CAPTURING ENERGY SAVINGS WITH STEAM TRAPS

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ABSTRACT

This paper will discuss the energy savings potential of steam traps and present the energy, economic, and environmental reasons why an active steam trap maintenance program is good for the company's bottom line. Each topic will be reviewed in addition to some new services, products, practices and technology available to help maintain or improve the efficiency of steam systems.

INDUSTRIAL ENERGY CONSUMPTION

Of the total energy consumed by industry, approximately 50 percent is used to generate steam which can cost between $3 and $8 per 1,000 pounds. Therefore, steam energy conservation must be a priority issue and can represent significant savings. Steam energy conservation is also important for other reasons, including the reduction of environmental emissions.

For any steam system to be energy efficient, it's important to select and install the correct type and size steam trap for each application. This means a commitment must be made to training those responsible for steam traps on a daily basis. Finally, it's important to recognize that a steam trap program will reduce steam waste, which will reduce the amount of fuel burned, which will reduce pollutants generated.

THE ENERGY IMPACT

When steam leaks are allowed to go undetected and unrepaired, considerable energy can be wasted. The following example shows just how much. One steam trap (with 1/8" orifice) leaking just 12 pounds of steam per hour (a leak so small that it is almost impossible to detect with the human eye) loses 288 pounds per day or 100,800 pounds over the 350 operating days (or 8,400 hours) each year.

It's not uncommon for a steam system to have a thousand or more steam traps. Furthermore, a neglected steam system could typically have from 10 to 50 percent of the traps wasting steam. Without an effective steam trap testing and maintenance program, these failed traps may go unattended for years - wasting valuable steam on a daily basis.

THE ECONOMIC IMPACT

In an under-maintained or neglected steam system, leaks can be found in the piping, valves, process equipment, steam traps, flanges and other connections. The economic loss can be significant. To appreciate the massive economic impact of wasting steam, see Table 1.

Let's go back to our example of a 1/8" orifice blowing steam, which costs $5.00 per 1,000 pounds to generate. It will cost more than $500 to replace the lost steam.

As a leak becomes larger, even on the 30 pound system, the more costly it becomes. As can be seen in the table, a 1/2" leak going unrepaired for one year will cost more than $8,000 and if the leak is on a system with 125 pound service, the cost skyrockets to more than $25,000 a year.

Multiply these figures by the number of leaks in a system that have gone unattended for years, and the steam loss becomes astronomical. The out-of-pocket costs for replacing the lost steam could help improve productivity and the profit line in most companies.

Table 1 Steam Energy Loss by Orifice Size

Trap Application	Pressure psig	Orifice Size, In.	Steam Loss	
			lbs / hr	$ / Yr.
Process Traps	30	1/8	12	$504
	30	1/4	48	$2,016
	30	1/2	192	$8,064
	125	1/8	38	$1,596
	125	1/4	150	$6,300
	125	1/2	602	$25,284
Drip & Tracer Traps	150	1/8	69	$2,898
	300	1/8	132	$5,544

One of the most economical ways to reduce energy waste is to identify, then eliminate areas of steam loss. Based on the successes of hundreds of companies that have addressed these issues, steam traps are the obvious starting point. Therefore, understanding the role and function of steam traps and why a continuing process of trap testing and maintenance are essential.

STEAM TRAPS

A steam system is designed to transport energy from a central location - the boiler - to remote locations in the plant, building, or operating complex. A properly designed and maintained system can lower energy, maintenance and operational costs by promoting system efficiency.

To accomplish this efficiency demands that the condensate be removed from the piping as soon as it forms. Water moving along the bottom of the pipe can be effectively discharged with an automatic valve called a steam trap.

An efficient steam trap must do more than just remove condensate. It must minimize steam loss, have a long and dependable service life, resist corrosion, vent air and CO_2 which can form corrosive carbonic acid, operate even in the presence of dirt and scale and operate against the system's back pressure.

BUT WHICH TRAP

There are many different types, sizes and models of steam traps to choose from and each is designed to respond to conditions associated with specific applications. It's important to know which unit to install on each application. Before this can be determined, one must understand how each type of trap functions under certain conditions.

