Risk Based Survey in Steam Trap Management

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ABSTRACT

Inside the steam pipe, slight portion of steam will be condensed during the process of delivery. The presence of steam condensate will initiate some damages to downstream equipment. Therefore, the steam condensate must be flushed from steam line. The equipment that is utilized to flush the steam condensate is called steam trap. In order to maintain the reliability of steam trap, special survey should be conducted periodically. Through this survey, we will know the condition of steam trap and then conduct the needed maintenance action. Most of the industry applied time based survey. Longer the interval periods will increase trap's faulty rates and vice versa.

Badak LNG implemented the 4-yearly survey program on its steam trap's system. The last survey has been conducted on 2012. From 1048 trap, 32% of them are found leak. The quantified steam loss from those leaking traps is 63.3 kton/year. Also, a typical result has been showed by 2008 survey results which 33.30% of traps population was found leak and gave 28.6 kton/year steam loss. From these results, it's believed that the existing survey interval should be adjusted to more reliable pattern in order to get significant decrease of trap's faulty rates.

This study explored the plan of implementing Risk Based Survey (RBS) replacing the traditional time based survey. Through RBS, all the installed traps are assessed by its type and service pressure, grouped based on the risk, and then determined the initial survey periods for each of the trap. The principles of RBS rely on how likely the failure to be occurred and how the consequence will be if the failure occurred. Therefore, the traps that have a higher risk will be surveyed in shorter interval. In contrary, the lower risk traps will have a longer interval.

Introduction

Naturally, slight portion of steam will be condensed during the process of delivery. The presence of condensate is dangerous and will initiate further damage to steam piping and downstream equipment. Therefore, the condensate must be flushed from the steam line through steam trap. Steam trap is an automatic valve that installed on a steam pipe in order to removes condensate and other impurities such as air and non-condensable gases. Nowadays, three major steam traps were mostly selected to handle steam system i.e. Mechanical, Thermostatic, and Thermodynamic.

Badak LNG plant has 1412 steam traps. All of these traps should be checked and maintained periodically in order to measure the potential losses of steam. Existing periodic survey has been conducted in 4-yearly basis while the repair or replacement was conducted right after the survey. Figure-1 shows the result of trap's survey conducted on 2008 and 2012 where trap's faulty rates were more than 30%. US DoE, 2004, has quoted that between 15% - 30% of the installed steam traps may have failed in steam systems that have not been maintained for three to five years. This statement is in line to the result of the mentioned survey. Therefore, we need more advance method in order to reduce the faulty rates effectively.

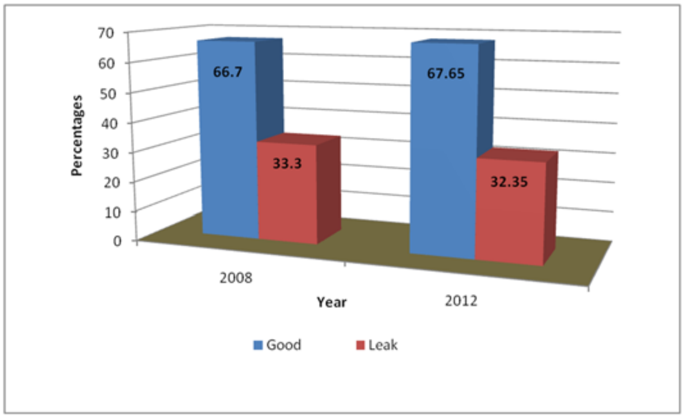

Figure 1. Faulty rates of traps on 2008 and 2012 survey.

Existing steam trap's survey program

Badak LNG has implemented the 4-yearly survey program for all 1412 steam traps. This is the time based model that commonly used in the other industry. The last steam trap survey has been conducted on 2012 covering trap counting and condition checking. Inverted Bucket and Thermodynamic traps respectively share 43.2% and 43.6% of trap's population. Table-1 shows the summary of trap's quantity.

