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Continuous Improvement with PM Optimization

Lessons Learned
From
Kewaunee Nuclear Power Plant's
Living Program

Continuous Improvement with PM Optimization: Lessons Learned from Kewaunee Nuclear Power Plant's Living Program

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Abstract

Feeding back the results of PM activities after Reliability Improvement program implementation is necessary to maintain a PM program in optimal condition. It is through the Living Program that PM tasks are continually updated to maintain the best balance between the cost of performing tasks and their effectiveness in preventing or reducing failures that impact equipment reliability and system availability.

This paper describes the lessons learned and cost savings achieved during Kewaunee's four-year-old Living Program. This is the follow-up of the paper presented at the 1995 SMRP annual conference titled *Improving Equipment Reliability and Plant Performance Through PM Optimization at Kewaunee Nuclear Power Plant: An Integrated Approach to Plant Maintenance*.

Introduction

When a facility decides to utilize an Asset Reliability Improvement Program (ARIP) to improve their maintenance program, a commitment must be made to support the long-term review and update of the task recommendations after implementation. The facility must assign staff to periodically monitor maintenance program effectiveness and to feedback new experiences into the maintenance program.

This paper examines how Kewaunee Nuclear Power Plant's (KNPP) Living Program helps them maintain PM program effectiveness and reviews the lessons they have learned along the way.

Background

KNPP is a 503 MW Westinghouse pressurized water reactor that began commercial operation in 1974. The plant is located on Lake Michigan, about 30 miles Southeast of Green Bay Wisconsin. Industry observers recognize KNPP as the best operated and maintained Nuclear power station in the United States. KNPP has earned the nuclear industry's Award of Excellence seven times, a feat achieved by only one other plant[1]. Additionally, the Nuclear Regulatory Commission awarded KNPP top ratings in Maintenance during their last two SALP inspections[2, 3].

KNPP commenced their ARIP in March 1994. One year and sixty five systems later, they completed their ARIP analysis phase, implementing 7,300 task recommendations and commencing their Living Program[4].

The principal responsibility of the project resided with the maintenance organization. High craft participation was one of the contributing factors to its success. Some of the best information collected was from the plant personnel's wealth of detailed knowledge of plant operation and maintenance. In addition, having craft personnel on the team simplified program acceptance and technical result implementation because they could communicate directly with their peers.

Success Factors

During the research to identify the factors influencing KNPP's successful Living Program, it became apparent that a number of the factors were unique to KNPP's operating environment. Nonetheless, many of the factors identified were general in nature and would be appropriate in any plant environment. These were broken into the five categories shown in Figure 1. The following sections describe each category and the contributing factors of their success.

Category
❑ Technical Results
❑ Change Control
❑ Effectiveness Monitoring
❑ PM Optimization
❑ Analysis Tools

Figure 1: Elements of a Successful Living Program

Technical Results

For many organizations, completing RCM analysis marks the successful end of their ARIP. Nothing is further from the truth. In fact, until the "wrench hits the nut" by transforming task recommendations into scheduled activities, the entire RCM effort is nothing more than an expensive exercise.

If the project plan does not explicitly address how final task recommendations are converted into plant activities, then the technical content and format suffer. Omitting this critical step may lead to results that have little in common with the procedures and checklists that the maintenance organization are accustomed to seeing and will be unsuitable for implementation.

During KNPP's pilot project they established two technical content requirements: a.) The final recommendations had to be in a format suitable for direct implementation into their maintenance programs and b.) The implemented recommendations had to be retrievable for review and reanalysis during the Living Program.

The first step was identifying the mechanisms, or implementing vehicles, where KNPP managed their PM activities. This ultimately included operator rounds, predictive maintenance programs, and their planning and scheduling program. Each implementing vehicle format and content requirement was documented in the program instructions and the RCM software output was modified to match the implementing vehicle requirements.

Technical Results
❑ Define technical content and format for each implementing vehicle (CMMS, operator logs, etc.).
❑ Develop a comprehensive procedure for those requirements.
❑ Keep RCM jargon out of final task recommendations.
❑ Identify operating constraints (shutdown, operating, etc.) to aid performance grouping.
❑ Create PM job plans as part of the Program.
❑ Expand the Program scope to include implementation and the Living Program.

Figure 2: Technical Content and Format Success Elements

KNPP manages their planning and scheduling program separate from their work management system. Frequent schedule meetings keep maintenance impact on equipment availability to a minimum. A project to migrate their legacy planning and scheduling program to a client/server environment began during the analysis phase, which allowed coordinating the ARIP with the planning and scheduling system upgrade. This up-front coordination of related projects permitted the team to produce results that could converse directly between the new management systems.

