White Paper

What you don’t know about steam traps

Total cost overview

of mechanical steam traps

during the 30 year lifetime of your plant

Summary

Your steam powered process and utility equipment need condensate removal.

A choice to work with mechanical steam traps is the starting point to generate ever returning costs.

There are much better alternatives on the market, which are often looked upon as untrue, despite a respectful track record and a proven +30 year lifetime.

We kindly challenge you to permanently consider innovative technologies, which keep your installations state of the art.

Your reward is double: energy savings for your plant and reductions on greenhouse gasses.

Total cost overview of mechanical steam traps during the lifetime of your plant

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1 Introduction

You deserve insight on the total cost aspects of condensate removal.
These costs are widely spread and well-hidden in your organisation. It makes it difficult to group and point them to the initial cause, which is: the intended and irrevocable nature of any mechanical item to fail.

To efficiently assign budgets from valued resources, plant managers want to predict the total cost generated by these failures.
This paper looks beyond the yearly budgets that only show the daily maintenance cost. It gives insight in all costs behind the scenes, during the total life time of your plant.

You can only evaluate potential alternatives once this life time cost is worked out

The desired outcome would be to cooperate with your plant by handing you a new method of implementing maintenance free condensate removal systems.
Doing so, you will avoid all operational costs that pop up during the lifetime of your plant. This will not only benefit your efficiency, but all of us by you saving lots of energy and limit your exhaust on unnecessary greenhouse gasses.

2 Background

2.1 Purpose of steam traps

Plants that apply steam in their processes usually receive this steam from a boiler house or from exothermic processes. Steam is distributed throughout the plant to supply process applications with required heat capacities. Such transport goes along with radiation losses that convert a corresponding amount of steam into condensate. Also, during the heat transfer in all kinds of process exchangers, where steam gives up its latent heat, steam converts into condensate.

The remaining liquid (condensate) should be removed as fast as possible for several reasons.
A few technologies are used to drain this condensate, but the most common way to do this are mechanical steam traps.

2.2 Process versus Utility steam traps

Process steam traps are used in the heart of your production. They serve big heat exchangers such as reboilers, autoclaves, air heaters, evaporators, coils, reactor jackets, for which the operational outcome is linked directly with your production output.
Average sized chemical and petrochemical plants have only about 20 to 40 of such bigger process steam traps. Not much in numbers, but yet, they handle about 90% of your steam.
(level controlled systems are also a reliable alternative for traps but not the scope of this paper)

Utility steam traps drain the steam distribution network or smaller heating supports such as tracing, double pipe jackets and other heat loss compensating systems.
Average sized chemical and petrochemical plants have about 500 to 5.000 of such small steam traps. Pretty high numbers, but they handle only about 10% of your steam.

2.3 Basic principle of steam traps

Based on their operating principle, mechanical steam traps usually are classified in 4 groups:

- Floating
- Inverted bucket
- Thermostatic
- Thermodynamic

Detailed operating principles of traps are not the scope of this paper.
However, as a short summary: all the above principles are based on mechanical elements that open or close an internal valve at certain moments so condensate and non-condensable gasses can be drained.
Most of these traps open and close discontinuously, which is not 100% in line with the continuous outcome of condensate from heaters. However in most cases, it is acceptable to drain intermittent.

The alternative venturi traps are non-mechanical and always drain continuously.

2.4 Failure positions of steam traps

Service companies that inspect steam traps describe several categories of failure:
partly leaking / full blowing / closed / low temperature / out of service / upside down installation / wrong direction / …

When they classify failures of traps under normal conditions, there are usually only two positions to fail: in the open, or in the closed position.

<u>When steam traps fail in the closed position</u>
They obstruct the condensate removal and the application will drown in flooding and sub-cooling condensate. Your process will come to a stop. An eventual bypass might help, but could also result in less efficiency, steam losses, erosion and safety issues.

<u>When steam traps fail in the open condition</u>
They constantly pass steam. The Napier formula (see further) is a common way to quantify this amount of steam loss.
Although open failure unfortunately goes along with a lot of steam loss, at least the process can continue more or less in an acceptable way until the next shutdown to replace the trap.