Table 1. Number of installed steam trap

Model	Quantity (unit)
Float & Thermostatic	37
Free Float	97
Inverted Bucket	610
Thermostatic	52
Thermodynamic	616
Total	1412

Condition checking was conducted by using an ultrasound device in combination with thermograph test in order to achieve an accurate result. From total 1412 traps, only 74.22% (1048 ea) that in operation while remaining is not in service regarding to idle status of some certain Plants. From 1048 trap, 32.35% of them are found leaking. The quantified steam loss from those leaking trap is to be 63,280 ton/year.

Table 2. Summary of traps survey 2008 & 2012

Results	2012		2008	
	Qty	%	Qty	%
Total Steam Traps surveyed	1412	100	1405	100
Not in Service	364	25.78	480	34.16
Traps in Operation	1048	74.22	925	65.84
Good traps	709	67.65	617	66.70
Leaking traps	339	32.35	308	33.30

Also, a typical result has been showed by 2008 survey where 33.30% of traps population was found leak and gave 28.6 ton/year steam loss. At typical faulty rate, 2008 survey shows that the steam loss is 60% smaller than 2012 survey since the most leakage occurred in small to medium pressure of steam line.

The role of trap survey

Each of installed traps has a specific lifetime and it is different to each other. The lifetime difference is caused by varied operation condition, diverse trap population, and different time of trap installation/replacement. Figure-2 shows the typical traps faulty rates when we implementing time based inspection method (example: 4-yearly). The increase of faulty rates is caused by some new leaks occurred during in between period of survey.

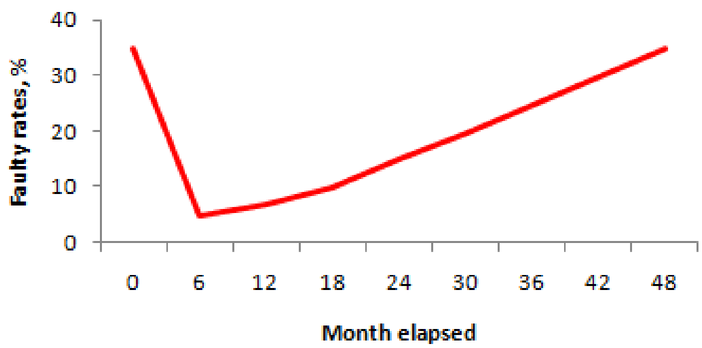

Figure 2. Faulty rate tendency in 4-yearly survey program

It is essential to have performing annual examination to understanding the trap's health (Risko, 2011). On the other side, routine maintenance depends on the type of trap and its application (Bhatia, 2007). Combination of both interval adjustment and traps grouping arise the concept of risk based survey.

Proposed RBI program

API RP 580 quotes that risk is the combination of the probability of some event occurring during a time period of interest and the consequences associated with the event. In mathematical terms,

$$\text{Risk} = \text{Probability x Consequence}$$

The objective of RBI is to determine how likely the incident will happen and how severe is the cause of that incident when it truly occurred. Assessment of risk is conducted in three ways; qualitatively, semi-quantitatively, or quantitatively. Semi-quantitative, somehow, is the preferred choice since the assessment has combined a professional/engineering judgement and historical data element of particular equipment. The result is then numerized and plotted in the risk matrix. This method gives a simple and accurate determination of risk.

Figure-3 shows how RBI manages the operating risk of particular equipment; a circle of inspection planning process. RBI helps to determine and prioritize the high risk equipment. The equipment placed on high or unacceptable risk level will be prioritized and more stringent mitigations are set up to move the risk to acceptable risk.

The assessment related to steam trap is directly conducted to the equipment basic since the installation or part assembly is typically simple and facing the same operation condition i.e. same steam pressure and temperature. The probability of failure (PoF) is assessed based on the the type of steam trap while the consequence of failure (CoF) is assessed based on service pressure.

