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RESULTS OF MECHANICAL SNUBBER CONDITION MONITORING ON DEGRADATION RATE OVER TIME

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ABSTRACT

This paper summarizes the current results of Mechanical Snubber Condition Monitoring Programs implemented at certain operating US nuclear power plants. The condition monitoring is utilized to validate reliability and extend service life. Service Life Monitoring is a requirement of ASME OM. Subject operating units with large mechanical snubber populations instituted programmatic condition monitoring as early as 2005/2006. Degradation rates compared over time indicate that the programs resulted in an improvement in the reliability of the mechanical snubber population.

Keywords: Snubber

1. INTRODUCTION

Several operating plants with large mechanical snubber populations instituted programmatic condition monitoring after operating for many cycles with no such programmatic actions. Prior to that point the reliability of the snubber population was primarily based on the functional testing program in accordance with Technical Specifications and/or ASME Code requirements.

The implementation of condition monitoring was in response to both industry and site Operating Experience indicating potential for worsening degradation and failure rates. The condition monitoring program primarily consists of manually exercising each installed mechanical snubber on a rotating periodic basis. In most cases individual mechanical snubbers are unpinned at one end and then manually stroked in place by a trained technician. In some instances, a mechanical stroking tool is used to exercise larger models of snubber which require greater force. The desired result is to redistribute the lubricant inside the snubber and thus recoat the internal surfaces. Exercising the snubber helps to prevent the lubricant from hardening over time as well. In addition, a trained technician performing the stroking can often detect minor degradation in early stages and allow a suspect snubber to be replaced or repaired prior to any significant impact upon the snubber function.

The results of such programs at several operating plants are summarized in this paper and indicate that such practices can result in significant improvement in the reliability of a mechanical snubber population. A review of actual performance data over time consistently shows a downward trend of the degradation/failure rates since the implementation of these condition monitoring programs. The data shows that the degradation rate of previously untouched snubbers drops significantly on the second time through the population, and less dramatic but significant decreases thereafter. Current data indicates that the degradation may level off over time, but at an acceptable rate. This indicates that such programs are an effective tool in extending service life and reliability of the mechanical snubber population.

2. METHODS AND DATA

All plants considered for this review implemented a method of manually exercising (stroking) the mechanical snubbers through their range of motion on some periodic basis. The number of snubbers so stroked and the periodicity varies from plant to plant depending upon site specific preferences and limitations.

In the most clearly documented case, the snubbers are divided into 3 groups which are stroked in a staggered time frame over a 3-cycle period, resulting in 100% inclusion over the 3-cycle period. However, different intervals and population groupings have been used at various plants due to specific population and resource requirements.

As a measure of effectiveness, a degradation rate is determined by comparing the number of degraded/failed snubbers to the total number of snubbers that had any type of “hands-on” work performed during the current cycle (testing, stroking, removal/restoration). Over time this measure provides trendable data representing a “living” picture of the overall reliability of the subject population.

2.1 Plant “A”

2.1.1 Plant “A” Background

Plant A is a two-unit site, both units being four loop PWR designs. The units began began commercial operation in the mid 1980’s. Initially both units had large snubber populations. Unit 1 began commercial operation with approximately 1900 snubbers and Unit 2 had approximately 1100. Both populations were originally 100% mechanical snubbers.

A snubber reduction effort was implemented between 1990 to 1995. This resulted in a significant decrease in the number of installed snubbers, with a final reduction of approximately 50% in one unit and 40% in the other unit. Over time some of the original mechanical snubbers have been replaced with hydraulic snubbers, but the populations remain over 85% mechanical snubbers.

Following the snubber reduction effort, it was recognized that the elimination of so many snubbers also meant that much redundancy was eliminated and that remaining snubbers in general had reduced margin regarding adverse impact on supported systems or components. This resulted in an even greater emphasis on the reliability of the remaining snubbers.

In the late 1990s and early 2000s, both site specific and industry operating experience indicated significant concerns pertaining to the reliable performance of mechanical snubbers over time. The functional testing failure rate of mechanical snubbers indicated an adverse trend, especially among snubbers with little or no history of previous in-service maintenance or testing. Due to the statistical sampling methods utilized to satisfy the testing requirements, many if not most of the installed snubbers in large populations may go untested for many years – and possibly for the life of the plant. These “untouched” snubbers seemed to be especially vulnerable to performance degradation. The implications of this were an increasing number of test failures over time. This would not only result in significantly more outage testing, but also more challenges to the design basis of the supported components and systems. It was recognized that a more complete maintenance program was needed to address the total population.