There are four basic types of steam traps: Inverted Bucket (IB), Float & Thermostatic (F&T), Disc, and Thermostatic. Each type of trap has its own unique mode of operation and is, therefore, employed in different types of applications. Table 2 shows a comparison of how various traps perform against a few of the most desirable characteristics.

In addition to the operating characteristics, close attention must be paid to properly sizing the steam trap to be installed. If the trap installed is too small to handle the condensate load that reaches it, the condensate will back up and eventually block the flow of live steam. By contrast, a trap that is too large will wear out prematurely and waste steam. In either case, the trap performs at less than maximum efficiency.

TRAINING TEACHES THE WHY AND HOW

Maintaining an efficient steam system also requires well trained personnel who understand all facets of the system. This includes understanding how various trap types operate, how to size and specify traps, where and how to install each type, and how to test traps.

Few, if any, schools or universities include courses to educate students about steam traps. Therefore, steam trap manufacturers have filled the void with many quality training programs.

Some trap manufacturers offer extensive steam energy seminars. Sophisticated glass piped exhibits and demonstration laboratories help educate participants about what actually happens inside a steam system and inside vari-

Table 2 Selected Steam Trap Performance Characteristics

Characteristic	Inverted Bucket	F & T	Disc	Thermostatic
Method of Operation	* Intermittent	Continuous	Intermittent	Intermittent
Energy Conservation (Time In Service)	Excellent	Good	Poor	Fair
Resistance to Wear	Excellent	Good	Poor	Fair
Corrosion Resistance	Excellent	Good	Excellent	Good
Resistance to Hydraulic Shock	Excellent	Poor	Excellent	Poor
Vents Air and CO_2 at Steam Temperature	Yes	No	No	No
Operation Against Back Pressure	Excellent	Excellent	Poor	Excellent
Ability to Handle Dirt	Excellent	Poor	Poor	Fair
* Drainage of condensate is continuous. Discharge is intermittent.				

ous types of traps under conditions that can be varied on command. In addition to factory training programs, similar training programs are offered by company representatives in customers' plants as part of regular maintenance training efforts.

The training efforts are supplemented with extensive training aids, field experience, trap surveys, and knowledgeable field representatives committed to continuing education programs of their own.

Some trap manufacturers have expanded their value-added service offerings to meet a customer demand for steam trap audits and regular trap testing programs.

TOOLS FOR TESTING

Several trap manufacturers now offer proprietary tools that help make trap testing easier, quicker, and more accurate. These products help identify potentially failed traps by sensing heat or measuring variables across the trap. Some products are designed for a particular type of trap.

For example, one manufacturer is now marketing a system specifically designed for its inverted bucket traps. The products can analyze conditions in the trap in a matter of seconds, while the trap is on-line and in-service.

This new technology offers several advantages. First, an initial steam trap survey shows that three out of every four steam traps in a facility are operating properly. To locate the 25 percent that are failed has required checking every trap in the system. With these testing products, one can quickly identify the failed traps without investing hundreds of staff hours testing properly functioning traps. Field results show a 100 percent accurate trap reading with respect to traps that are closed or blowing through.

These new products utilize a multi-sensing probe inserted into the bottom of an inverted bucket steam trap to monitor the condensate level beneath the bucket, and the temperature of that condensate. The data from the probe can be processed through a PLC or a PC and transmitted via modem hundreds of miles away.

WHO WILL TEST THE TRAPS

Because trap testing is essential to a sound steam energy conservation effort, someone or some organization must take responsibility for the process. Trap testing is a process because it must go on year-in and year-out.

The most successful steam system maintenance efforts will be found in organizations that have made a commitment to reducing energy waste. Someone within these organizations surfaces as the "champion" of steam traps and commits to being trained and fully informed on subjects related to traps.

Because of the significant time, labor and cost commitments that must be made to having a designated trap champion on staff, other organizations are choosing to contract with trusted outside suppliers or service companies to manage and test their traps on a scheduled basis.