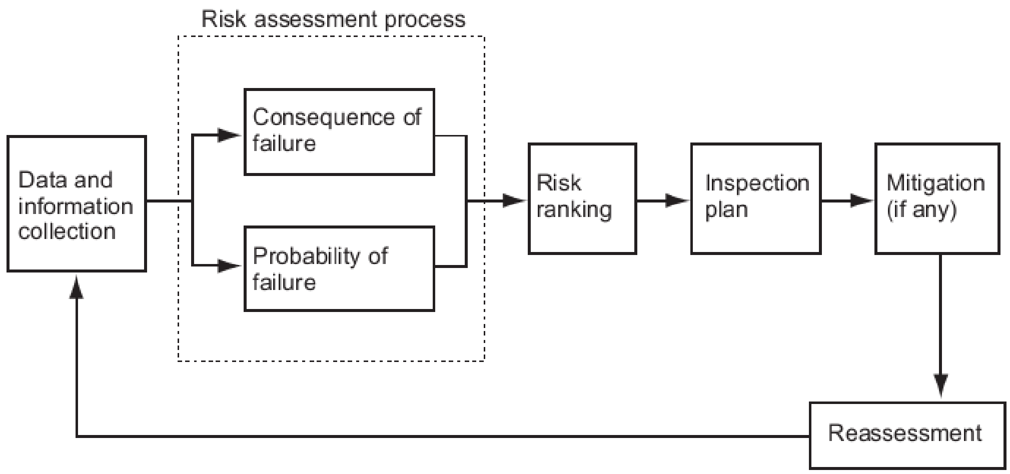

Figure 3. Risk based inspection planning process (API RP 580).

The mitigations for established risk ranking are replacement to more reliable or right trap, stringent frequency of inspection, establishing comprehensive test method, trap's installation modification, and adjusting the operational procedures. Typically, frequency of inspection is become the most effective way of mitigation since the stringent monitoring is the key of successful detection of early abnormal condition of steam trap. Therefore, risk ranking mitigation is better to focus in establishing the steam trap's inspection interval.

Steam trap risk matrix

RBI has designed to divide the equipment risk based on its probability (likelihood) and consequence (severity). The value of both risk elements will then plot on the matrix in order to get easy reading. The same method can actually be applied to steam trap in simple 3x3 matrixes which is adopted and modified from API RP 580. The ranking will then determine the interval of steam trap's inspection and maintenance.

Probability of trap failure

Steam traps are assigned to a probability of failure score from L (low), M (medium), and H (high), based on traps characteristic summarized on Table-3 below. The decisive factors that significantly affect the grade of probability score are resistancy to wear, ability to handles dirt, and ability to response the load change.

Consequence of trap failure

Like a PoF, steam traps are assigned to a consequence of failure (CoF) score from L (low), M (medium), and H (high), based on steam line service pressure traps. The CoF is directly related to the monetary impact. At the same size of leaking orifice, higher the steam pressure higher the steam loss, and thus higher the monetary loss.

Table 3. Trap characteristic (above) and trap's service pressure (below)

Characteristic	F&T	Free float	IB	Thermo dynamic	Thermo static (1)
Load change response	Excellent	Excellent	Good	Fair	Fair
Handles dirt	Fair	Fair	Excellent	Poor	Good
Waterhammer resistance	Good	Good	Excellent	Excellent	Excellent
Handles start-up load	Excellent	Excellent	Fair	Poor	Fair
Suitable for superheat	No	Yes	Yes	Yes	Yes
Failure mode	Close/Open	Close/Open	Open	Open	Open
Resistance to wear	Poor	Excellent	Fair	Poor	Good
Score	**H**	**L**	**M**	**H**	**M**

(1) Bimetallic type

Service Pressure (Kgf/cmsq)	**3.5**	**10.5**	**17.5**	**60**
Score	**L**	**L**	**M**	**H**

Mitigation of the risk

Evaluating the risk ranking, we have now three grades of trap maintenance interval; based on L, M, and H segregation. The principles of risk based mitigation rely on how likely the failure to be occurred and how the consequence will be if the failure occurred. Therefore, the trap that has a higher the risk will be surveyed in more frequent the interval. Contrary, the lower risk trap will have a longer interval. The base interval value of each risk ranking is stated as follow:

- High risk: 6 monthly,
- Medium risk: 12 monthly
- Low risk: 18 monthly

This interval can be further evaluated – shorten or extend – after some periods of survey which accurate data is available. Figure 5 below shows the number of the traps which is plot to high, medium, or low risk classification.