At that point the existing snubber maintenance and testing program for the site was re-examined. It was noted that per an original Technical Specification requirement the mechanical snubbers on certain systems were inspected each outage for evidence of transient damage. This inspection was performed by manually stroking all the snubbers on those designated systems. Review of historical data showed that among those snubbers that were stroked each outage the degradation rate was much lower than those in the population that were not stroked. In fact, the data that was retrievable indicated that those snubbers had a degradation rate of about 10% over the first two outages but then the rate dropped to be consistently between 2.5% to 3% over subsequent cycles.

However, that program only addressed about 35% of the total population. Over 65% of installed snubbers were not included. It was decided to expand the stroke program to include all snubbers, but to perform them on a periodic basis. The population was divided into 3 groupings, each representative of the overall population with regard to size, system, and location. Each group was to be stroked every third cycle on a rotating basis. In this way every snubber was to be stroked at least once every 3 cycles. Representative snubbers of those systems addressed in the Technical Specification transient inspection requirement were included each cycle to satisfy that requirement.

By utilizing a three-cycle period and utilizing a rotating schedule it was possible to stroke 100% of the snubbers over that period without increasing the scope of individual outages. In fact, the number of strokes per outage was slightly reduced under the new program. It was also discovered that 20% - 30% of the strokes could be performed online utilizing system and train windows, or the snubber Technical Specification LCO 3.0.8 to allow maintenance. In this way outage scope was not increased.

The new stroke program was implemented in 2005 and 2006 for Unit 1 and Unit 2 respectively. At the time of this publication each grouping of snubbers has undergone 3 to 4 cycles of stroking. The following data from those cycles indicates that the program has been highly successful in reducing the degradation rate and increasing reliability of the mechanical snubber population.

2.1.2 Plant “A” Performance Metric

The reliability metric used for Plant A is the “Total Degradation Rate “. In laymen’s terms this is simply “Problems Found” versus “Snubbers Handled”.

This metric is calculated for each cycle as the ratio of the total number of discrepancies to the total number of snubbers that are manipulated in any way during that cycle. For this metric, a discrepancy is any finding that requires further corrective action for a given snubber. Technicians are trained to conservatively identify anything that they deem unusual about a snubber’s operation during stroking or testing. Such suspect snubbers are generally replaced as a preventive measure, even though they will often pass a subsequent operational readiness bench test. These snubbers are still considered as degraded due to the abnormal operation and counted in this metric. For the metric any snubber that is replaced, scheduled to be replaced, or repaired due to a finding is counted as a discrepancy. Although the process is somewhat subjective, training enforces the objective of making conservative decisions regarding any questionable findings.

All mechanical snubbers that are manipulated or worked in any way are considered in the metric calculation. This includes those snubbers removed and tested in accordance with the sample plan requirements, service life monitoring testing, snubbers stroked during the cycle, snubbers removed and reinstalled as interference items, or any other activities that involve unpinning at least one end of a snubber assembly. By including all of these activities in addition to the stroke program snubbers, the number of snubbers validated by "hands on" tasks generally far exceeds one-third of the total population each cycle.

2.1.3 Plant "A" Results

Data trending began with initial implementation of the expanded stroke program in 2005. The tables show the calculated Total Degradation Rate for each group overtime. The interval between data points for each group of snubbers is 3 cycles, approximately 4.5 years.

As an example of how the data is compiled consider the following inputs:

For the most recent Unit 1 Cycle for Group A (4th Time for this group) a total of 39 mechanical snubbers were functionally tested and 269 other mechanical snubbers were stroked or otherwise manipulated during the cycle. This results in a total of 308 snubbers worked during the cycle. There were no sample test failures, however 2 snubbers were replaced as preventive maintenance due to problems noted during stroking. Thus, the resultant rate is 2/308 or .65%. This calculation is performed each cycle.

As can be seen by the tabulated data, each group has shown a downward trend in the degradation rate over time. Conversely, this can be denoted as an increase in population reliability.

It is noted that the various groups do show some deviation in degradation rate relative to the other groups. This is attributed to the fact that although the groups are generally representative of the population at large, they are not identical to each other. In order to efficiently bundle outage work some of the groups are more heavily weighted with snubbers in specific areas, which can result in more exposure to severe environments, which in turn contributes to varying discrepancy counts. For example, snubbers located in the pressurizer cavity are grouped to be worked together. Likewise, snubbers in steam doghouses are grouped together. This facilitates more efficient and safer work conditions for the respective cycles but can result in some data differences due to some groupings having more snubbers in harsh environments than others.

