INDUSTRY ANALYTICS TO OPTIMIZE TIME BASED MAINTENANCE FOR I&C COMPONENTS

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ABSTRACT

Using Industry Analytics to optimize time based maintenance for I&C components allows a nuclear site to increase cost efficiency without impacting equipment reliability. Reductions in frequency or deletions for non-value based Preventive Maintenance (PM) improves cost efficiency by decreasing man-hours, parts costs, and planning costs of that PM; while maintenance performed too frequently can induce maintenance related failures.

Benchmarking Industry PM Performance and Equipment Failure data allows sites to efficiently optimize time based maintenance frequencies. Equipment Failure history identifies gaps in maintenance frequencies as well maintenance-induced failures. Overlapping the PM frequency from a site with Industry PM Performance identifies opportunities to justify cost savings by reducing the PM frequency. The opportunities are then validated by the site's living PM program to ensure that the site can support the extension.

This paper will discuss an Industry analytical technique used for maintenance frequency reductions. The major aspects evaluated under the technique are validation of the Industry data, review of the component's history and comparison of additional information. Industry data from 180 sites is used as a benchmark to identify opportunities for PM frequency extension on like-for-like components based on manufacturer/model and application. The component history composed of preventive maintenance feedback history and corrective maintenance history is reviewed to determine if the frequency can be extended without adversely affecting equipment reliability.

Key Words: Optimize, Industry Data

1. INTRODUCTION

Maintaining equipment reliability by performing time-based maintenance on established schedules has led to high capacity factors for nuclear power, but at a hard to compete cost of $36.27 per megawatt-hour, Ref. 1. The use of an industry data analytical technique to optimize maintenance frequencies while maintaining the equipment's reliability is a powerful approach to reducing O&M cost and allowing nuclear power to compete in today's low cost market.

1.1 Discussion

The nuclear industry uses time-based maintenance strategies to ensure a high equipment reliability factor of all of its key components with instrumentation and controls (I&C) components being a large part. A methodology using industry data analytics is a way to optimize the maintenance frequencies which will lower annualized parts cost, reduces planning efforts and saves on maintenance department man-hours. The industry data can be composed from fleet data, user group sharing, benchmarking, Electric Power Research Institute (EPRI) data, and Proactive Obsolescence Management System (POMS) database. Fleet data is composed of comparing the maintenance strategy of different sites contained in one fleet for the most optimal maintenance frequency. User group sharing provides a method for members of the group to collaborate on a single topic such as Equipment Reliability Working Group focuses on equipment issues. Benchmarking is a very specific comparison of a site's maintenance strategy to the industry for a common piece of equipment. EPRI has developed a database for maintenance strategies of generic component and that can be used for industry data guidance. The POMS database contains a collection of data from 190+ sites that includes manufacturer models, function of component, criticality of the component, maintenance plans, maintenance frequencies, and work order history which is a good reference for industry information.

An example of using industry data to optimize the maintenance frequency is, a calibration performed on a transmitter every 4 years could be analyzed to allow an increased frequency to perform the same calibration on an 8 year period based on what industry data shows for the frequency of performance of the same calibration of the same transmitter with the same reliability rates. This would result in cutting the annual maintenance cost of this task in half. For this analytical technique, the industry data includes information from the POMS database to identify similar components that could provide a basis for frequency extension. The criteria to determine which components are similar are manufacturer model, function and application of the component, criticality of the component, and service condition. Industry data provides a detailed picture of how the industry as a whole maintains the equipment reliability of a component. Comparing a site's maintenance plans against the industry shows where the site could align to the industry to improve equipment reliability and maximizing cost savings. Figure 1 below shows how comparing the site's PM program to industry data can find a balance between equipment reliability and cost of the maintenance.

