Streamlined Reliability-Centered Maintenance (SRCM) Program for Hydroelectric Power Plants

TR-111488

Final Report, November 1998

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REPORT SUMMARY

Following a philosophy of using and expanding existing technology if it makes economic sense, EPRI has adopted a reliability-centered maintenance (RCM) process called streamlined RCM, or SRCM. SRCM provides a utility a cost-effective process to determine the optimum maintenance strategy for plant systems and equipment based on importance to business objectives. SRCM maintains all the basic steps of traditional RCM.

Background

The advent of nonregulated has prompted electric utilities to optimize their operation and maintenance (O&M) programs. For hydro generators, controlling O&M includes the transition from reactive maintenance to a preventive/predictive maintenance strategy. To help its member utilities make the transition and become more competitive, EPRI has initiated Plant Maintenance Optimization development efforts. These efforts are intended to help utilities reduce production costs by developing and demonstrating cost-effective maintenance methods. This project is part of that program.

Objectives

To develop an integrated program based on RCM methodology that assists a utility in cost-effectively developing and maintaining an optimized maintenance program for their hydro generation facilities.

Approach

By using a logical step-by-step approach to determine the maintenance strategy for plant/systems, utilities are able to document the basis for the maintenance program, more effectively manage change to the plant maintenance program, and focus resources on doing the right task at the right time on the right equipment. This report describes how all of the SRCM tools and processes work together. Accompanying the SRCM process is software, program management, system and component templates, implementation support, training, and living program development.

Results

Several utilities with varying degrees of plant maintenance programs have used SRCM. Some plants with essentially no formal plant maintenance program are using SRCM to create a program for the first time; other plants have used SRCM to optimize their existing plant maintenance program. All utilities anticipate a reduction in unscheduled breakdown maintenance. Other benefits include improved communication between key plant staff concerning system functions, equipment failure causes, and their significance. Additionally, most utilities that have applied SRCM have computed a payback of less than one year.

EPRI Perspective

To date, several utilities have applied SRCM at their various plants with paybacks on the order of 1 year. As more utilities participate in EPRI's program, process and product refinements will evolve to enhance SRCM-based tools. EPRI envisions enhancements to the current SRCM program to include a SRCM user's group, implementation support, continued templates data enhancement, and living program support.

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Interest Categories

Hydroelectric

Keywords

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INTRODUCTION

As the electric power industry evolves into a non-regulated industry, extreme pressures are being placed on plant organizations to reduce costs for competition while maintaining or enhancing plant performance. Several utilities have gone through staff reductions as a first line of action for cost reduction. This has prompted a drive to control the operation and maintenance (O&M) programs. For the hydroelectric plants in the industry the controlling of the O&M program includes the transition from reactive maintenance as the main stay to a preventive/predictive maintenance strategy. World class facilities know having the proper mix of maintenance is key to cost-effective and enhanced maintenance. The Electric Power Research Institute (EPRI) embarked on a program to assist member utilities in making the transition and becoming more competitive.

A key element of EPRI's program is the use of reliability-centered maintenance (RCM) technology to guide a utility in improving and optimizing their maintenance program. While not trying to re-invent the wheel, EPRI has adopted an RCM process called "Streamlined RCM" or SRCM. While maintaining all of the basic steps of RCM, SRCM allows a utility to analyze down to the level required to make a maintenance strategy decision. Accompanying this process are software, program management, component templates, implementation support, training and living program development. All of these integrated products assist a utility in cost-effectively optimizing and maintaining an optimized maintenance program. Figure 1 shows how these tools and support provide EPRI members with cost-effective solutions when developing or refining systems and equipment strategies.

Over the past few years, several utilities have embarked on the implementation of SRCM at their various plants. These utilities are at various stages of the program. As more utilities participate in the EPRI program, process and product refinements will evolve to provide more enhanced tools to develop and maintain an RCM-based maintenance program.

- Every utility and plant needs to decide the objectives and goals of conducting an SRCM program. Usually utilities use SRCM as one means to achieve competitive production costs through maintenance optimization. SRCM will optimize maintenance by utilizing the following principals:

- Concentrate maintenance resources where they will do the most good.
- Eliminate unnecessary and ineffective maintenance.

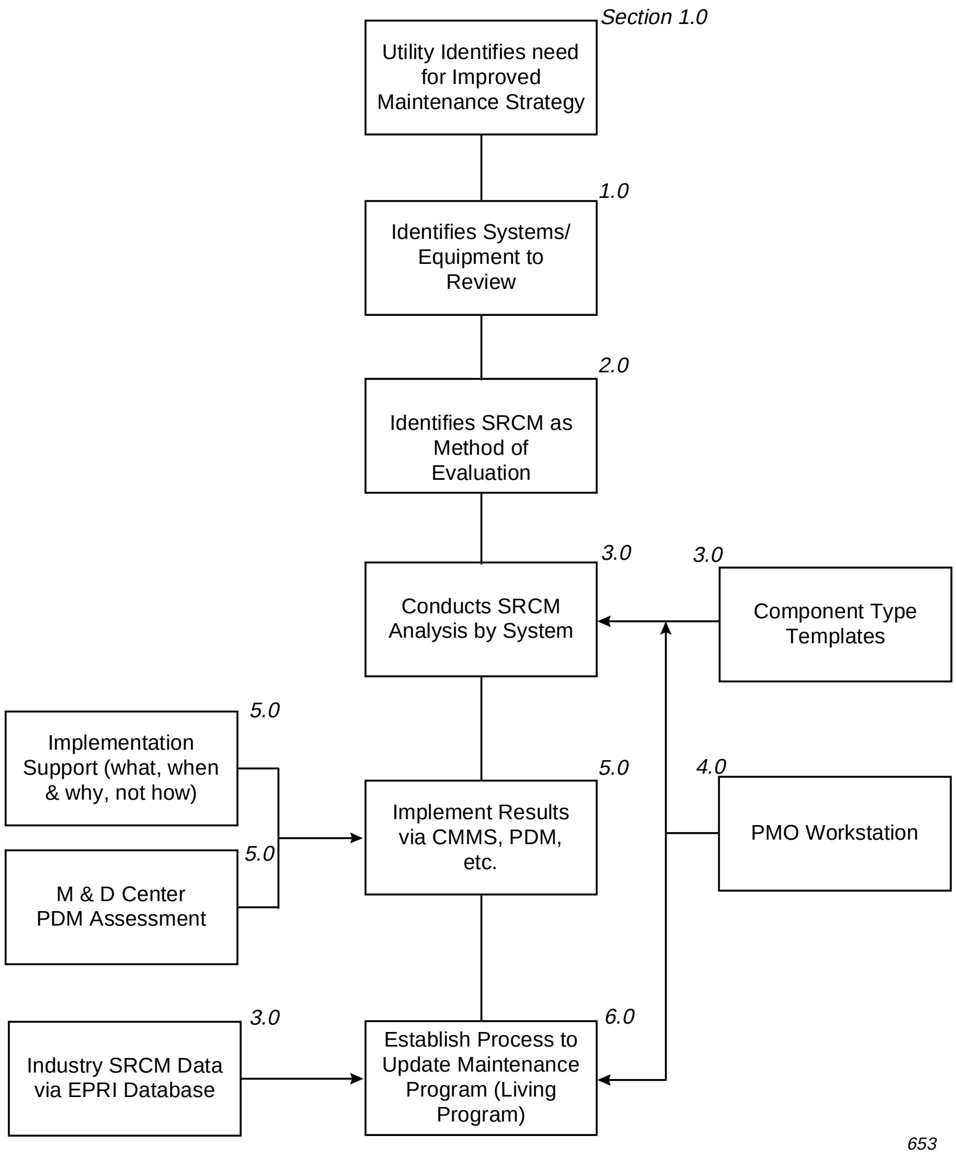

Figure 1-1
EPRI's SRCM Program

- Devise the simplest and most cost-effective means of maintaining equipment, or testing for degradation focusing on predictive or condition monitoring activities, where applicable.
- Develop a documented basis for the maintenance program.