The team also decided to include performance grouping within the scope of the ARIP. Performance grouping organizes related PM tasks in a job plan to minimize the impact of equipment availability and to maximize labor resource productivity and utilization. This decision was based in part on the need to adjust frequencies away from their "optimized" values for performance grouping.

Change Control

Traditional PM programs tend to be segregated, with maintenance responsibility seldom crossing organizational boundaries. Adapting ARIP changes that. RCM analysis creates a carefully balanced multi-disciplined equipment strategy, optimized to prevent failure using the fewest number of resources. Teardown maintenance is no longer performed on a fixed interval; instead, plant organizations must rely upon each other to communicate degraded equipment condition and schedule the appropriate activity only after reaching a preset level.

Personnel external to the ARIP may not be cognizant of the multi-discipline equipment strategy, so even a seemingly innocuous change to a PM task could disrupt the strategy's overall effectiveness. To prevent uncontrolled changes to the PM program during both the analysis phase and the Living Program, PM change requests must be routed through the Reliability organization for review and final disposition.

KNPP's team composition simplified the change control because their team members were the already the final approval authority for the PM program changes before the project began.

During the Living Program, the people performing the work normally initiate PM change requests. Feedback, which may be in the form of a task change request submitted by the worker, triggers a review as represented in Figure 3. What is done with craft feedback once received is discussed in the Effectiveness Monitoring section.

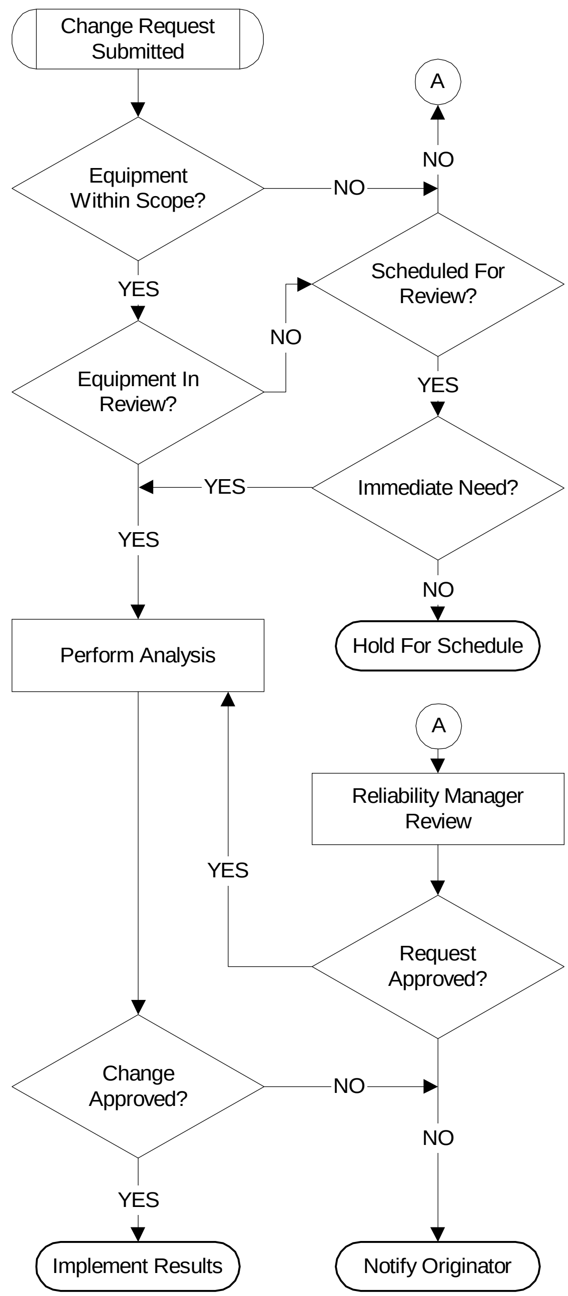

Figure 3: PM Program Change Control

Getting multiple plant organizations to agree to transfer program ownership is one of the more challenging activities in an ARIP. To accomplish this, it is essential to develop the administrative procedures to make change control an integral part of the PM program. Without the administrative procedures, plant personnel can too easily dismiss the ARIP as a short-term project that is not part of the PM program.

Change Controls

- ❑ Make Change Control an integral part of the plant procedures.
- ❑ Route all PM change requests through the Reliability organization for review and approval.
- ❑ Revoke edit permission in the CMMS PM module from everyone except the Reliability organization.

Figure 4: Change Control Success Elements

Effectiveness Monitoring

The purpose of monitoring maintenance program effectiveness is twofold: first, to identify and correct errors made during analysis and second, to incorporate new information into the program.