This commitment to steam traps, whether it includes an in-house program/process or if a contract service is used, has shown a favorable cost/benefit ratio for many companies. Some of the results are shared in the following examples.

CASE EXAMPLES

Following are two case studies that reflect the economic importance of testing steam traps and maintaining steam systems. They were selected from hundreds of published success stories.

A **Canadian refinery** with more than 7,000 steam traps has a dedicated steam trap individual who reports that even after 10 years of continued service, the trap failure rate is still under 5 percent. In the first few years following the trap testing program and the trap replacement effort, energy savings were more than $1 million a year. Many of the traps installed were of the energy efficient inverted bucket style. Even after 10 years, the energy savings related to traps range from $30,000 to $40,000 per year - after expenses.

A **plastic laminating facility** in Ohio uses 80 percent of its 540 million pounds of steam for process equipment such as treater ovens and flatbed presses. After testing and upgrading its traps to inverted bucket traps, steam pressure to this equipment was reduced from 225 psig to 150 psig. Steam energy savings equaled $20,000 a month, plus productivity was improved.

Case studies show that certain traps have longer service lives than others and the longer a trap functions properly, the less costly it is in the long run. Therefore, it may be more economical to replace the short-life traps with designs that have longer operating lives. Furthermore, this will result in a more efficient use of energy and that equates to less fuel being burned and thus less air pollution.

ENVIRONMENTAL FACTORS

To understand and appreciate the environmental impact of wasting steam, let's revisit that small leak in a steam trap with a 1/8" orifice that can waste more than 100,000 pounds of steam each year.

As a leak becomes larger, even on the 30 pound system, the more costly it becomes. For example, a 1/4" leak going unrepaired for one year will waste more than 400,000 pounds of steam. If this same 1/4" leak is on a system with 125 pound service, the steam loss increases to more than one million pounds a year.

THE FUEL TYPE FACTOR

Obviously the type of fuel, the method used to fire the boiler when using coal, the heating value, and the analysis of the fuel all contribute to the amount of pollutants generated. The emissions measured include: particulate matter, sulphur oxides , nitrogen oxides, carbon monoxide and total carbon. See Table 3.

As an example, locate 150 psig and 5/64" orifice then follow the chart from left to right for bituminous coal. That one little leak would require 11.9 tons of coal per year to replace the lost steam. When that amount of coal is burned under the stated conditions, the following pollutants are generated:

727 pounds of Particulate Matter
465 pounds of Sulfur Oxides
250 pounds of Nitrogen Oxides
7.2 pounds of Carbon Monoxide and
9.7 tons of Carbon per year.

If the coal costs $57 per ton, then the annual fuel bill to replace that 27 pounds per hour is $679. The fuel savings alone can easily justify replacing a failed steam trap as soon as it's identified.

Proceed further to the right and see the pollutants created by using residual oil and natural gas as the boiler fuel. Remember, these figures are for just one steam trap, or system leak, wasting steam for 350 days per year.

SUMMARY

Whether the reason for wanting to improve the efficiency of the steam system is economic or environmental, properly functioning and maintained steam traps should be a priority. To ensure this, it's recommended that steam traps be checked and tested on a regular basis whether by the in-house dedicated "champion" or the contracted service organization.

Traps should be tested no less than once a year. And, it is important to recognize that utilizing steam traps with long service lives are more efficient over time. This will help reduce the fuel consumption at your boiler and when less fuel, even natural gas, is burned, you will save significant amounts of money and simultaneously reduce harmful emissions.

REFERENCES

1 Table 3 "Steam Energy Loss and Environmental Pollutants Generated by Blow-through Failure of One Steam Trap" is taken from Chart No.1131-B generated by Armstrong International Inc., and © October 1996.