		Consequence		
		H	M	L
Probability	H	1	2	3
	M	2	3	4
	L	3	4	5

(red)	High risk	180 ea
(amber)	Medium risk	824 ea
(green)	Low risk	408 ea

Figure 4. Risk matrix

Faulty rate projection

Implementing more frequent survey, the faulty rate will basically decrease in a significant number. This fact has reported by some companies that applied more frequent maintenance at the first time – at minimum once a year – and been evaluated for some years afterwards. Kashima Oil Co., Ltd – at Kashima Refinery – shows a decrease of trap's faulty rate as much as 16.7% in six month and remaining only 0.1% in the next one-half year (Figure-5) by implementing yearly survey interval.

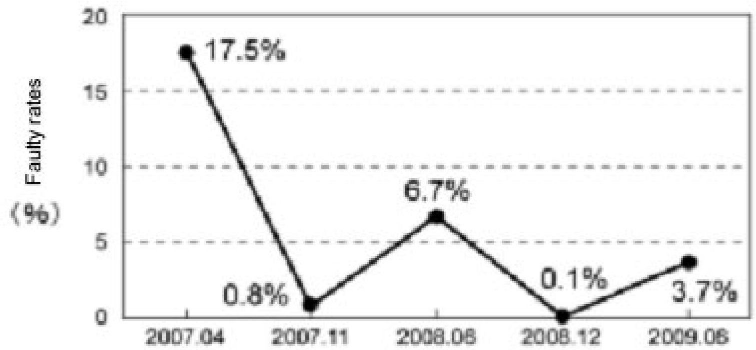

Figure 5. Trap's faulty rates on Kashima Refinery

On the other case, US Department of Energy has sourcing that the loss rate would be reduced to about 8% by the minimum proactive maintenance program while intermediate program should yield some reducing losses to perhaps 4%. The minimal program is the surveyed that conducted on yearly basis while intermediate program is on 6-monthly basis. In Badak LNG case, combination of 6-monthly and yearly survey can be assumed as abovementioned risk based survey and projected to reduce the faulty rate to 5% at the first 6 months and keep under 5% afterwards as figure out in Figure-6 below.

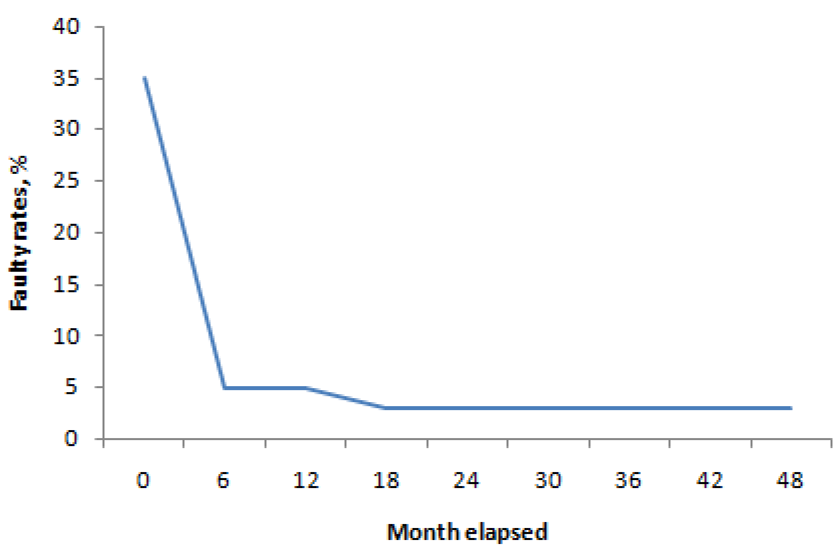

Figure 6. Projected trap's faulty rates on Badak LNG plant by using risk based survey method

Summary and conclusion

Based on 2008 and 2012 survey, the 4-yearly survey gives a high faulty rate of steam trap's population at the 4th period that yielding a significant monetary loss. One of the efforts to reduce the faulty rates is by conducting Risk Based Survey. The survey is not only provides more frequent interval, furthermore, it promotes cost saving since the survey sorts the traps into some group and prioritize the high risk traps then.

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