At this time the disparity between the groups is not considered to be of extreme significance, relative to the fact that all groups indicate a downward degradation rate. It is anticipated that the delta between the groups will narrow over time, as the degradation rates for all groups is expected to level off in the long term. However, further data trending is needed to confirm such assumptions.

Related to this data, a review of the degradation rates prior to the implementation of the 100% stroke program indicates that previous rates of 2.5% to 3% were largely due to degraded and failed functional tests of snubbers which were NOT included in the previous stroke scope. It can be surmised that had those snubbers been included in that scope the degradation rate would have been lower. Since the implementation of the 100% stroke program Unit 1 has not experienced a sample test failure and Unit 2 has only had two failures, both of which were due to mishandling of the snubbers during maintenance rather than age or inservice issues.

Table 1

Unit 1 Group Trending of Degradation Rate				
	Group A	Group B	Group C	Average
1st Time	4.08%	3.56%	2.72%	3.45%
2nd Time	3.43%	2.99%	1.15%	2.52%
3rd Time	0.86%	0.29%	0.91%	0.68%
4th Time	0.65%	0.00%	N/A	N/A

Table 2

Unit 2 Group Trending of Degradation Rate				
	Group A	Group B	Group C	Average
1st Time	6.25%	2.54%	3.94%	4.24%
2nd Time	2.40%	1.50%	2.48%	2.12%
3rd Time	1.91%	0.90%	1.42%	1.41%
4th Time	0.88%	0.44%	N/A	N/A

2.2 Plant "B"

2.2.1 Plant "B" Background

Plant B is a two-unit, four loop PWR design. It has a very large mechanical snubber population but has never implemented snubber reduction. One unit is predominantly hydraulic snubbers and the other is predominantly mechanical. After 15 cycles of operation the plant implemented a 100% stroke program of the mechanical snubbers. On one unit one-half of the snubbers were stroked each cycle and on the other 25% are stroked each cycle. Thus, the population of one unit was stroked every 3 years and the other every 6 years. This schedule was maintained for another 20 years, at which time both units were placed on the 25% or 6 year schedule.

2.2.2 Plant "B" Results

Due to multiple changes in program ownership the historical data for Plant B is not as complete as that of Plant A. It is not a simple matter to calculate a definitive degradation rate without expending significant resources. However, it is possible to review overall data and make subjective conclusions. Plant B did have a "significant" history of failed and degraded mechanical snubbers prior to implementing the stroke program. Raw numbers clearly indicate that the number of failed mechanical snubbers has decreased over time, even if detailed cycle by cycle comparisons are not readily available. Data compiled over the last five cycles indicate that the average degradation rate is approximately 2% for both units, which subjectively represents an improvement over time.

2.3 Plant "C"

2.3.1 Plant "C" Background

Plant C is a single unit, three loop PWR design. It has a large mechanical snubber population of over 1300 snubbers. For the first 20 cycles the snubber program consisted of visual examinations, 37 Plan sample testing, and stroking of a minimal number of snubbers. The stroked snubbers consisted of a select group of approximately 60 snubbers installed outdoors on the main steam system (which were stroked every other cycle) as well as others that may have been affected by a dynamic transient event. Near the end of those first 20 cycles there were repeated testing failures with multiple sample expansions as a result. The failure rate for those later cycles was greater than 5%. Subsequently a stroke program was implemented for the mechanical snubbers.

2.3.2 Plant "C" Results

The Plant "C" stroke program is designed to rotate through the entire population over four cycles. Due to the recent implementation of the program this will be accomplished over the next several cycles. Although the entire population has yet to be stroked, the current failure rate has been reduced to 2% and is expected to improve even more as the stroke program rotations complete.

3. CONCLUSION

The implementation of a Mechanical Snubber Condition Monitoring Program consisting of manually exercising (stroking) the snubbers has resulted in more reliable snubber populations in the three operating plants researched for this paper. Such programs have proven to be beneficial with regard to reducing degradation over time. The data presented herein does not address specifics related to cost effectiveness, as those determinations are site specific relative to population size and resource availability. For the sites noted the programs were determined to be beneficial and cost effective based on the site-specific needs and existing scope. In cases where a stroke program can be justified such a program could be utilized to increase the mechanical snubber population reliability.