- Utilize plant maintenance and contractor experience when determining PM tasks and frequencies.

In order to achieve the goal of an improved maintenance program at a plant, it is necessary to select systems that will meet the specified goals of the program. The systems typically selected for review are:

1. Generator/Exciter
2. Turbine/Governor
3. Station Service (AC Power)
4. DC Distribution
5. Cooling Water System

The criteria for selecting these systems are overall importance to plant operation, safety, reliability and historical maintenance costs, thus supporting the overall objective of developing a cost-effective maintenance program.

A real, but difficult to document, benefit is that the SRCM process involves and improves communication between the key plant staff functions (operations, maintenance and tech support in traditional organizations, and Production and Support Teams in more recent organizations) concerning system functions, equipment failure causes and their significance. The need for and benefits of, participation by key plant staff in the SRCM process can not be over-emphasized.

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WHY SRCM?

2.1 Classical RCM vs. SRCM

EPRI's experience with RCM methodology began in 1983 with trial applications to nuclear power plant systems. These applications were a direct transfer of an existing methodology from the commercial airline industry. Since then, numerous utilities have applied RCM to their nuclear plants in some form or other. In 1991, EPRI responded to utility concerns that classical RCM requires too many resources to perform an analysis on an average system. As a result, EPRI embarked on a major project to investigate possible methods of lowering the cost of performing an RCM analysis while maintaining the technical integrity of the process and results. One approach that resulted from this project was the SRCM process. The SRCM process was validated against classical RCM by applying both methods independently on the same plant system. The comparison found essentially identical PM recommendations with only minor differences driven by the two analysts different knowledge of the plant and equipment involved. A thorough knowledge of basic RCM is necessary to ensure accurate results when performing SRCM. Figure 2-1 shows a comparison of the two methods.

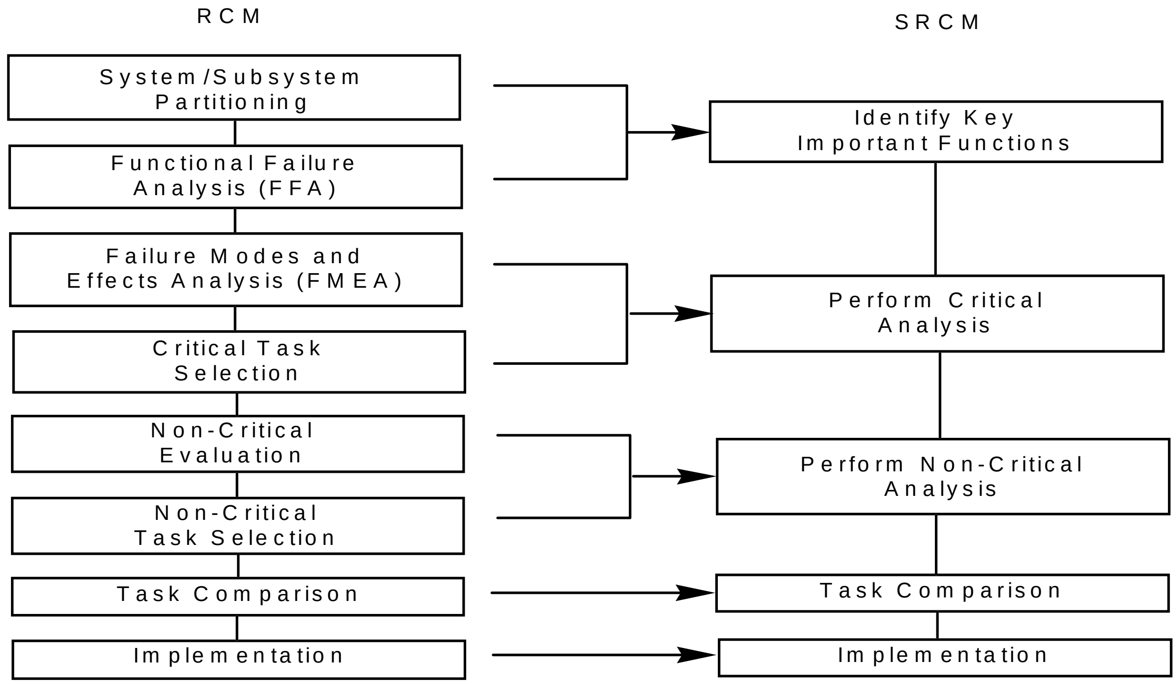

Figure 2-1
RCM/SRCM Comparison

Given the success of SRCM in the nuclear sector of the power industry, EPRI's fossil group funded several pilot SRCM applications at fossil plants. Over the past three years, the EPRI-sponsored SRCM process has been applied to over 120 systems at nine utilities. Currently an additional 200 plus systems are being analyzed. EPRI's hydro group has also funded SRCM studies at several hydro plants. Two plants have completed the SRCM analysis and two more are presently being analyzed. These successful SRCM applications together with a high level of utility acceptance has prompted EPRI to develop several additional tools and the enhancement of a commercial RCM software tool specifically designed to support the SRCM process. This commercial tool known as the PMO Workstation, developed by ERIN Engineering and Research, Inc., has been used to support the EPRI projects and is now available to members. The software enhancements, funded by EPRI, consist of system and component templates as well as a living program module.

2.2 Typical Results and Benefits from an SRCM Program

The application of SRCM at several utilities has had widely varying results and benefits. Some plants have essentially had no formal PM program thus using SRCM to create a program for the first time. Other plants have used SRCM to optimize their existing PM program. All utilities anticipate a reduction in the amount of unscheduled breakdown maintenance.

The SRCM process includes the review of all equipment in a system thus providing analysis to define the maintenance program for the complete system not just 'critical' equipment in a system. If a system is needed to meet critical plant needs then all critical elements of the system must function properly, not just certain components.

The results to date have included adjustments in time-directed tasks, both content and frequency, identification of PdM technology applications, functional testing and single point failure identification. The maintenance task recommendations have included optimization of all types of PM/PdM tasks, identification of design reliability issues and institution of new performance testing and other condition monitoring as well as reducing ineffective maintenance tasks.

The plants using the SRCM process range from new to over 30 years old. Each have experienced staff with varying degrees of PdM programs in place. SRCM has allowed all the plants to focus their maintenance resources on the right maintenance strategy, integrate the departments for efficiency (e.g. electrical, mechanical, I&C, operations, and engineering) and reprioritize the PM tasks with clear understanding of the ramifications if a task is deferred.

Table 2-1 provides some of the overall results from SRCM application at EPRI member fossil utilities (hydro members have not accumulated enough data to specify values, but experience indicates that they would be similar in ratio to the size of the units analyzed)

Table 2-1
SRCM Savings

Utility	Payback Period	Annual Savings*
1	1 year	~$300K
2	< 1 year	$270K
3	1 - 2 year(s)	$200K
4	1 year	$600K

*Only includes PM man-hours and parts

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HOW TO PERFORM SRCM

3.1 The SRCM Process

The SRCM produced PM plan must support an individual unit's mission (base load, load following, or standby, etc.) to assure the unit performance is in compliance with that mission. Thus, a unit's mission provides the basis for determining component criticality and subsequent PM task selection.