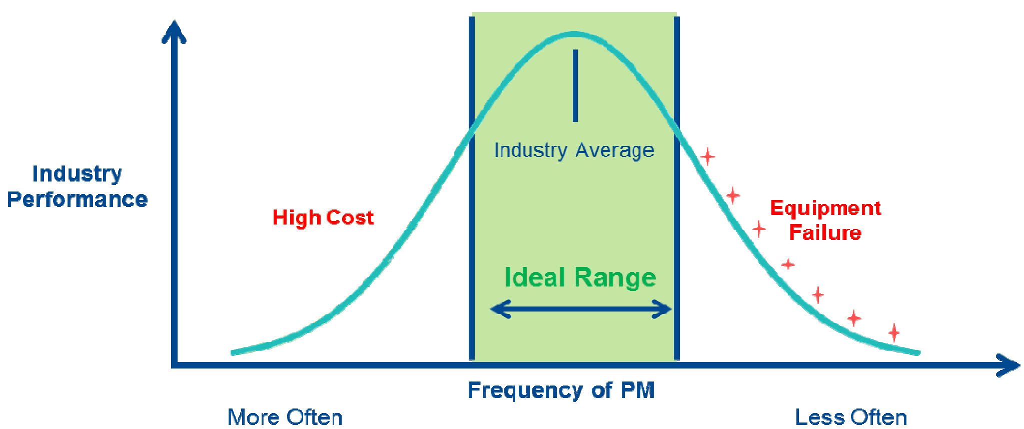

Figure 1: Comparing site's PM program to industry data

To reach a balance between equipment reliability and cost of the maintenance, a site will have to move away from unnecessary PMs and towards PMs that work to prevent or mitigate the failure modes of the component. With each unnecessary PM there is a greater chance that there will be maintenance induced failure and the added cost of performing that maintenance. This analytical technique uses industry data to determine unnecessary PMs by comparing the site's current maintenance plan to the industry and looks for any discrepancies. One such discrepancy is a transmitter calibrated every 4 years and similar transmitters in the industry performing the calibration at 8 years with no corrective maintenances (CM). Extending the calibration to 8 years would lower the PM cost without increasing the CM cost. The industry data is also used to identify any potential maintenance gaps in the site's current maintenance plan that would mitigate failure modes of the component and in turn result in a decreased CM cost. Figure 2, Ref. 2, below shows the goal of using industry data to approach the point of minimum CM or maximum reliability.

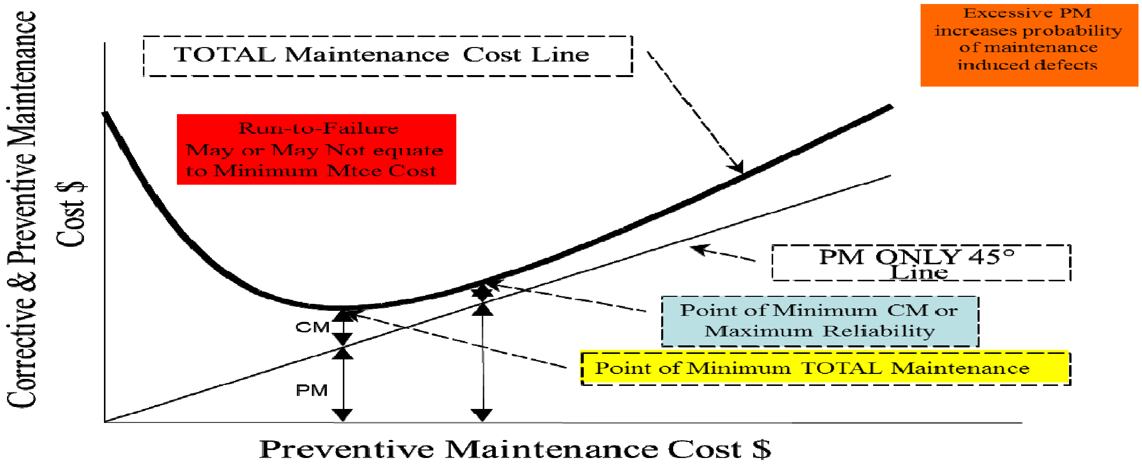

Figure 2: Shows the relationship of total maintenance cost to just PM cost.

The following is an example of comparing the typical living PM program change to the industry data analytic approach. A non-critical resistance temperature detector (RTD) is replaced every 8 years with no recorded failures. A site using a feedback maintenance strategy without industry data might change the frequency to 10 years based on the past good component history. An industry data search using matching manufacturer make and model and component function identified seven sites that perform a PM that replaces the RTD at an average frequency of 12.5 years and at a maximum frequency of 21 years with good component reliability. A site using a maintenance strategy with industry data could align the frequency to the industry average of 12 years without waiting another 10 years to go through an additional iteration of PM feedback to get to the new frequency.

Using industry data is one of the ways this analytical technique determines if the maintenance periods can be extended. To validate if time-based maintenance can be extended, the industry data analytical technique also reviews multiple sources in addition to industry data to get a representation of how a different frequency can influence the overall equipment reliability of the component. The sites corrective maintenance history for the component, any industry operating experience (OE) related to the component, industry preventive maintenance (PM) templates such as the EPRI PMBD are all used to analyze how a particular preventative maintenance task change in frequency could impact the components performance.

An analysis of the component's history provides information regarding the number of equipment failures and the 'as found' maintenance data. A low number of corrective work orders or equipment failures could indicate that there are not many issues with reliability and it could potentially have its maintenance frequency extended. For the above transmitter example, if the past 3 calibrations performed at every 4 year calibration only shows needing to adjust every 8 years then a case could be made to extend the frequency of the calibration to every 8 years which would match the industry data for this component giving validation there will be good equipment performance with the new frequency.