For most mechanical traps the position of rest is equivalent to open failure. After all, a closed failure results in a forced process stop, for which nobody wants to take credit for.
It makes sense to build traps for open failure since the operator at least can maintain most of his production output while accepting the (unknown) energy loss. And Maintenance can prepare corrective actions for the next shutdown.

> *“The ‘Enbridge steam trap survey’ tested the condition of 41.124 traps in 216 plants over 5 years. This study showed a total of 24% defective traps (9.870 pieces).*
> *68% ‘blow through’ (6.719 pieces) and 32% ‘blocked’ (3.151 pieces).”*
> *B Griffin, Enbridge Steam Saver/Steam boiler plant efficiency, March 1, 2006.*

2.5 Average life time and failure rates of Steam traps

The average lifetime of your traps is found by dividing the total number by the broken ones in a year time.
For example, 150 yearly failures on a population of 1000 traps result in an average life time of 6,7 years.
The failure rate for that year is 15%

> *“Average-quality traps may have just a 4-year life expectancy (which implies a 25% failure rate), while higher-quality steam traps may have an 8-yr life expectancy (12.5% average failure rate).”*
> *Risko, J., Understanding Steam Traps, Chemical Engineering Progress, Feb 2011*

An acceptable average yearly failure rate is about 15 to 20%, which corresponds with a 5 to 7 year life time.

2.6 Average failure time of Steam traps

Most steam trap check-ups are performed on a yearly base. This means traps can fail from the day after the previous check, or from the day before the present check. Such a yearly check logically results in an average failure time of 6 months.

Raising the frequency will lower the failure time, but it will also increase the internal or external costs to perform these check-ups.

2.7 Methods to check Steam traps

There are several ways to perform steam trap audits. It is a prerequisite of course that your traps are in service, which might require various interventions.

With the numerous amount of different traps principles and applied check technologies, it requires quite some skills to come to correct judgements.

Plants report very good results with ultrasonic tools via the combined check of flow noise and temperatures. The recent versions compare results with a database for which you need to complete lots of details. This might be labour intensive to find and upload.

Some apply a combination of the ultrasonic check with a thermal infrared camera. Attention is to be given on the trap and piping materials to avoid reflection. Also the downstream pipe size influences the flow pattern and judgements on corresponding temperatures.

More recent, some companies promote a real time and continuous monitoring of the traps.
Transmitters are built in for each trap and connected to a central computer. From then they continuously check and analyse the trap status.
It is a pretty expensive solution, but in return you continuously know how your traps are doing, at every moment.

2.8 Steam loss of Steam traps

Traps that fail open still drain the condensate but simultaneously blow steam through their orifice.
John Napier wrote down the widely used equation to estimate the steam flow passing the internal orifice of a failing steam trap while draining condensate.

Imperial	Metric
W (lb/h) = 24.24 x P_{abs} x D^2	**W(kg/h) = 0,247175 x P_{abs} x D^2**
Lb/h = cte x psia x inch2 Here in: W = steam loss in lb/h P_{abs} = delta steam pressure in psia D = diameter of the internal orifice in inch 24.24 = constant	kg/h = cte x bara x mm2 1 kg/h = 2.20 lb/h 1 bara = 14.50 psia 1 mm = 39.37x10-3 inch 0,24712 = constant

As an example, we worked out 2 cases on average steam pressure:
(Steam cost € 25/ton - 8600 h/yr)

1. Utility steam trap 1/2” – internal orifice 1/8” (3,18 mm) - Blow-through failure
   Steam pressure 5 barg to back pressure 0 barg – condensate load 15 kg/h

   $W = 24.24 \times 72,5 \times (1/8)^2$
   $= 27.5$ lb/h ~ **7,5 €/day**

   $W = 0,247175 * 5 * (3,18)^2$
   $= 12,5$ kg/h ~ **7,5 €/day**

2. Process steam trap 3” - internal orifice 5/16” (7,9 mm) - Blow-through failure
   Steam pressure 16 barg to back pressure 2 barg – condensate load 16000 kg/h

   $W = 24.24 \times 203 \times (5/16)^2$
   $= 480.5$ lb/h ~ **129 €/day**

   $W = 0,247175 * 14 * (7,9)^2$
   $= 216$ kg/h ~ **129 €/day**

2.9. Impact of leaking traps on your boiler load

Unless you benefit from exothermal processes that generate steam, it is your steam boiler that produces all energy to feed your process installations.