The following describes the PMO process utilized to determine component criticality and PM task selection. Figure 3-1 illustrates the steps of the process.

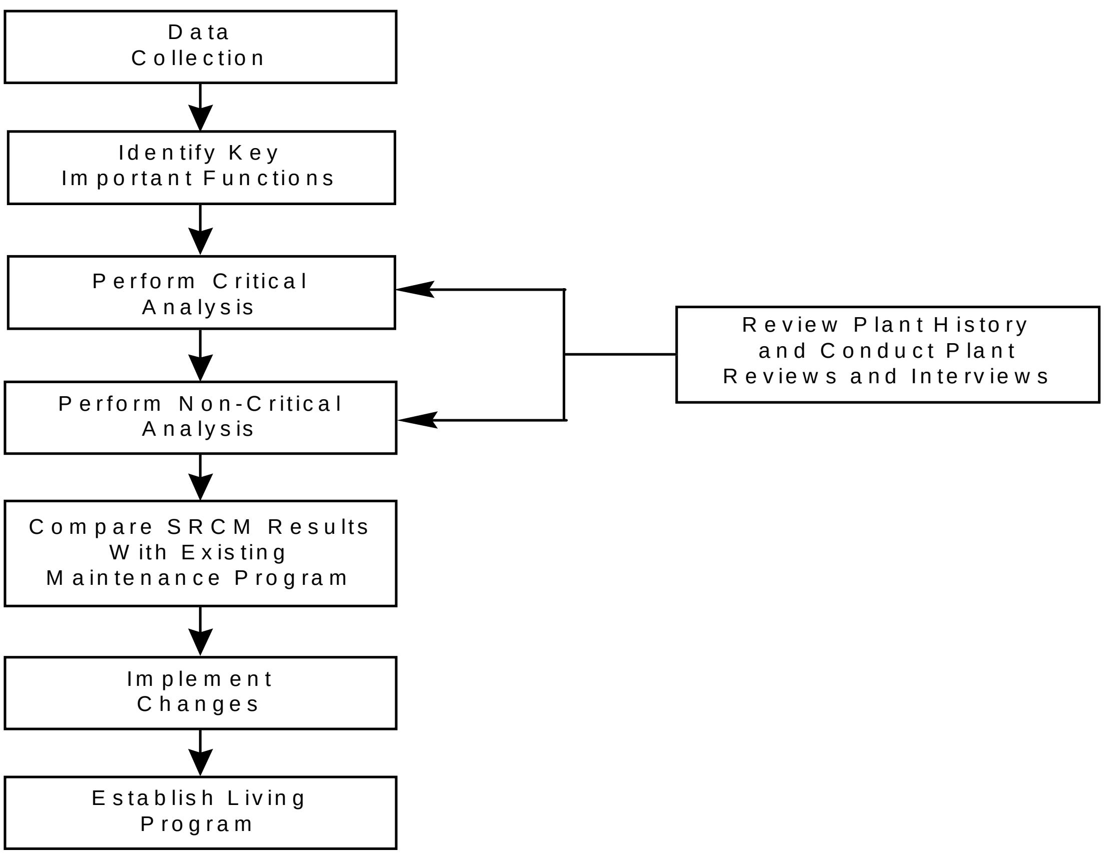


Figure 3-1
SRCM Process

Data Collection and Plant History Review

The same system data is required to perform this streamlined analysis as is needed for a standard RCM analysis. In order to facilitate this streamlined analysis process and maximize the associated cost benefit, the analyst should perform a detailed review of all the pertinent system information including corrective maintenance and existing PM and testing programs prior to starting the main analysis process steps. Sources of information for this review are obtained from various plant documents and data.

Typical documentation or data includes:

- System Description
- System Drawings (P&ID's, electrical schematics, logic diagrams, etc.)
- Component Listing (electronic)
- Component Corrective Maintenance History (3-5 yrs. if available)
- Existing Preventive Maintenance and Surveillance program (PM and PdM tasks, operator rounds, etc.)
- Commitments/Requirements for existing PMs and tests

Information not readily available from the above sources may be obtained through interviews or review meetings with knowledgeable plant personnel.

Identify Functional Failures

The identification of system functional failures is performed in the same manner as in standard RCM. This process varies from standard RCM by focusing the analysis resources on the important functional failures through streamlined approaches to documenting the analysis. The analyst identifies all applicable functions for the system and then sorts the functions into two groups with appropriate justification: (1) Important functions and (2) Non-important functions. The criteria for determining whether a function is important can be modified by the organization performing the analysis. Generally, any function that directly affects plant safety or power production is considered important. Non-important functions typically include such items as local indication or ancillary system functions. Components that support important functions will be evaluated in the Criticality Analysis module. Even though the remaining system components that support non-important functions are not analyzed in the Criticality Analysis, they may still be analyzed in the Non-critical Analysis module.

One way to provide additional simplification in the analysis effort is to limit identified functions to only those that are important for plant operation and safety. This can be done by first characterizing the functions in fairly general terms and only using resources to identify the functions that are important. This avoids wasting time identifying functions that are not going to be analyzed in the Criticality Analysis module, while the remaining system components get analyzed through the Non-Critical Analysis module.

Critical Analysis

Following the standard RCM analysis methodology, the determination that a system component is 'critical' places heavy emphasis on the overall plant effect caused by a specific failure mode of the component. However, in this streamlined process, only the important effects are identified in the Criticality Analysis module, which is a streamlined Failure Modes and Effects Analysis (FMEA), to determine critical equipment. Also, in this streamlined process, the FMEA and the Task Selection can be combined and completed in one step. The following discusses the FMEA portion of the analysis and the Task Selection process is described in the PM task recommendation section:

FMEA

In standard RCM analysis, the analyst typically has an individual FMEA record for each dominant failure mode and the resultant local, system, and plant effects. This documentation provides direct linkage of the Functional Failure Analysis (FFA), specific component failure mode, and the local, system, and plant effects for each separate component-failure mode combination to determine component criticality. However, in the SRCM process, the analyst identifies every component that supports the functional failure and lists only the most significant failure modes for each component, along with the most dominant plant effects for the failure modes, all in one component record. The analyst determines the component criticality based on the various failure mode/plant effect combinations. Typical reasons for classifying a component as critical are that the plant effect results in a unit trip or shutdown, significant (costly) damage, reduction in power output, personnel hazard, or a violation of some regulation (e.g., environmental).

If a component is determined to be critical, the next step is to identify reasonable causes for the possible failure modes to allow the analyst to identify applicable and effective maintenance tasks, which should address preventing those causes or mitigating the possibility of the failure occurring when it is unwanted. (If a component is determined to be non-critical, it is evaluated further in the non-critical analysis, discussed later.) Task recommendations for critical components is discussed in a later section.

As with standard RCM, it is important and beneficial to receive engineering and operations review and input into the critical evaluation of the system components.

Non-Critical Analysis

The non-critical evaluation applies a different set of criteria for when maintenance should be performed. This places more emphasis on equipment-level economic considerations for the components that were determined to be non-critical in the criticality analysis or components that support non-important functions. These new criteria will evaluate the benefit of maintaining existing PM tasks or identifying new PM tasks rather than allowing the component to run to failure. The criteria used for the non-critical evaluation can be modified to meet plant specific requirements. If the component does not meet any of the non-critical criteria, then there is no need or cost benefit to spend routine maintenance resources and the component is allowed to run-to-failure then perform corrective maintenance. If there is a 'yes' response to one of the non-critical evaluation criteria, an appropriate PM task recommendation is made. Task recommendations for non-critical components is discussed in a later section.