Table 3

Table 3 — **Steam Loss and Pollutants Generated by Blow-through Failure of One Steam Trap[1]** **(Data by pressure, orifice size, and fuel type.)**

Biduminous Coal

	Press. psig	Orifice Size	Steam loss lb/hr	Fuel Used tons/yr	Fuel Used $ / yr	* Pollutants Generated P.M. lb/yr	SOx, lb/yr	NOx, lb/yr	CO lb/yr	Total C, ton/yr
Process Traps	30	1/8	12	5.3	$304	325	208	112	3.2	4.4
	30	1/4	48	21	$1,217	1302	832	448	12.8	17.4
	30	1/2	192	85	$4,866	5208	3330	1793	51.2	69.7
	125	1/8	38	17.0	$968	1036	663	357	10.2	13.9
	125	1/4	150	68.0	$3,874	4145	2650	1427	41	55
	125	1/2	602	271.8	$15,494	16581	10601	5708	163	222
Drip & Tracer Traps	150	5/64	27	11.9	$679	727	465	250	7.2	9.7
	150	No.38	42	18.4	$1,047	1121	717	386	11.0	15.0
	150	1/8	69	31	$1,739	1861	1190	641	18	25
	300	5/64	51	23	$1,307	1398	894	481	13.8	19
	300	No.38	79	35	$2,014	2158	1378	742	21	29
	300	1/8	132	59	$3,345	3580	2289	1232	35	48

Residual Oil

	Press. psig	Orifice Size	Steam loss lb/hr	Fuel Used gal/yr	Fuel Used $ / yr	* Pollutants Generated P.M. lb/yr	SOx, lb/yr	NOx, lb/yr	CO, lb/yr	Total C, ton/yr
Process Traps	30	1/8	12	1042	$427	10.4	491	57	5.2	3.6
	30	1/4	48	4169	$1,709	41.7	1964	229	21	14.4
	30	1/2	192	16675	$6,837	167	7854	917	83	58
	125	1/8	38	3320	$1,361	33	1564	183	16.6	11.5
	125	1/4	150	13280	$5,445	133	6255	730	66	46
	125	1/2	602	53118	$21,778	531	25019	2922	266	184
Drip & Tracer Traps	150	5/64	27	2385	$978	23.9	1123	131	11.9	8.3
	150	No.38	42	3677	$1,508	36.8	1732	202	18	12.7
	150	1/8	69	6106	$2,504	61.1	2876	336	31	21.2
	300	5/64	51	4588	$1,881	46	2161	252	23	15.9
	300	No.38	79	7072	$2,900	71	3331	389	35	25
	300	1/8	132	11745	$4,815	117	5532	646	59	41

* † Natural Gas

	Press. psig	Orifice Size	Steam loss lb/hr	Fuel Used CCF/yr	Fuel Used $ / yr	Pollutants Generated P.M. lb/yr	SOx, lb/yr	NOx, lb/yr	CO, lb/yr	Total C, ton/yr
Process Traps	30	1/8	12	1372	$556	0.41	0.08	19	4.8	2.3
	30	1/4	48	5489	$2,223	1.65	0.33	77	19	9.2
	30	1/2	192	21955	$8,892	6.59	1.32	307	77	37
	125	1/8	38	4371	$1,770	1.31	0.26	61	15	7.4
	125	1/4	150	17484	$7,081	5.25	1.05	245	61	29
	125	1/2	602	69938	$28,325	21	4.20	979	245	118
Drip & Tracer Traps	150	5/64	27	3141	$1,272	0.94	0.19	44	11.0	5.3
	150	No.38	42	4841	$1,961	1.45	0.29	68	17	8.2
	150	1/8	69	8040	$3,256	2.41	0.48	113	28	13.5
	300	5/64	51	6040	$2,446	1.81	0.36	85	21	10.2
	300	No.38	79	9312	$3,771	2.79	0.56	130	33	16
	300	1/8	132	15464	$6,263	4.64	0.93	216	54	26

* Source: Air Pollutant Emission Factors (Document AP-42), U.S. Environmental Protection Agency.
† SOx emissions are based on "average" sulfer content of 0.2 grains per CCF. Specification limits, and SOx emissions could be several orders of magnitude larger.
Fuel costs: Bituminous Coal = $57 / ton Residual Oil = $0.41 / gal Natural Gas = $4.05 / mcf