward may not be evident. New personnel are often tasked with steam improvements when the programs restart, and they may experience difficulty in determining the true key factors that can help reduce system cost.

The urgency for lowering long term fuel use and reducing the cost of producing steam is near for each plant. Population growth and resultant global demand are inevitable, so the global economy will expand, production will increase, more fossil fuel energy will be needed, and that fuel will become scarce and more costly. Although fuel prices are low now, energy costs can be expected to trend significantly upward as global production and demand increase. Now is the time for plants to make certain that they can deliver high quality steam to process equipment at lowest system cost.

There are three stages to help optimize plant steam for best performance at a low system cost;

Phase 1: Manage the condensate discharge locations (where the steam traps & valves are located),

Phase 2: Optimize steam-using equipment, and

Phase 3: Optimize the entire steam system.

This presentation will focus primarily on management of the condensate discharge locations (**CDL**s) and show sites how to use readily available data to more efficiently achieve goals; but will also provide insight into how the three stages interact to reduce system cost and improve process performance.

BACKGROUND

<u>Are Steam Systems Taken for Granted / Overlooked?</u>

Steam represents the lifeblood of an industrial steam plant, bringing needed heat or power to each key process. Even so, how often is the quality of the supplied steam considered as critically important, especially by taking proactive measures to eliminate the amount of wetness (entrained moisture and condensate) in the steam system? In addition to the heat transfer value contained within, how else does steam affect the plant's system cost?

<u>A Self-Help Checklist</u>

Here's a quick checklist of 25 questions to determine the real importance of steam at a site:

1. Are there multiple instances of external steam leaks from piping, especially flanges or valves?
2. Is water hammer present in the system?
3. Are multiple bypass valves opened around steam trap locations, particularly at process equipment (like heat exchangers)?
4. Are multiple blowdown or bleed valves open and discharging live steam to the atmosphere?
5. Is condensate at key process equipment being wasted to drain?
6. Are key steam-using process equipment suffering unexpected failures or shortened service life, particularly;
   - Loss of flare control or damaged flare tips?
   - Channel head gaskets leaking steam?
   - Turbine trips or blade plating?
   - Rotted heat exchange tubes / stratified coils?
7. Is the "annual" steam trap testing program sometimes skipped for a year or two?
8. Is steam trap testing and replacement given a third-tier priority?
9. Were less than 90% of all steam traps working properly after installing intended replacements following the last survey?
10. Are cold / blocked traps replaced as a second priority – with leaking traps replaced first?
11. Would the site like to improve the quality of the steam system, but there's never enough time or budget?
12. Does the site have a shortage of qualified personnel to replace steam traps?

13. Is there never enough time or resource to periodically blow down strainers / drip pockets?
14. Is there a "one size fits all" approach towards steam trap selection; using the same model for all drip and tracer applications?
15. Does the site remove strainer screens from steam traps to prevent blockage?
16. Is at least the same amount of steam produced today as 4 years ago?
17. In the past 3 years, has the plant suffered a major outage caused by retained condensate damage?
18. Do product lines or tracing lines freeze?
19. Is the sulfur area a nightmare?
20. Is the site worried about excessive CO_2 emission?
21. Is the same amount of condensate (or less) recovered today as 4 year ago?
22. Is vent steam increasing?
23. Has the plant identified valuable recoverable condensate for which no project has yet been established?
24. Has the site suffered a water-induced flare-out in the past 3 years?
25. Are the majority of single stage turbines slow-rolled?

Interpreting the Checklist Responses

Following the principle that actions can speak louder than words, the checklist represents a site's self-evaluation report. Even well-intended sites can subconsciously ignore strict adherence to a best practices program that sustains a high performance steam system. The original plant was probably designed well enough, but with additional steam demand and reduced maintenance budget or care, the steam system can unknowingly be allowed to slowly deteriorate.

Each increment of deterioration can lead to a new, "reduced-expectation benchmark," that becomes accepted by the site relative to how they measure the health of the steam system. This can be particularly true with newer employees who did not witness the original steam system viability and reliability. The tendency is often to challenge each benchmark to "do more with less." Resultantly, less maintenance expense and reduced investment may seem to justify the common practice of "do only what is absolutely necessary" because steam tends to be somewhat forgiving; even as a system's health embarks on a slow downward spiral.