A Maintenance Engineer review of the non-critical evaluation is important to ensure a well documented evaluation. This should be performed in conjunction with the review of the critical evaluation to maximize the efficiency of the process. Depending upon the task developed for the non-critical evaluation, it may also be desired to have the responsible Operations personnel available to provide input on some of the maintenance related criteria in the non-critical evaluation.

PM Task Recommendations

Once a component has been determined to be critical or non-critical, but not allowed to run-to-failure, the next step is to recommend applicable and effective preventive maintenance tasks based on the component's importance. Selecting the type of task to be performed and the frequency of the task can be accomplished in several ways.

The approach will utilize preventive maintenance templates as much as possible (see Section 3.4). SRCM projects use generic templates that combine EPRI's current "in-house" templates with capabilities and maintenance philosophies of the plant. Because the maintenance templates do not identify specific component failure modes or links to any specific plant effect, careful consideration must be exercised to ensure that the analyst selects preventive maintenance tasks that will prevent specific dominant failure modes and causes to ensure they are adequately addressed by the preventive maintenance programs. These failure modes and causes can be incorporated from specific facility experience or generic industry experience on similar equipment.

For critical components, the analyst selects failure causes associated with the dominant failure modes and effects that should be addressed through the preventive maintenance program. The analyst then identifies the applicable and effective preventive maintenance tasks to recommend. A similar step is performed for non-critical components that have been identified as requiring a PM task, except that no failure causes need to be explicitly identified.

Another method available to determine the appropriate preventive maintenance tasks for each component is the standard RCM Logic Tree Analysis (LTA). This method can also be used for any component type that does not have a maintenance template. The LTA directs the analyst to first determine if a condition monitoring technique exists that can prevent the unwanted failure from occurring. If not, then the LTA directs the analyst to determine if there are time-directed tasks that are applicable and effective in preventing the unwanted failure. The time-directed tasks should be considered from the least intrusive (no, or little disassembly) to the full overhaul (most intrusive). This is because past history has shown that unnecessary disassembly increases the chance of future failures and should be avoided, if possible.

Task Comparison

After the SRCM PM recommendations have been identified, the final step in the process for a utility is to implement them into the plant's PM program. The Task Comparison is a tool that is used to reconcile these recommendations with the existing PM program resulting in a guide for implementation. The existing PM program documentation should consist of every task performed on a component that has the ability to identify or prevent potential component failures and adverse effects (e.g. Preventive Maintenance tasks, functional or performance tests, lubrication, condition monitoring, etc.). The task comparison report becomes the basis for the actions required to implement the final recommendations after approval from the appropriate station personnel.

Appendix A contains examples of SRCM work products that illustrate the steps outlined above.

3.2 What Does It Take To Conduct SRCM?

Performance of SRCM on any plant system entails a coordinated effort between plant personnel and the analyst. The plant personnel involved include craft, engineering, operations personnel, as well as those directly responsible for the project. In order to obtain the most thorough and accurate information about the system under analysis, the analyst must solicit input from these various organizations. For this to happen, the project lead/manager must coordinate schedules such that, for the most favorable impact on the project, the personnel most knowledgeable are available for interviews and analysis reviews (Criticality, Task selection and Task Comparison). This can, at times, be a substantial investment of manpower into the SRCM analysis. Therefore, it is vital that the reviews and interviews be conducted efficiently, without sacrificing quality for speed.

Typically, the plant's project team make-up consists of personnel from engineering, operations, planning and maintenance (including supervisors, foremen and craft personnel). These personnel should be empowered to make decisions and implement changes in the maintenance program (change existing PM tasks, add new tasks, purchase PdM technology/equipment, etc.). The project team will also know which personnel are "expert" on a particular system, and will ensure that these experts are available to participate in the analysis. Most often, the analyst will perform the analysis with predetermined steps identified as review points. Usually, these points are the Criticality Analysis, Task Selection and Task Comparison. The reviews are usually conducted by the analyst with the appropriate project team members and any other plant personnel as appropriate. Quite often, the Criticality Analysis is reviewed by the analyst with only a representative from Operations. This is acceptable, as Criticality is a functional determination based on the effects of failure on the operation of the plant. However, the criticality review and determination should also involve members of the project team as this will ensure that members of the group understand the reasoning behind a component's criticality. Task Selection and Task Comparison, however, require greater project team participation in the reviews to develop the best PM program and how to implement the results.

As part of the Task Selection process, it is valuable for the analyst to obtain input from the system experts to identify relevant problems, design deficiencies, ineffective existing maintenance tasks and practices, as well as suggestions for improvement of the maintenance performed. These experts are usually senior craft personnel or foremen/supervisors from the mechanical, electrical and instrumentation disciplines, as well as from operations and engineering. This input can be obtained through interviews conducted individually or collectively, depending on availability, with the goal to collect information to determine equipment performance and make recommendations as to what maintenance should be performed.

Table 3-1 lists the typical man-hour requirements for performing an SRCM system analysis.

Table 3-1
SRCM Analysis Labor

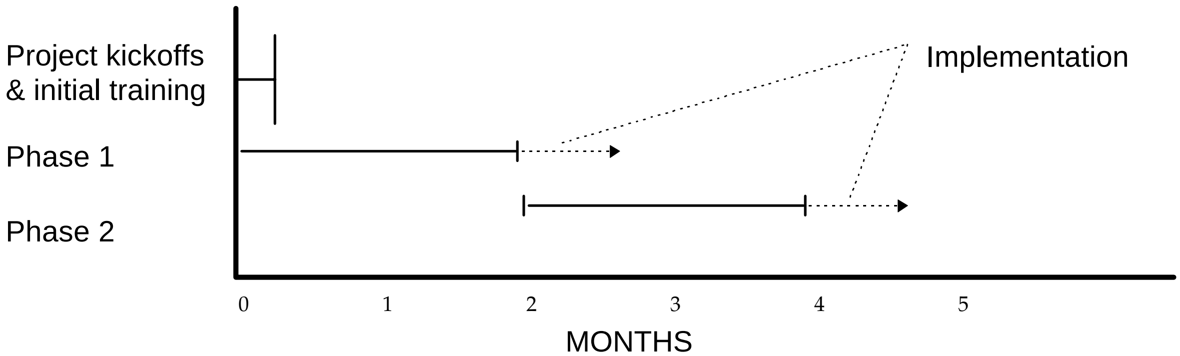
ACTIVITY	HOURS	
	Analyst	Resource/Core Team
Data Collection	24	8
Critical Analysis and Task Selection	80	20
Non-Critical Evaluation and Task Selection	16	8
Analysis Reviews	16	16
Task Comparison and Review	24	12
Implementation	--	20-200 (1)
Totals	152	76-256 (1)

s(1) The number of hours required for implementation is utility-specific and driven by a variety of factors, including the scope of changes to the PM program, purchase and installation of new PDM equipment, training in the use, upkeep and interpretation of PDM data, interface between the SRCM software and the utility's maintenance management software, etc. Some systems may require as little as 20 hours.

Schedule

The key to success for multi-system SRCM projects of this nature is to allow a continuous flow of analysis and recommendations that can be reasonably implemented. The timeline below depicts the overall project schedule.

Table 3-2
SRCM Project Schedule



Note: 2 systems in Phase 1, 3 systems in Phase 2.

The timeline above shows the process used to complete 5 systems in 2 phases. Note this is a nominal timeline, the actual schedule for a specific phase may be longer depending on the system sizes, data collection, and availability of plant staff.