The boiler capacity that compensates for the steam loss from traps is also called ‘phantom load’. It is the energy that is produced but not available for your process applications.

The well-meant actions from your operators to open the bypass a little over your closed failing traps, will even increase this phantom loss, which also might result in safety issues.

At the end, it’s all about the fuel bill and additional greenhouse gasses to produce this phantom load.

3 Impact of failing traps for the next 30 years

3.1. Financial impact

The total cost from failing traps is built from following actions and events:
Check-ups / Spare parts / Replacement time / Energy loss / Production impact / Shutdown preparation / …
And minor costs such as repeated actions from *Purchasing / Warehouse / Accounting / …*

We highlight a few to give an idea of the total impact of your repeated actions. We tried to work with average but conservative field values, however, we encourage to apply your data.

Starting points:

Energy loss: Via the Napier formula, we came to an average leak for a small utility steam trap about 7,5 Euro/day and for a process trap about 129 Euro/day.

Leak time: Most plants organise yearly check-ups.
Mathematical this results in an average half year leak time since it can leak from yesterday, or the day after previous check.
Question: Are you able to replace on the fly, or only in the next shutdown?

Life time: With ref to article in 2.5, an average life time 6 to 7 years results in 4 replacement for each trap in the 30 year plant life time.

Numbers: Suppose you have a plant with 1000 utility traps and 25 process traps.

Results:

Initial purchase (1000 x 150 €/piece) + (25 x 1500 €/piece) = 187.500 €

Energy loss: With ref to article in 2.4, we also assume only 68% open failures

- Utility: 1000 traps x 4 failures/30yr x 7,5 Euro/day x 365/2 days x 68% = 3.723.000 €/30yr
- Process: 25 traps x 4 failures/30yr x 129 Euro/day x 365/2 days x 68% = 1.600.890 €/30yr

The total average energy loss 30 years = 5.323.890 €

Spare traps: (4 x 1000 x 150 Euro) + (4 x 25 x 1500 Euro) = 750.000 €

Installation: 1 hour labour (50 €/h) per location = 4100 hours x 50 = 205.000 €

Yearly check: 1025 traps at 15 traps/hour = 2050 hours x 50 = 102.500 €

TOTAL COST generated by steam traps / next 30 years = 6.568.890 €
(this is a factor x35 to the initial purchase, see also graph on page 8)