However, if the steam system isn't at least comparable or in better shape than when the plant was constructed, then something's drastically wrong. Materials, knowledge, and methods to track performance are better now than ever. If a steam system hasn't been at least maintained to the original standards, then that outcome is at least partly by choice.

It may seem like a somewhat harsh scenario, yet even today in the face of some of the highest energy prices experienced by industry, it is all too often reported that sites don't repair failed steam traps, don't repair blocked steam traps with a first priority (even though it is clear that blocked traps can no longer remove condensate from the system), and neglect to perform proactive, focused annual surveys of the steam trap population.

Basically, every "Yes!" answer to the checklist indicates that the steam system doesn't have a high priority. The need for quality steam is a core principle. In order to achieve superior performance, steam must have almost all condensate removed, typically by properly functioning steam traps. High quality steam delivers maximum heat without incident to using equipment.

On the other hand, poor quality steam is typically characterized as steam that contains significant amounts of water or corrosion elements. Retained water has such a far-reaching, negative effect on steam system performance; which is why those self-help questions are fairly good indicators of the site practices and true concern for the steam system. Industrial sites are production facilities, relying on quality steam to deliver the most effective heat. It's an impossible task if the steam source is not protected and well-maintained.

Steam Systems Can Be Flexible – To a Point

There can be a tendency to feel that a neglected steam system will still perform well enough, until a catastrophic event occurs. Here are some worst case issues that confirm the steam system's health may have deteriorated too much:

- Shattered steam distribution pipe
- Personnel injury from flying pipe shrapnel
- Turbine compressor / pump shutdown damage
- Flare tip destruction
- Hundreds of flange, piping, & valve leaks

For case history valuations of some catastrophic events, see **Table 1.**

BACK TO BASICS

Control Your Own Destiny

Well before calamity strikes, there are typical warnings which are contained in the checklist questions. As such, the checklist can serve as a guide to minimize catastrophic events.

Improvement just requires a deeper understanding of the root causes of system failures. In many cases, the cause is retained condensate – condensate meant to be removed, but for some reason it was not discharged from the steam system. Often, the site may have actually chosen this outcome over another by having a repair practice to fix leaking traps first, or neglecting to address cold or blocked CDLs.

Fix Leaking Traps or Blocked Traps First – Which?

Everyone involved with steam trap repair has heard the valuation of a single "Leakage Failure" steam trap. Suppose a single blowing steam trap may leak energy valued at $2,800 / yr. For 1,000 leaking traps, that's over $11 Million during a 4 year period if not repaired. Why would anyone allow those traps to keep blowing live steam?

Since the cost to replace each leaking trap might only be $500, and its life is expected to reach 4 years, then replacing those traps only costs $500,000; and the site stands to gain over $10 Million in reduced operating expenses based on their investment. It should be an easy decision. Even if not all of the Leakage Failure steam traps are blowing steam at full force, and the failed traps just experience various lower steam leakage levels; even at half valuation the repair opportunity still represents a $5 Million return on investment, or a 10:1 return factor. For a simple chart analysis, see **Table 2.**

However, unless they are somehow related to safety issues, Leakage Failure steam traps should probably not be given first priority for repair. The worst things about Leakage Failure traps are that they pressurize the condensate returns, cause excess CO2 emission, and waste energy. Even so, they still perform the basic function of a steam trap – removing condensate from the steam system. It's just that leaking steam traps are inefficient in performing their basic task.

The really serious and potentially dangerous issue is with the Blockage Failure steam traps – traps which no longer perform the basic function of removing condensate from the system. If the thought process goes back to the beginning of the system's design, it can be imagined that perhaps the original designers allowed for 5 – 10% redundancy in CDLs. Since that original time, the system probably flows a lot more steam, and it is possible that the boilers are being pushed to the point of having more entrained condensate. When a CDL is blocked, the condensate is retained in the system. Where does it go?

Utility steam typically moves at velocities of 75 – 100 mph in a steam distribution line, even higher at times. When retained condensate pools, wave action can cause it to be propelled like a missile through the pipeline. Any elbow, pipe bend, or other directional change becomes the target. Typical targets include turbines, flares, valve packing, and flange gaskets that release the dynamic energy upon impact.

The difficulty with Blockage Failures is that most sites haven't performed sufficient root cause of failure or cost analysis to justify the repair of blocked CDLs or their traps as a first priority. The cost of energy loss goes directly to the bottom line, but it is more difficult to value the cost of damages caused by a population of multiple, blocked traps.