During each phase, the EPRI contractor conducts several meetings on-site. Typically, there are 3 or 4 meetings. The first is at the beginning of the phase to collect the data for the systems to be analyzed. The second meeting is to review the criticality analysis (FMEA) portion of the analysis. The third meeting is to review the task recommen - dations for the critical and non-critical components. The final meeting is to review and complete comparison. Some plants may not have the fourth meeting since task comparison is not always possible with the present PM program documentation.

3.3 Training and Analysis Support

A Typical 5 system project provides detailed SRCM training at multiple levels. The project team members receive extensive training through participation in the analysis reviews and data gathering. Others will have training commensurate with their level of participation. Training for project team members is provided at the plant and includes anywhere from an overview of the process to training in a workshop environment in which utility personnel would obtain actual experience performing SRCM analyses on a simplified system. The workshop includes:

- System function and functional failure determination
- Equipment failure mode and effects analysis (FMEA) and criticality determination
- Component task selection
- Implementation

- Living program development

This training is conducted over one (1) day and provides employees a firm understanding of RCM/SRCM concepts.

The primary training method used is on-the-job (OJT) training. Training is held during site visits for reviews and interviews for the system studies. This OJT will provide project team members the required knowledge for implementing results and supporting the remaining phases of system studies.

To complement the training of project team members, it is important for the plant staff to have an understanding of the SRCM process. While at the plant site, EPRI provides a 1-2 hour training session to as many plant staff members as desired. The presentation material is left with the utility to continue training by project team members for future needs.

The following support options are minimal to full service support. Even though the PMO Workstation is free of charge to hydro target __ members, EPRI requires a member to at least have the minimal training.

1. Software provided without enhancements for immediate use (PMO Workstation, Version 3.1) with training consisting of 1½ days on SRCM process, plus ½ day on workstation, plus 1 day of facilitation assistance. Note: if personnel to do system study received SRCM training via EPRI SRCM workshop, then the option changes to 2 days of facilitation support instead of 1 day.

2. Facilitation support consisting of 3 one-week hands-on training on-site at one plant.

3. Pilot project where utility personnel conducts 1 system in parallel with an ERIN analyst conducting 1 system.

4. Pilot project where ERIN conducts 1 system study with utility training.

5. Total unit project where ERIN conducts 5 system studies.

6. All plants/units conducted by ERIN - cost subject to number of units/plants and similarity of units.

3.4 System Templates

System templates are expected to be developed for a more automated SRCM analysis by system (e.g. generator, station service, etc.) using previously performed system studies for the bases. These system templates may be arranged by various types (e.g. governor oil pump - Type A is no redundant pumps, Type B - redundant pumps) allowing the user to select the type that most closely reflects the users' system. The generic system templates will be electronically available through the PMO workstation and once selected, electronic guidance via analysis checklists/questionnaires, etc. will be used to guide the user in the conversion of the generic study to plant specific results. Currently there are generic system templates for fossil plant systems and their use will help the development of hydro system templates. Additionally, as more systems are analyzed via EPRI's SRCM program, the use and expansion of available system templates can occur.

When available, each system type will include variations in system configuration. The types are by system and allow the user to select a system type closest to his to begin his own analysis. Once a type has been selected, the PMO Workstation generates the appropriate copy of the data to allow changing for specific aspects of any plant. The workstation prompts the user to review the template for appropriate changes of minor configuration differences, operational and maintenance use/strategies, specific history differences, and equipment identification. Once the analyst has completed his review, a specific system study is ready for final review and implementation.

3.5 Component Type Templates

The second kind of template developed is the component type maintenance templates. These templates consist of maintenance strategies for various component types. This is similar to the work ERIN conducted for EPRI Nuclear during the PECO Limerick project. These templates will be based on system studies previously analyzed via the SRCM program. The templates will be expanded as more information becomes available, particularly by make and model or new component types. The templates will be made specific to hydro unit experience and include component types unique to hydro such as turbine types. The templates will be automated and provide user customization based on criteria such as technology capabilities and level of conservatism desired in a utilities maintenance program.

The workstation accommodates an unlimited number of component templates allowing expansion. The templates support the task selection activity for critical and non-critical equipment. The templates provide information similar to that found in Table 3-3.

For each of the templates a basis screen is included to provide further justification information for PM tasks and frequencies. Also, an ability to review a general instruction on how to perform each task in the template is included (e.g. PdM, time-directed or testing).

Table 3-3
Example of a Generic Maintenance Template

Component type:	**PUMPS (CENTRIFUGAL)**										
Component Classification Category:											
Critical	YES	√	√	√	√						
	NO					√	√	√	√		
Environment	Harsh	√	√			√	√				
	Non-Harsh			√	√			√	√		
Usage	Frequently	√		√		√		√			
	Seldom		√		√		√		√		
		Frequency								Failure Cause	**COMMENTS**
Condition Monitoring Tasks:											***Tasks identified for Non-Critical should ONLY be performed on expensive/large pumps. Otherwise, choose from the Time-Directed listing.***
Perform full spectrum vibration monitoring. Establish baseline and action levels. Trend results.		3M	6M	3M	6M	6M	12M	6M	12M	BS; GW; LC; SC	
Perform lube oil analysis. Establish action levels. Trend results.		3M	6M	3M	6M	12M	12M	12M	12M	BS; SC; SL; DL	*Sampling and analysis of lube oil to include water, sediment, viscosity. A qualitative and quantitative analysis of metal and impurity content to be performed for diagnostics only.*
Perform component performance test over full range of operation. Establish baseline and action levels. Trend results.		18M	18M	18M	18M	NN	NN	NN	NN	IW; SC	*This test should include pressures, temperatures, flows, leaf-offs, etc.*
Time Directed Tasks:											
Perform detailed clean and inspect. Include inspection for erosion/corrosion.		CD /54M	CD /54M	CD /54M	CD /54M	CD /90M note 2	CD /90M note 2	CD /90M note 2	CD /90M note 2	BS; DL; IW; LC; PL; SC; SL; UD	*Use these frequencies only if NOT implementing ALL the Condition-Monitoring and Surveillance Tasks, otherwise, condition direct this task.*
Perform overhaul of component		CD /60M	CD /90M	CD /60M	CD /90M	NN	NN	NN	NN	BS; DL; IW; SC; UD; GW; AG; PL	*Use these frequencies only if NOT implementing ALL the Condition-Monitoring and Surveillance Tasks, otherwise, condition direct this task.*
Perform visual/pump seal inspection		OR	OR	OR	OR	OR	Note 1	OR	Note 1	DL; LC; PL; SL; UD	*The qualitative observation of a component's condition or performance.*
Perform check of lubricant, add or change oil when needed		OR	OR	OR	OR	OR	Note 1	OR	Note 1	BS; DL; SC; SL	*Use lube oil analysis to condition direct the oil change when possible.*
Lubricate (Greased bearings and coupling)		18M	18M	18M	18M	24M	24M	24M	24M	BS; DL; SC; SL	
Perform changeout of lubricant		CD /18M	CD /18M	CD /18M	CD /18M	CD /24M	CD /24M	CD /36M	CD /36M	BS; DL; SC; SL	Use these frequencies if not performing lube oil sampling.
Surveillance Tasks:											
Monitor vibration and temperatures, and performance.		1D	1D	1D	1D	1W	1W	1W	1W	BS, LC, SC	*Data log and trend either daily or weekly.*
Economic Considerations:											
Run until corrective maintenance is required		NA	NA	NA	NA	ü	ü	ü	ü		

4

PMO WORKSTATION

The SRCM program at EPRI includes the use of ERIN's PMO Workstation. Through a cross license, EPRI has obtained a no-cost to member license for the installation and use of the PMO Workstation at a member's plants.

