Energy Efficiency Obligation Scheme

Guidelines for claiming energy savings from steam trap replacement

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Sustainable Energy Authority of Ireland
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1. Introduction

Steam traps are essential for the proper performance of steam distribution systems. During system start-ups, steam traps allow air and large quantities of condensate to escape from the steam system into the atmosphere. During system operation, the traps allow collected condensate to pass into the condensate return system, while minimizing the accompanying loss of steam. In effect, steam traps are used to discharge condensate, air and other incondensable gases from the steam system while not permitting the escape of live steam.

There are a range of steam trap types with different associated principles of operation including mechanical, thermostatic and thermodynamic and fixed orifice steam traps. Invariably, steam traps can become faulty and can thus release steam which is wasteful.

When a steam trap malfunctions, steam in the form of vapour escapes through the outlet valve or orifice. Steam traps can fail in a number of ways, including sticking in the open position, partially open position or fully closed positions. The steam that escapes is wasted energy that cannot be recovered.

The rate of leakage from faulty steam traps varies greatly and can be difficult to quantify. Good Energy Management practice involves conducting a steam trap audit of all the site steam traps, either by visual check or with thermal imaging and/or ultrasonic testing to record the operational status of each trap.

These audits should be scheduled at regular intervals (typically annually). The stream trap audit is used for maintenance and plant status purposes. The audit should also be used to establish the steam trap replacement schedule for the next scheduled plant shutdown.[1]

[1] https://www.spiraxsarco.com/

2. Determining energy losses from faulty steam traps

Energy credits can be claimed for the site fuel energy saved as a result of the reduction in steam energy demand arising from the replacement of the identified leaky steam straps. The determination of site energy savings (i.e. the reduction in the amount of steam that a boiler needs to produce), resulting from the replacement of faulty steam traps, can be claimed as energy savings under the Energy Efficiency Obligation Scheme (EEOS). The process of determining these savings involves three main steps:

1. Determining the steam flow rate/loss at the identified faulty steam traps.
2. Establishing the level by which the traps are faulty; (not all steam traps leak 100% of steam)
3. Converting the steam loss to energy, then relating this to a reduction in steam demand

The determination of the reduction in steam energy demand arising from the replacement of leaky steam traps can be estimated using a range of methods but is generally done by engineering calculation. This is because the measurement of steam losses from faulty/leaky steam traps is generally not feasible on most sites. Although there is some progress being made on advancements in the real time monitoring of steam trap status[2] involving sensor/transmitter technology that can allow real-time and continuous monitoring of steam traps, this is not in widespread use yet

Also, the measurement of a reduction in boiler output may not be fully relied upon either, as a method of establishing energy savings. This is mainly due to the wide range of factors that may contribute to boiler demand aside from leaky steam traps. Steam leakage is generally only a small fraction (<1%) of site steam use and the timing of when each of the steam traps became faulty may not be known.

Various engineering calculation methodologies exist, based on fluid flow and thermodynamic engineering principles, along with online calculators for the determination of energy losses due to faulty steam traps. Most of the steam trap manufacturers/suppliers provide support to establish

[2] https://www.emerson.com/documents/automation/White-Paper-Impact-of-Failed-Steam-Traps-on-Process-Plants-en-1258726.pdf

steam losses from leaky steam traps services either directly or through engineering consultants. They generally can assist with the provision of the associated business case for replacement of leaky steam traps losses.
There are a number of engineering calculation methods that can be used to estimate the losses due to faulty steam traps. One method that is more commonly used, and which is the basis of this guide, is the adjusted Napier's formula.

John Napier developed the equation for calculating steam flow through an orifice based on the operating steam pressure and orifice diameter. Since every steam trap has an internal orifice to reduce steam losses in the case of a failed open steam trap, the equation is widely used to estimate the losses through a failed trap:

Napier's Adjusted Formula[3] using original Imperial units and SI units	
SI units	Imperial Units
Steam flow through a sharp-edged orifice $W=0.24725*P*D^2$	Steam flow through a sharp-edged orifice $W=24.24*P*D^2$
Where W is leakage rate in kg/hr. P is absolute pressure drop across the orifice (gauge pressure added to atmospheric pressure) in bar. D is inner diameter of the orifice in mm.	W = leakage rate lb/hr P is absolute pressure drop across the orifice (gauge pressure added to atmospheric pressure) in psi. D is the inner diameter of the orifice in inches.

All engineering calculations are estimates of steam loss and no one method is considered better or worse than another. The advantage of using Napier's method, apart from the fact that it is widely used, is that it relies of two just input site parameters that are readily known for each steam trap.
Therefore, this guide recommends that Napier's adjusted formula be used as the method for establishing steam loss in order to claim energy credits under the Energy Efficiency Obligation Scheme.

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[3] http://invenoinc.com/wp-content/uploads/2017/05/Estimating-the-Steam-Loss-through-a-Orifice-of-a-Steam-Trap.pdf

It is relatively easy to apply the formula using an EXCEL spreadsheet. It should be stressed however, that this guide is purely for the purposes of providing a uniform approach that obligated parties may use to establish eligible energy savings under the EEOS. It is not to be interpreted as the only method for establishing losses by stream trap manufacturers/suppliers or energy consultants. It is to.