Use Available Data to Lower System Cost

Blocked traps do represent a significant cost reduction opportunity, but each site has to determine a representative *preventative* site value. This can be done by accumulating data relative to historical system failures over an analysis time period, summing the resultant prior costs, dividing by the number of traps in the area, and then dividing again by the number of years evaluated. The result is the annual average blocked trap value estimate per installed steam trap.

Suppose that during the past 2 years, there was a single event where a main compressor turbine failed due to water hammer because 4 traps on the supply line were Blockage Failures that were not repaired, resulting in a shutdown worth $3.6 Million. How could this event be valued?

Imagining the area had a total of 360 steam traps, then dividing the loss value from the event by both the trap quantity and the number of years; yields an estimated failure cost of $5,000 per blocked trap. Clearly if all traps in the area had removed condensate, the damaging slug to the turbine would not have occurred. So, the value of each CDL in the area to be removing condensate at all times can be estimated at $5,000 each.

Alternatively, only 4 traps failed blocked, and dividing the loss value by the 4 blocked traps directly responsible estimates the individual value of their blockages at $900,000. Alternative estimation methods for Blocked Failures are shown in **Table 3.**

ZERO RESET

Fix All Failed Steam Traps

One result should be evident, it's not justifiable from an operating cost standpoint to ignore the repair of Leakage Failures; nor is it effective from a Reliability, Maintenance, or Process standpoint to not repair Blockage Failures. All traps have to be repaired to restore the system to an "as designed", "as built" condition. This maintenance strategy is called "Zero Reset," and is a major requirement to sustain a high performance steam system.

HOW TO EVALUATE TRAP SELECTIONS

Use Available Data?

Manufacturers and distributors tend to develop strong loyalty and confidence in their products. However, the best person to evaluate trap performance is often the member of the site's steam trap management team who has the most accurate data, and who knows how to use it. Want to determine how long a particular trap lasts?

Here is a simple method or strategy to obtain a valuable trap population database:

1. Qualify exactly what constitutes a trap failure condition. A trap that is only "slightly leaking" or "low temp" is still failed. Establish the definition of "failure" to provide clear guidance to testers of what to report. A clear definition is necessary to compare historical trend data. Typically, a "failure" is any steam trap that does not test perfectly "good" as compared to its originally installed condition. The high probability is that "slightly leaking" steam traps will soon be "blowing" live steam. Identify them for replacement to avoid unnecessary loss.
2. Use independently validated testing tools, such as the TrapMan® System to determine trap condition based on an empirically derived judgment.
3. Use experienced surveyors that possess up-to-date testing certificates to ensure diagnosis quality.
4. Perform a trap survey annually for 4 years straight to gain historical "state of the population" data.
5. Perform "zero reset" for all failures within 6 months after the survey is completed.
6. Record all trap failures over the 4 year period.
7. Calculate the life cycle of the steam traps used by dividing the trap population by the zero reset replacement quantities – up to the point where a full "turn" of the population occurs. For example, if a population contains 5,000 steam traps, how many months does it take until the sum of "zero reset" replacement traps totals 5,000? If it occurs within 3.5 years, then the population life can be similarly estimated.
8. Understand that 4% annual failure rates aren't sustainable in mature populations. A 4% annual failure rate would correlate to a 25 year trap life.
9. Individual trap surveys provide "failure state" information relative to the system's current health. Multiple surveys are needed to trend performance & obtain "failure rate" data.
10. Select reasonable trap reliability targets (sustainable failure rates) that are achievable, then work the plan forever to maintain steam system quality.

Once the site has a reasonable and continuous steam trap testing program in place as a core foundation to build upon, then an advanced, long term improvement strategy can be developed. With a solid survey database and historical maintenance records in hand, a site can use the available data to find other opportunities that will lower system cost.

When analyzing such data, a key criterion is to identify which events or characteristics provide the most feasible, high value targets. A summary of typical areas to consider are shown in **Table 4**.

Opportunity Targets

Potential value from improvements exists wherever there is loss. Typically loss focus is on the blowing steam from Leakage Failure steam traps, but there are often other, much more valuable targets. It could be useful to have a map of sorts to know where to look; to find the best opportunity targets.