PMO WORKSTATION DESCRIPTION

The Plant Maintenance Optimizer (PMO) Workstation Version 3.1 is an MS-Windows 3.1, Windows 95, or Windows NT relational database management software package for the PC that uses dBase 3plus file structures. (The next version, Version 4.0 will use MS Access file structure.) The PMO Workstation provides an on-line data entry, storage, retrieval, and report generating capability. Databases are used for each of the principle PMO tools: Functional Failure Analysis (FFA), Criticality Analysis, Non-Critical Evaluation, Critical and Non-Critical Task Selection, PM Task Comparison, and Implementation Tracking. Lookup files are used to store common information such as component descriptions, failure modes, failure causes and effects, and the current maintenance program for the system(s) being analyzed.

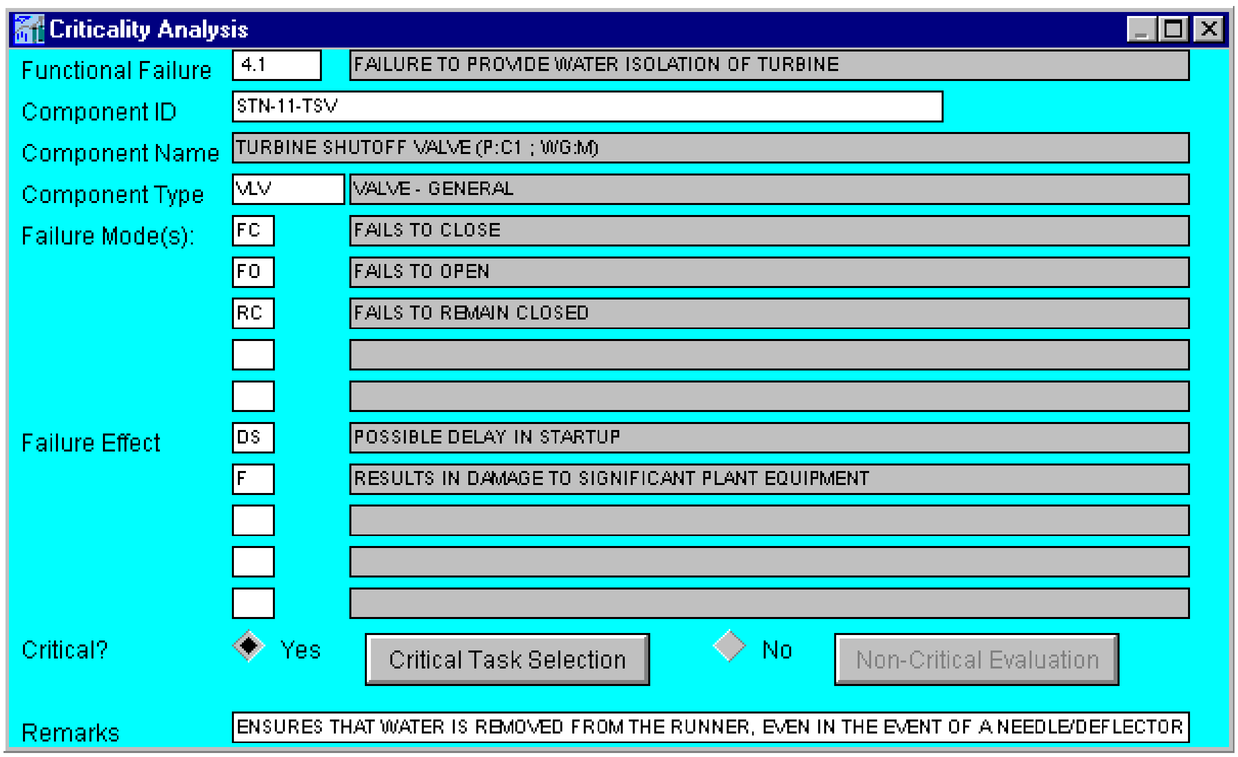
The PMO Workstation is designed to be used efficiently with simple manipulations of a mouse, thus minimizing keystrokes. PMO has extensive built-in reports. These may be modified by the user through the use of the report generation software package (separately purchased by user, not an ERIN product). Reports are printed using standard MS-Windows fonts and may be viewed in their entirety prior to printing through the PMO View Report window. In addition, reports may be filtered to isolate any portion of the database.

The PMO Workstation is completely self-contained and requires no additional database software. To assist with setting up new system analyses, certain data files may be imported by the user by using "flat files" in ASCII comma-delimited format. This data includes System Component Lists, Current Maintenance Program data, and Corrective Maintenance History data, if desired. Additionally, many of the lookup files are pre-loaded with standard data. These files consist of codes and corresponding descriptions that are used to simplify the data entry in many PMO modules. The lookup databases including Component Types, Failure Effects, Failure Causes, Task Bases, Recommended PM Tasks, and PMO Recommendation Justifications were developed by

ERIN Engineering to provide a set of commonly used choices for these fields and to provide a foundation for developing plant-specific lookup databases for PMO Workstation users. The component types and failure modes were obtained from a review of industry sources including the IREP Generic Database and IEEE-500.

NOTE: As with PMO Workstation databases in general, the contents of any lookup file may be customized by the user at any time.

A sample Criticality Analysis data entry screen is shown below, as well as a brief description of several major features that are included with the PMO Workstation.