The leakage rate for claiming EEOS credits is assumed as a conservative **50%.** The percentage leak can vary and is difficult to establish as leakage rates can vary for each faulty steam trap. Manufacturers have used a 33% leakage rate compared to theoretical calculations and has used this 33% correction factor for Steam Trap Audit reports. The correction factor of 50% is thus selected here for EEOS energy savings determination as being balanced and conservative. This takes account of the probability that the steam trap is only being partially faulty, and the possibility that the steam trap may become faulty again within the timeframe of the Energy Efficiency Obligation Scheme.

The nature of steam traps is that they can develop faults at any time and failure rates as high as 20% have been reported from audits. Even more reliable steam traps have been seen to have failure rates of 12.5%[4]. Also, steam traps stuck in the open position may not be leaking at 100% rate because the design of the orifice is such as to limit the level of leakage.

For example, a partially open steam trap leakage rate can have significantly lower level of steam loss than an engineering calculation would predict and one manufacturer applies a 33% correction factor to the theoretical engineering calculated steam loss[5].

The conversion of steam loss savings to boiler demand reduction savings should be based on at least 12 months of recent site measured data. This is the site SEC in terms of tonne of steam produced (kWh/tonne of steam).

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[4] https://www.emerson.com/documents/automation/White-Paper-Impact-of-Failed-Steam-Traps-on-Process-Plants-en-1258726.pdf

[5] https://www.spiraxsarco.com/Resources-and-design-tools/Savings-Calculator/Savings-Calculator

3. Worked example

This example is based on replacement of four steam traps tagged as faulty. The assumed leakage rate is 50% (as per SEAI guidance) and the key input data is set out below.

Key Input Data:

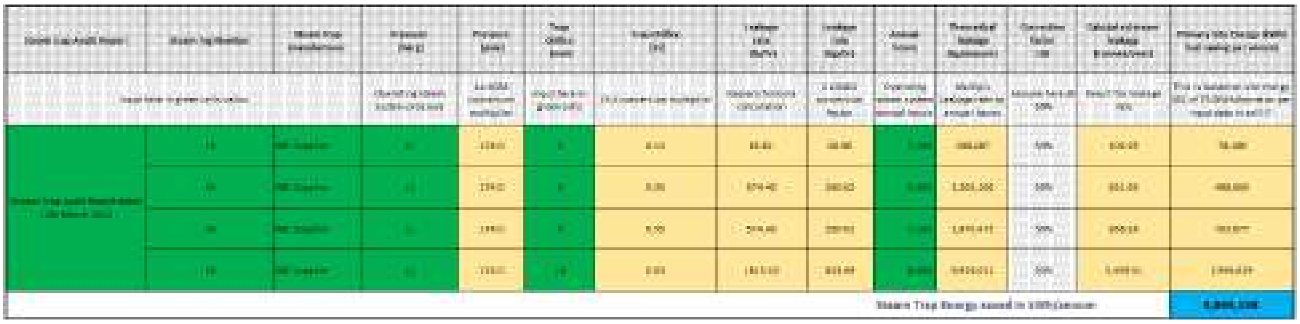
Operating steam system pressure	12 bar g
Orifice diameter of four steam traps	1*3 mm, 2*9 mm & 1*16 mm
Hours of operation	Based on site steam operations
Site SEC in kWh/tonne of steam	750 kWh/tonne of steam

The site SEC for input fuel per tonne of steam produced should be based on at least 12 months of measured data and also represent the overall average SEC in kWh/tonne of steam for the site. Some sites use a combination of Steam Boiler(s) and CHP including possibly also After-Burner for site steam generation. Each site will have its own operating regime for steam demand profiles so it is essential to provide measured site fuel energy and steam demand to, spanning at least 12 months, to substantiate/verify the site SEC for energy in kWh/tonne of steam. This SEC is then used as the basis for establishing the energy savings when applied to the calculated steam savings using Napier's formula along the 50% correction factor.

Site Energy Savings in kWh = Napier's calculation for steam flow in kg or tonnes of steam * 50% correction factor * SEC (kWh of fuel/tonnes or kg of steam)

In the example extract below, the cells marked green require input data. This input data is then used to calculate the values in the cream-coloured cells and the resulting energy savings are displayed in the blue coloured cell below.

Use Adjusted Napier's Equation (EXCEL) for Steam flow through trap orifice.



The EXCEL spreadsheet first determines the steam losses for each trap, applies the 50% correction factor and then calculates the primary site energy (kWh) based on the site SEC which for this worked example is 750 kWh/tonne of steam. The resulting energy savings are thus determined as 3,865,158 kWh with assumption of steam trap leakage rate correction factor of 50%.

The EXCEL calculator contains Tab 1 for determination of steam trap savings with Tab 2 showing the worked example for basis of savings determination for the above.

4. Conclusion

If a site only performs a steam audit on a yearly basis, this leaves the plant vulnerable to long periods of being exposed to the safety, process and energy costs associated with failed steam traps. The more insight the site energy manager has into the health of their steam trap system, the better able they are to manage the maintenance activities and to lessen the impact of failures and improve the performance of the system.

The basis of determining energy savings for the replacement of faulty steam traps requires that a structured approach to maintenance is in place. Ideally this will involve a cyclical auditing program of all steam traps (typically annually though may be more frequent). Otherwise, the volume of faulty steam traps and associated energy lost will not be sustainable and credits claimed would be inclusive of lack of basis maintenance programme.

If such a preventative maintenance and auditing system is not in place obligated parties may not report energy savings.
The maintenance plan and Audit Report should be available in the event that SEAI requests them as supporting information for any EEOS credits reported.

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