Corrective maintenance feedback from a facility's Computerized Maintenance Management Systems (CMMS) is the principal source for identifying analysis errors. Errors may include program scope omissions and misdirected PM tasks.

Refer to the workflow diagram in Figure 5 during the following discussion. If the work order were equipment related, the first question asked would be: could any type of maintenance have prevented the failure? If it is clearly determined that the failure is not maintenance preventable, then it is not within the scope of the ARIP and should be addressed by the root cause analysis process.

If the failure was maintenance preventable then the next question asked would be: could the consequence of failure by undesirable in regards to the PM program goals and objectives? If the failure caused a loss of revenue, environmental event, or personnel injury then it passes through to the next question. If the failure did not have significant consequences then a check is made to see if this equipment failure was recurring and if so, was the accumulated corrective cost significant? Equipment with costly corrective maintenance is treated the same as critical failure and passed on to the next question.

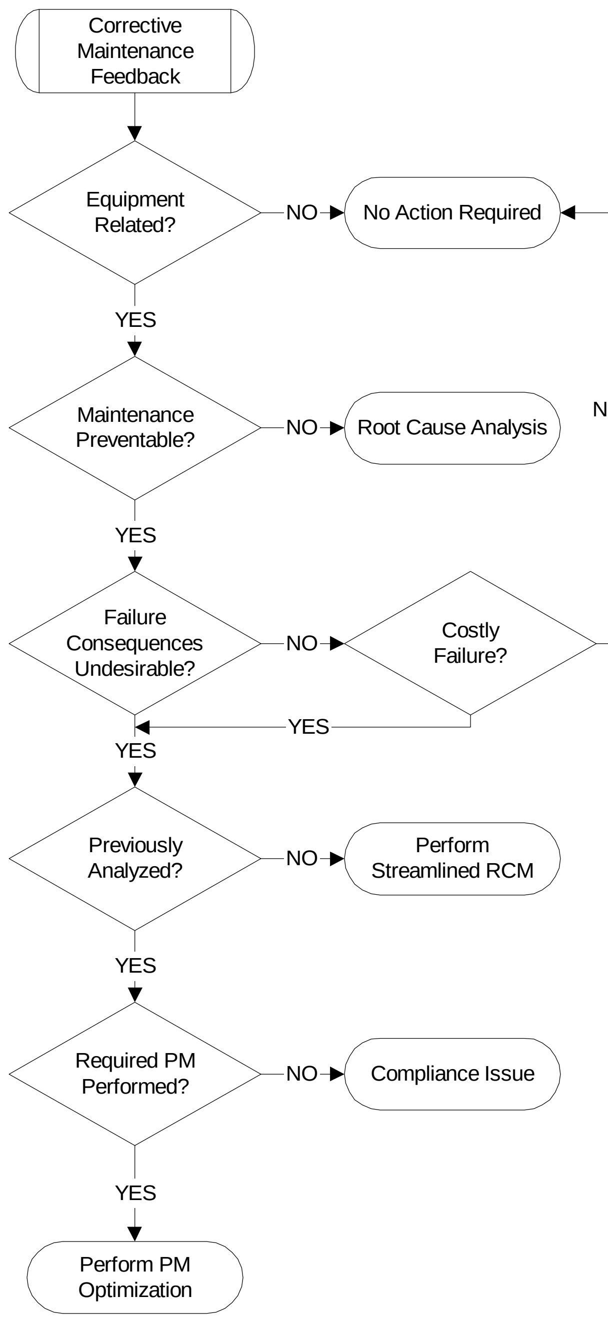

Figure 5: Corrective Maintenance Feedback

At this point, the work order is for the equipment that had a maintenance preventable failure with undesirable consequences and is now of obvious interest to the ARIP. The next question asked is: if the equipment was included in analysis anytime in the past? If not, then perform a component-based streamlined RCM analysis and determine if this is an initiating event for possible ARIP scope expansion.

If the failure occurred on equipment within the ARIP scope, it is important to determine if the prescribed PM strategy was performed. If the PM activities were not performed or they were performed incorrectly (i.e. improperly executed procedures, skipped steps, etc.), then there would be a compliance issue to address. If the PM activities were performed correctly, then a task-based evaluation would be performed using PM Optimization.

PM task feedback from the personnel performing the work triggers a task-based reanalysis. Work force input usually identifies inadequate or excessive task requirements. If the feedback on task performance repeatedly questions the need for the task then it is a candidate for task-based analysis. The same is true of tasks whose performance feedback indicates more should be done. In both cases, a potential Living Program adjustment is possible and PM Optimization is performed.

Effectiveness Monitoring

- ❑ Identify and monitor CMMS failure and performance indicators.
- ❑ Assure PM activities are performed on time and as scheduled.
- ❑ Collect, review, and incorporate new performance techniques.
- ❑ Use craft feedback to optimize existing PM tasks.