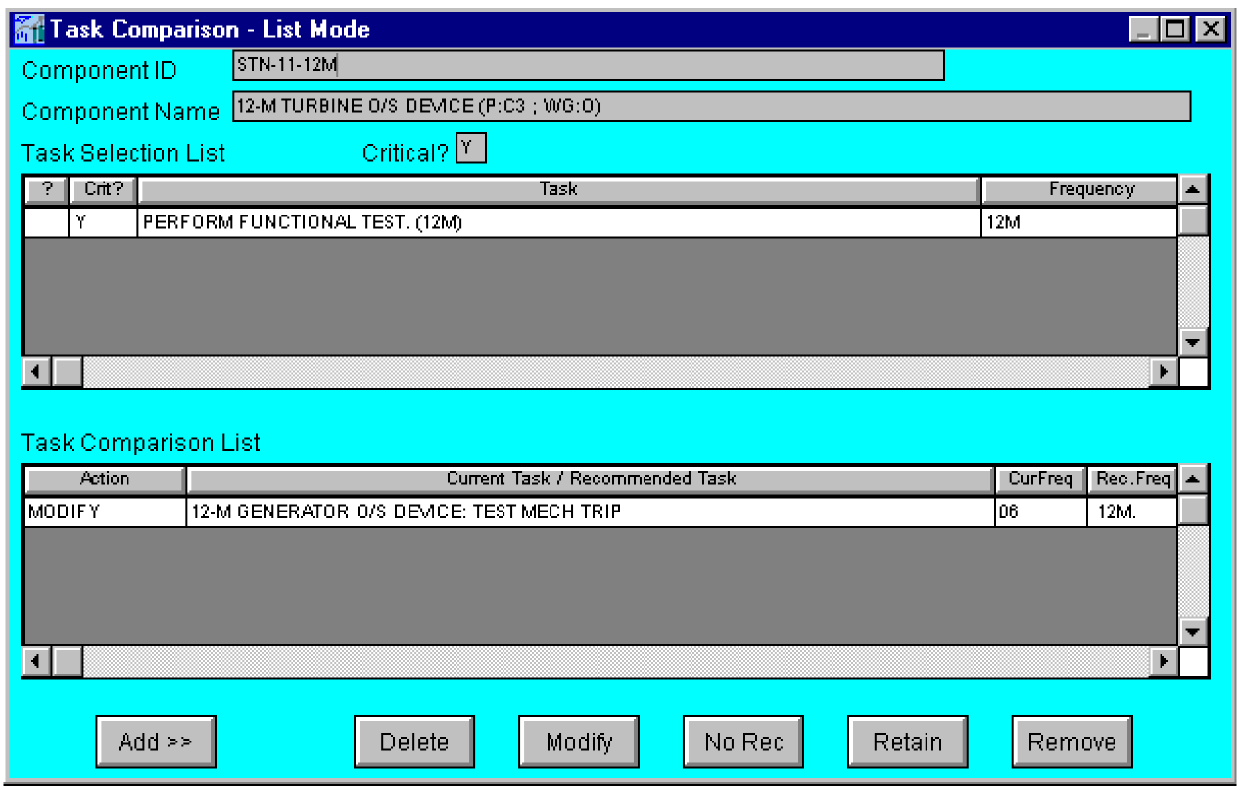


Notice the menu items presented along the top of the window. These menus provide quick access to each PMO module. For example, while editing the Criticality Analysis data above, you may decide to add a new component to your component list. You would simply select the System Data menu item, select the Component List submenu, and proceed to add a new component on-the-fly, without the need to exit the Criticality Analysis module. To include this new component in the Criticality Analysis, return to the Criticality Analysis screen (by closing the Component List screen), and double click in the Component ID field. You will be presented with the entire Component List. Locate the component you just added and double click on it. It will then be automatically placed in the Component ID field on the screen.

NOTE: All "code" fields in PMO may utilize this "expert assistance" by placing the cursor in the desired field and double-clicking the mouse. A selection list will be presented from which you may select an item by, once again, double clicking on the desired item.

You will also notice the PMO toolbar across the top of the window. Each PMO data entry screen is provided with its own toolbar, which gives users the ability to navigate quickly through the data, add or copy records, filter the database, print a report, etc. If you would like to view the Criticality Analysis Report on the screen, merely click the Printer icon in the toolbar (e.g. the third icon from the right). Once the report is presented on-screen, you will have the option to view the report, print the report, or close the report.

The PMO Workstation also greatly simplifies the Task Comparison process by allowing users to view all Recommended Tasks and all Current Maintenance tasks on the same screen, as shown below:



Utilizing this module, analysts can quickly perform the Task Comparison on-screen. A comparison of current maintenance tasks and recommended tasks (shown in the Task Selection List above) may be made by highlighting the desired line item from each list, and then clicking the appropriate button shown on the bottom of the screen. The final result of this step in the analysis is presented in the lower list box titled "Task

Comparison List". This box contains all of the final task recommendations that will individually need to be implemented.

As you can see, the PMO Workstation greatly simplifies the PMO analysis by reducing the effort required for data entry by providing the ability to import existing electronic information and utilizing preloaded lookup files for answering the information needs of the analysis. Finally, although the software is extremely user-friendly, a comprehensive User Manual is included with the product that describes, in detail, each module in the Workstation.

The following describes the hardware and software requirements for the Plant Maintenance Optimizer (PMO) Workstation Version 3.1.

Hardware

- IBM Personal Compatible (or compatible) with a 80386 processor or better;

  Note: a 80486-based or Pentium processor is highly recommended due to increased speed while operating in the Microsoft Windows environment.

- At least 20 Megabytes of hard disk storage, either local or network based (greater storage may be required if extensive PMO analyses are performed;
- VGA graphics capability;
- 1 Meg of RAM for Microsoft Windows 3.1 or Windows for Workgroups 3.11, 4 Meg of RAM for Windows 95, 8 Meg of RAM for Windows NT;
- Keyboard and Microsoft-compatible mouse;
- HP Laserjet printer, or compatible, with at least 1 MB of memory;

Software

- Microsoft Windows 3.1 or Windows for Workgroups 3.11, Windows 95, or Windows NT;
- Expanded memory manager such as QEMM, 386MAX, or EMM386 while operating in the Microsoft Windows 3.1 or Windows for Workgroups 3.11 environments;

In addition to the PMO Workstation for managing the data developed by the SRCM analysis, EPRI has funded enhancements to the PMO Workstation to automate the component type and system templates and the living program. These features are designed to make more efficient the generation of SRCM results while providing sound technical and consistent results. The living program enhancement is to facilitate all aspects of maintenance program optimizing. The living program tool guides the reviewer to determine which component's PMs should be changed, documents the decisions, and maintains a historical file of this review. It is also designed to easily link to information provided by the plant's computerized maintenance management system (CMMS) to obtain historical work order records for the review.

An EPRI user group will be funded to allow for direct inputs from users on enhancements, modifications, and other aspects of the workstation. Periodic meetings and newsletters will be the major means of interface.

5

IMPLEMENTING SRCM RESULTS

The results from an SRCM analysis include the addition of new PM tasks or the deletion, modification, or retention of existing tasks. For the tasks to be retained, no effort is required for implementation other than ensuring the tasks are packaged and planned appropriately. For new tasks, determining whether it is for a critical component or not and the type of PM task (e.g., condition monitoring, operator rounds, PdM, time-directed, or testing task) is necessary to understand the importance and effort required for implementation. In fact, these recommendations tend to be the most time consuming, particularly when the recommendation is for a new PdM activity. For modification or deletion of current tasks, the activity is merely updating the task frequency or deleting the task from the plant's Computerized Maintenance Management System (CMMS).

Task information contained in the CMMS may include specific direction to the maintenance craftsman on what maintenance actions are required as well as what maintenance history information is needed. Emphasis is placed on what actions are required not on how to perform the actions. Maintenance history is very important for continuously optimizing the maintenance program and should be clearly stated when required.

Full implementation is achieved when an executable PM program is contained within the CMMS using the SRCM analyses as its bases. This will in-turn require updating the SRCM analyses when changes of the maintenance program are required. The living program is designed to manage the changes to the SRCM analyses.

6

LIVING PROGRAM

The objectives of the Living Program are to: 1) ensure that design changes and operation changes are reflected in the PM program, 2) ensure that new maintenance technologies are optimally used in the PM program, 3) track maintenance experience to confirm that the bases for the recommendations remain valid and that they are still effective, and 4) maintain the SRCM decision basis.

A Living Program procedure defining responsibility for the program, detailing the program elements, and specifying the schedule at which reviews and updates is one of the EPRI SRCM program deliverables.

The Living Program must have a complete listing of the system analyses, PM recommendations, and PM task implementation status.

Elements of the Living Program include:

1. Tracking and close-out of open items from the SRCM analyses implementation.

2. Completing timely reviews of PM change requests for components of systems with SRCM evaluations.

3. Reviewing plant modifications

4. Reviewing SRCM and PM program effectiveness by monitoring and trending maintenance history

5. Periodically reviewing predictive maintenance capabilities, and assisting maintenance personnel with optimizing application of new technologies.

6. Periodically updating SRCM analysis results based on corrective and preventive maintenance history as well as design changes, operating experiences, and other sources that may affect the SRCM analysis.

The approach described above provides a cost effective method for developing a reliability-based “Living” PM program. The approach uses a thorough, proven methodology for comprehensive analyses of plant components and systems. It utilizes an approach based on RCM principles that are the most cost effective while maintaining proper technical rigor.

The resulting PM program enhances plant safety and reliability while focusing maintenance resources on components that are important to key system functions. The program is structured to prevent dominant and recurring failure modes. The program application approach identifies proper tasks with frequencies that are applicable and cost-effective in preventing important component failures. It provides a thorough, documented basis for doing or not doing PM tasks while substituting unnecessary tasks such as scheduled overhauls with predictive maintenance tasks where appropriate.