One way is to identify correctable targets, then analyze the failures attributed to damage caused by condensate in order to learn how to eliminate or mitigate the future risk. Some of the focus areas are listed below:

1. Unscheduled Shutdown Events
2. Unscheduled Maintenance Events
3. Off-spec Products
4. Various Steam System Leakages

Unscheduled shutdowns occur when something goes wrong - a turbine trips, an analyzer floods, a key compressor is destroyed. Did the analyzer flood because the trap was blocked? Was the compressor's destruction due to condensate slugs or something else? Often the intent is to repair the damage and bring the system back online as soon as possible. It is said that anything that can go wrong will; so unless the cause is found, analyzed, and a solution implemented – the future risk for the same type loss exists. Studying the system data until the cause is clear is necessary to reduce future system cost.

Unscheduled maintenance events are similar to the prior reviewed situation. However, the system may continue to operate, such as a reboiler with a

[1] TrapMan® is a registered Trademark of TLV Co., Ltd., Kakogawa, Japan

blow-out on a channel head gasket. Clamps can be installed to keep operating, but more similar events can be expected until the cause is determined and eliminated.

"Off spec" products are often created when control systems don't work as designed, and the process can be rendered incapable of close control when condensate overruns the process. For example, extruders may suffer from poor cuts because of retained condensate in the knife section, tires may suffer cold spots for the same reason, or heat exchangers may experience wide temperature swings as retained condensate slugs its way through the exchanger as inlet steam pressure varies.

Steam System Leakage Types

Regarding various steam system related leakages, there are basically 5 types;

- Functional Steam Loss (**FSL**) is the loss of steam through properly functioning steam traps. The amount lost is related to steam trap design and manufacture quality, so improvements can be made to selection in order to lower costs.
- Failure Steam Loss (**XSL**) is the loss that occurs when steam traps fail. So, loss can be mitigated by using system data to determine the more reliable steam traps to standardize for future cost reduction.
- Coincident Steam Loss (**CSL**) is the loss that occurs when bypasses are opened around process traps because the system won't work without the bypass opened. It means that the installed steam trap can't do the job, and another drainage method must be used. CSL usually represents an exceptionally high value. Other examples of CSL might be bleeders ahead of turbines or on soot blower lines, or opened blowdown valves in a sulfur plant. Finding the root cause and implementing a correction will reduce cost.
- Coincident Condensate Loss (**CCL**) can be similar to CSL relative to cause, but instead of blowing steam to effect system drainage, operations are achieved by dumping perfectly good condensate. Finding the reason for inability to recover and return the condensate will also result in reduced generation costs.
- External Steam Loss (**ESL**) occurs when piping systems are damaged, and the usual causes are water hammer damage to flanges, valve packing, or fittings. Excess water in the steam line, or flash steam in the condensate line may also be the cause of erosion or hammer damage. Finding the root cause can result in significant cost reduction to the site.

CONCLUSIONS

Site members are often faced with many challenges, particularly just keeping operations intact and producing on target. It may often seem that there is not enough time or budget to focus on system improvements. However, the concepts, checklist, and tables in this article may provide some direction to using available site data to identify key opportunity value targets.

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TABLE 1

Failure Event	Historical Value
Flare Nozzle Replacement	$500,000
Analyzer Failure Plant Shutdown	$1,000,000
Flare-out Fine	$1,700,000
Gas Compressor Failure	$3,600,000
Main Turbine Failure	$20,000,000

TABLE 2

Leaks	Annual Value	4 Yr. Value	Repair Cost	Return Ratio (:1)
1	2,800			
1000	$2,800,000	$11,200,000	$500,000	21

Repair Cost $500
Blowing Steam Estimate $2,800 @ $10 / 1,000 # steam

TABLE 3

Failure Event	Term	Historical Value	# Traps	Cost / Trap	Annual Cost / Trap
Turbine Failure	2	$3,600,000	360	$10,000	$5,000
Turbine Failure	2	$3,600,000	4	$900,000	$450,000

TABLE 4

Focus Areas	Opportunity
Unscheduled Shutdowns	Find source & prevent reoccurrence of retained condensate
Unscheduled Repairs	Find source & prevent reoccurrence of retained condensate
Off-Spec Products	Find source & prevent reoccurrence of retained condensate
FSL (Functional Steam Loss)	Select Traps with more efficient design
XSL (Failure Steam Loss)	Select Traps with higher reliability
CSL (Coincident Steam Loss)	Eliminate causes for bypass, blowdown, or bleed steam
CCL (Coincident Condensate Loss	Eliminate cause for wasted condensate
ESL (External Steam Loss)	Find source & prevent reoccurrence of retained condensate

NOTES

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