Another method to determine the past history of the component is an OE search of similar components. An OE search can identify any industry or site failure mechanisms that could influence the component's equipment reliability. A reported OE lists the age of component at the time of failure, the failure mechanism that resulted in the failure and the action taken to prevent recurrence. For example, a certain current to current converter isolation device was identified through multiple events in an OE search as failing due to aging. From the multiple events, an average age of failure could be determined that could be used to determine an optimized replacement frequency less than the average age of failure. In the case of the current to current converter, the converter was being replaced every 8 years and the average age of failure identified through OE was 14 years. This allowed the converter replacement to be extended to 12 years. The past failures identified in an OE search are crucial in determining what maintenance strategies are required in the present or future to eliminate those failures.

A useful method of determining the present and future maintenance strategy of the component is a PM basis document. The PM basis indicates how a site plans on maintaining the equipment reliability of a component. The PM basis also provides additional reasoning into why the maintenance is performed and what steps are included in the maintenance. From the PM basis, a PM template or guideline is created that shows what maintenance is performed on the component, what maintenance could be performed and how often the maintenance is performed based on criticality. Understanding the entire maintenance strategy for the component can provide ways to optimize the maintenance without impacting equipment reliability. Figure 3 below shows an example of a transmitter PM basis template. In Figure 3, the frequencies (listed in years) illustrate what a PM template looks like. A frequency of AR on a PM template means the maintenance is performed as required.

I&C - Transmitter

	Classification:	Critical				Non-Critical			
	Duty Cycle:	High	Low	High	Low	High	Low	High	Low
Task ID	Service Condition:	Severe		Mild		Severe		Mild	
1	Performance Monitor								
1.1	None								
2	Predictive Maintenance								
2.1	None								
3	Preventive Maintenance								
3.1	Calibration	3Y	3Y	3Y	4Y	4Y	4Y	6Y	8Y
4	Preventive Replacement								
4.1	Replace	6Y	6Y	6Y	8Y	8Y	8Y	12Y	AR

Figure 3: PM template example

An example of using the PM basis to optimize maintenance frequency is a non-critical, low duty cycle, and mild service condition transmitter that is currently calibrated every 10 years and is replaced every 16 years prior to using a PM basis template. Using the PM basis to align with PM template, the calibration frequency is reduced to 8 years because it will determine if the transmitter is drifting, degrading or failing. With the reduced calibration frequency, the scheduled replacement period can be changed to as required since the calibration would detect any early signs of failure. The cost of performing calibration 2 times every 16 years is less than the cost of performing a calibration and high cost replacement. EPRI PM templates provide a conservative approach on how to maintain a component. These templates sometimes include additional predictive maintenance as compared to the site's PM basis which can be useful in extending a preventive maintenance such as a replacement. PM templates are also useful in determining similar components at a site that could be used to optimize maintenance since like object types have the same template.

Similar or sister component at a site have the same criteria as the original component such as manufacturer model, function, and classification. History has shown that components in a fleet or even across units are not always maintained with the same time based maintenance. For example, at site A unit 1 transmitter A is calibrated every at 4 years while site A unit 2 transmitter A is calibrated every 6 years. Reviewing sister components identifies more opportunities for maintenance frequency reduction and potentially reasons for optimizing if the frequencies are different.

Another opportunity for maintenance frequency reduction comparable to reviewing similar components at a site is reviewing I&C channel comparisons, since safety-related and some non-safety instrumentation are normally divided into channels. A channel is an arrangement of components and modules that generate a single action signal when required by a plant generating station condition for a trip system. There are normally three or four channels, depending on the plant, that monitor the same process variable via an independent transmitter for each channel. The multiple channels allow channel comparison on a real-time basis. Currently, industry calibrates many of the transmitters on a refueling cycle. Optimizing the calibrations to one channel per refueling cycle and then monitoring the other channels through comparison would allow the transmitter calibrations to be extended to every third or fourth cycle depending on number of channels. This method will limit the risk of failure due to extended maintenance frequency and decreased maintenance-induced failures.

After determining that the time-based maintenance can be optimized, the combined data from multiple sources can establish what steps should be taken. The time-based maintenance could be eliminated, reduced or extended. As part of digitalization initiatives in support of the industry Nuclear Promise effort, these analytical techniques can be automated and shared by industry to further refine maintenances and reliability data resulting in further cost savings.

2. CONCLUSION

This paper discussed industry analytical methods to increase cost efficiency without impacting equipment reliability. Utilizing industry data in the technique allows a site to compare their maintenance with the industry and identify any similar maintenance frequency reductions they could implement. Reviewing past component history provides an understanding of how the component has operated in the past. The PM basis is useful in determining the reasoning behind the maintenance and provides a large picture of what overall maintenance is performed. By using a few of these methods or a combination, these techniques can identify if maintenance frequency reduction can be performed.

3. REFERENCES

1. Nuclear Energy Institute, "Nuclear Energy 2016: Status and Outlook", (2016)

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