Figure 6: Effectiveness Monitoring Success Elements

PM Optimization

The Living Program has unique analysis requirements. It must support evaluating new equipment task requirements and it must support evaluating task effectiveness for equipment already within the PM program.

RCM is an equipment-based analysis process that, in essence, creates a new maintenance strategy where one did not exist before. The RCM method is suitable for new equipment but ineffective for evaluating PM task effectiveness after implementation, where a single PM task may require review. PM Optimization fills that role.

PM Optimization employs many of the same analysis techniques as RCM. However, PM Optimization is a more streamlined approach. RCM starts at the top with a system, breaks it down into subsystems, identifies critical components, recommends PM tasks and then compares those recommendations to existing PM tasks from which the final task recommendations are made. PM Optimization starts at the opposite end. The PM procedure is disassembled into tasks, the tasks are reviewed to identify the failure for which they are intended to prevent and related data is then collected and evaluated from which final task recommendations are made.

KNPP uses PM Optimization exclusively in their Living Program. Most of the team's effort is now directed towards evaluating craft PM task performance feedback and assuring tasks remain scheduled as originally intended.

Analysis Methodology

- ❑ Use RCM for new equipment additions.
- ❑ Use PM Optimization for evaluating task effectiveness.

Figure 7: Analysis Method Success Elements

RCM Software

The Living Program team at KNPP spends most of their time monitoring scheduled performance dates and managing Task Change Requests by means of their RCM software. Task Change Requests submitted by the technicians are run through PM Optimization analysis to document and analyze their requests. KNPP's selected RCM software is a commercial package called PREMO XPERTS®.

PREMO XPERTS® has supported KNPP both during the initial analysis project and during the last four years of their Living Program. It links directly to the inter- and intra- disciplinary PM tasks in KNPP's Planning and Scheduling system and supports full cycle analysis.

Besides satisfying the initial analysis phase requirements, it is essential to the Living Program's success that the RCM software meets the requirements in Figure 8 below.

Software Requirements

- ❑ Archive the complete path taken through analysis for every analysis cycle.
- ❑ Retrieve past analysis results for reuse or review.
- ❑ Support RCM analysis for equipment-based evaluation.
- ❑ Support PM Optimization for task-based evaluation.
- ❑ Enable PM task performance grouping.
- ❑ Upload analysis results directly to the CMMS's PM and associated scheduling modules.
- ❑ Link to the facility's CMMS work order module and retrieve, by single equipment ID, corrective and preventive maintenance results.

Figure 8: RCM Software Success Elements

Summary

In the simplest terms, monitoring PM task effectiveness is the key to the Living Program and perhaps even more important than the initial analysis results. Failures in critical equipment are likely to continue to occur from a number of causes, some related to the initial and ongoing program effectiveness and some not. Analysis of equipment failure using RCM or PM Optimization is necessary to prevent recurrence and identify program improvements.

In the four years since beginning their Living Program, KNPP has realized the following benefits:

Four Year Benefits Summary

- ❑ $1.5 million saved from interval extension and task elimination.
- ❑ 0% change in corrective maintenance.
- ❑ RCM Manager is a now staff position.
- ❑ 150 new tasks added because of new commitments and department preference.
- ❑ 5,370 PM work requests reduced to 1,753 by performance grouping related tasks between plant organizations.
- ❑ PREMO XPERTS® linked with procedures software for review/revision forecasting.
- ❑ Complete basis history on hard copy and in a relational DB environment.
- ❑ 12% reduction in maintenance staffing.
- ❑ Reliability program recognized as a strength from Nuclear Regulatory Commission (NRC) during two separate SALP reviews.
- ❑ Reliability program recognized as a strength from Institute of Nuclear Power Operations (INPO) during the last seven evaluations.
- ❑ Continues to be a point of immediate interest during visits from INPO and NRC.
- ❑ Spin-off for other Maintenance processes.
- ❑ Acceptance of new program was made through craft involvement.

Figure 9: KNPP Living Program Benefits

[1] "Kewaunee Nuclear Plant Again Recognized as Industry Leader", WPS Resources, June 8, 1998.

[2] Nuclear Regulatory Commission Systematic Assessment of Licensee Performance (SALP) report, March 1995.

[3] Nuclear Regulatory Commission Systematic Assessment of Licensee Performance (SALP) report, April 1997.

[4] Johnson L. and Johnson S. "Improving Equipment Reliability and Plant Efficiency through PM Optimization at Kewaunee Nuclear Power Plant", SMRP 3rd Annual Conference, Chicago Illinois, October 1995.