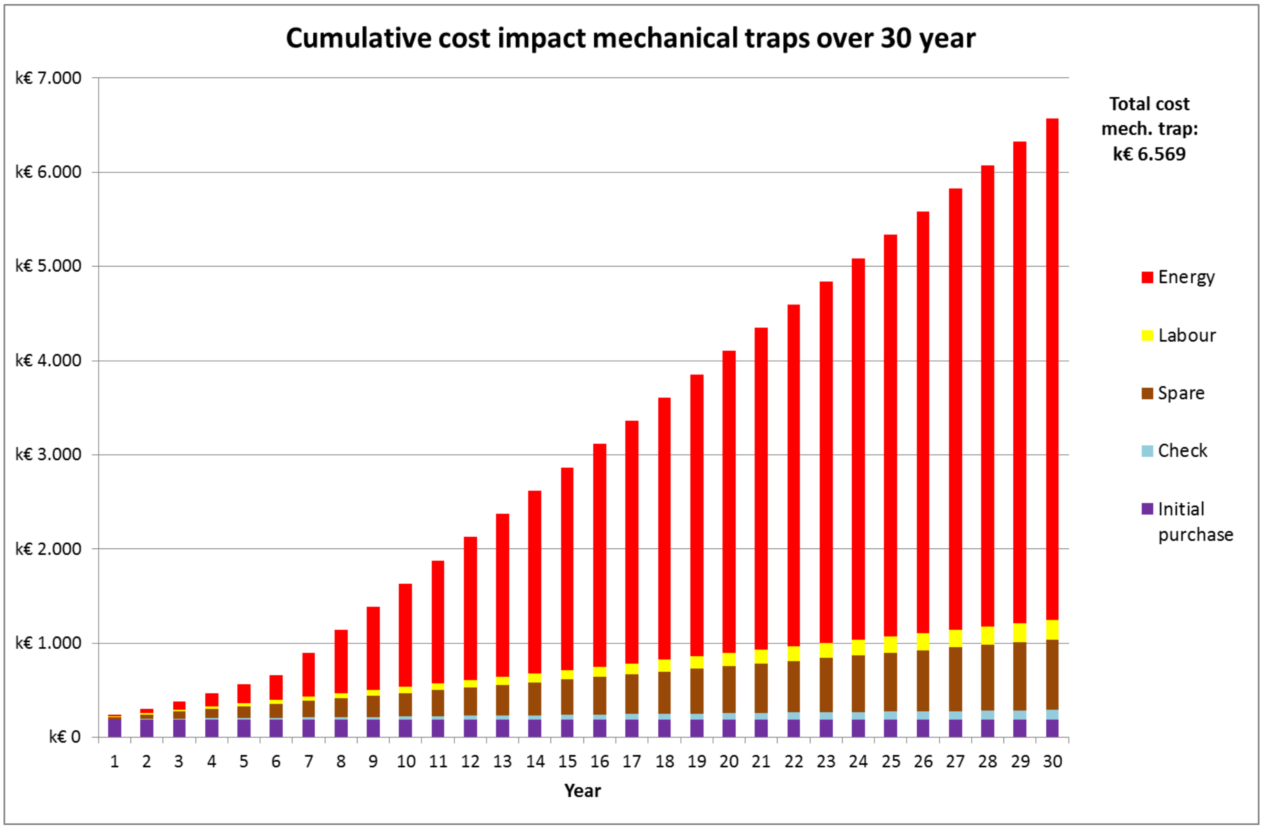
3.2. Environmental impact

In addition to the financial impact, we also should consider the environmental impact. Burning coal, fuel or gas generates a certain amount of GHG (greenhouse gasses CO2, N2O, CH4, …) that load our environment.

The above numbers result in a total steam loss of 213.253 ton steam on 30 years, which represent an extra exhaust of about 28.575 ton GHG.

> *"Natural gas fired boiler = 0.134 ton GHG/ton steam"*
> *University of Texas – Method for calculating CO2 Emissions – Ryan Reid – Aug 2010*

Of course this impact should be corrected with the used combustion (fuel, coal, …) and the overall efficiency of the steam boiler installation.



4 In fact, what are we doing (wrong)?

Looking at the numerous brands of steam traps, their different working principles, the necessary actions and skills, it looks like a complete '*industry*' is developed on this device.

Agreed, you need something to drain condensate. That's for sure.

But looking at it from a distance, it seems the market only provides mechanical steam traps for which everybody knows they fail. We then start doing repeated actions to find the broken ones under the show of diking the energy losses. And at the end, we replace them by the same, knowing what is going to come.

Looking from your angle, your actions are remunerative. They at least temporarily stop energy losses. And every plant manager will provide the budgets to do so.
However, it's only this maintenance cost that is visible. Nobody 'budgets' steam losses. Steam is simply expected to be there, loss or no loss.

You are ended up in a never ending circle that has only one winner, which is not you.
Because after all, it's still your company paying all the costs: check-ups, energy losses, production impact, spare traps and labour (not to mention your warehouse and administrative actions for each purchase).

This could only happen because you decided to work with mechanical traps from the start.

And now?

- Suppose you could work with something without mechanical parts
- Suppose you would not have the excessive energy losses from failed traps anymore
- Suppose you do not need to check traps for leaks with sophisticated tools
- Suppose you do not generate unnecessary greenhouse gasses
- Suppose, especially for process, it will stand the lifetime of your equipment
- Suppose it can be supplied ‘custom made’ to replace your traps
- Suppose such a technology has been proven for more than 30 years

Would you consider a change beyond traditional mechanical traps?

5 Conclusion

Your steam powered process and utility equipment need condensate removal.

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We kindly challenge you to permanently consider innovative technologies, which keep your installations state of the art.

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Appreciate you took some of your valuable time to study this paper.

Feel free to contact us for more detail.

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