In order to facilitate a Living Program it should be clear that good maintenance history is a cornerstone for the process. One of the best ways to easily manage a Living Program utilizes information stored in a good working Computerized Maintenance Management System (CMMS). A good CMMS is invaluable for tracking PM task scheduling and completion, retrieving maintenance history, both corrective and preventive, in order to perform the required reviews for continuously improving the PM Program, and easily changing PM tasks when the Living Program determines it to be necessary.

EPRI is funding continued software to reduce the cost and complexity of Living Program implementation through the development of a Living Program Module in the PMO Workstation. This module is intended to be most useful when directly utilizing CMMS maintenance history data, but hand entered information may also be used when necessary. The Living Program enhancement to the PMO Workstation will provide the framework for the process of periodically updating the SRCM analysis and subsequent component PM selection by using actual operating and maintenance experience. Appendix B provides more information on the software.

7

FUTURE PLANS

Since SRCM integrates, interfaces and affects many plant programs, there are several activities envisioned help EPRI members continue reducing production costs.

The development of enhancements to the current SRCM program is envisioned to include the following:

1. SRCM User's group
2. Implementation support
3. Continued data enhancement for templates
4. Living program support

Areas that seem to be a natural extension of the process and that appear to be needed technology or processes include:

1. Reliability Modeling
2. Spare Parts optimization
3. Reliability centered design and operation

A

PMO WORK PRODUCTS - SAMPLE SYSTEM STUDY

Plant Maintenance Optimizer Version 3.1

Date: 7/31/98 **Functional Failure Analysis - Functions** **Page:** 1

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

ID	Function
01.	CONVERT WATER ENERGY INTO MECHANICAL ENERGY AND TRANSMIT TO GENERATOR.
02.	PROVIDE WATER FLOW CONTROL.
03.	PROVIDE TURBINE BRAKING.
04.	PROVIDE WATER ISOLATION OF TURBINE.
05.	PROVIDE OVERSPEED PROTECTION.
06.	PROVIDE INDICATION.
07.	PROVIDE EQUIPMENT PROTECTION.
08.	PROVIDE TAILWATER DEPRESSION.

Plant Maintenance Optimizer Version 3.1

Date: 7/31/98 **Functional Failure Analysis - Functional Failures** **Page:** 1

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

ID	Functional Failure	Analyzed?	Remarks
01.01	FAILS TO CONVERT WATER ENERGY INTO MECHANICAL ENERGY AND TRANSMIT TO GENERATOR.	Yes	
02.01	FAILS TO PROVIDE WATER FLOW CONTROL.	Yes	
03.01	FAILS TO PROVIDE TURBINE BRAKING.	No	
04.01	FAILS TO PROVIDE WATER ISOLATION OF TURBINE.	Yes	
05.01	FAILS TO PROVIDE TURBINE OVERSPEED PROTECTION.	No	
06.01	FAILS TO PROVIDE INDICATION.	Yes	
07.01	FAILS TO PROVIDE EQUIPMENT PROTECTION.	Yes	
08.01	FAILS TO PROVIDE TAILWATER DEPRESSION.	No	

Plant Maintenance Optimizer Version 3.1

Criticality Analysis

Date: 7/31/98

Page: 1

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Functional Failure / Component ID	Failure Mode(s)	Failure Effect(s)	Critical?	Remarks
01.01 --> FAILS TO CONVERT WATER ENERGY INTO MECHANICAL ENERGY AND TRANSMIT TO GENERATOR.				
20-08-11 ---> TURBINE BEARING OIL PUMP AC	PUMPS --> FAILS TO START; FAILS TO RUN (INCLUDES DEGRADED OPERATION);	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	DC pump serves as back-up. (32-09/p3)
20-08-12 ---> TURBINE BEARING OIL PUMP DC	PUMPS --> FAILS TO START; FAILS TO RUN (INCLUDES DEGRADED OPERATION);	POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	No	Serves as back-up to AC pump. (32-09/p3)
20-08-21 ---> TURBINE HEAD COVER SUMP PUMP 1 (TOP PLATE)	PUMPS --> FAILS TO START; FAILS TO RUN (INCLUDES DEGRADED OPERATION);	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Sump pump #2 serves as back-up. (32-09/p1)
20-08-22 ---> TURBINE HEAD COVER SUMP PUMP 2 (TOP PLATE)	PUMPS --> FAILS TO START; FAILS TO RUN (INCLUDES DEGRADED OPERATION);	POSSIBLY RESULTS IN REDUCED POWER GENERATION;	No	Serves as back-up to sump pump #1. (32-09/p1)
20-08-22-SWITCH-LAG ---> TURBINE HEAD COVER SUMP PUMP FLOAT SWITCH LAG	SWITCH --> FAILS TO CHANGE STATE UPON DEMAND;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Starts sump pump #2. High level alarm serves a back-up. (32-09/p1)
20-08-22-SWITCH-LEAD ---> TURBINE HEAD COVER SUMP PUMP FLOAT SWITCH LEAD	SWITCH --> FAILS TO CHANGE STATE UPON DEMAND;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Starts sump pump #1. (32-09/p1)
65-08-07-BLADE ---> RUNNER BLADES (KAPLAN TYPE)	MECHANICAL EQUIPMENT - GENERAL --> FAILS TO OPERATE AS REQUIRED;	RESULTS IN UNIT OFF-LINE; RESULTS IN REDUCED POWER GENERATION;	Yes	Cracking and fatigue?????
65-08-08 ---> TURBINE VACUUM BREAKER (AIR CHECK VALVE)	VALVE - GENERAL --> FAILS TO OPEN;	POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	Yes	Results in cavitation and damage to packing seal.
65-08-11 ---> TURBINE PACKING (SHAFT SEAL)	RING - SEAL, ETC. --> FAILS TO	POSSIBLY RESULTS IN REDUCED	No	On excessive leakage head cover sump high

Plant Maintenance Optimizer Version 3.1
Criticality Analysis

Date: 7/31/98 **Page:** 2

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Functional Failure	Component ID	Failure Mode(s)	Failure Effect(s)	Critical?	Remarks
		OPERATE AS REQUIRED;	POWER GENERATION; POSSIBLE DELAY IN STARTUP (ROLLING UNIT); POSSIBLE ENVIRONMENTAL EFFECTS;		level float switch will alarm. (32-09/p1)
	65-08-22 ---> TURBINE BEARING ASSEMBLY	BEARING --> FAILS TO PROVIDE ALIGNMENT;	RESULTS IN UNIT OFF-LINE; POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	No	Low failure probability. (32-09/p3)
	65-08-24 ---> TURBINE RUNNER HUB ASSEMBLY	RUNNER - TURBINE --> FAILS TO RUN (INCLUDES DEGRADED OPERATION);	RESULTS IN UNIT OFF-LINE; RESULTS IN REDUCED POWER GENERATION;	No	Low failure probability.
	65-08-24-PRESS ---> TURBINE RUNNER HUB PRESSURE SYSTEM	MECHANICAL EQUIPMENT - GENERAL --> FAILS TO OPERATE AS REQUIRED;	POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	No	Low failure probability. Used only at unit 6. Prevents water from leaking into hub. (32-09/p4)
02.01 --> FAILS TO PROVIDE WATER FLOW CONTROL.					
	13-03 ---> WICKET GATE (CENTRAL) LUBRICATION SYSTEM	MECHANICAL EQUIPMENT - GENERAL --> FAILS TO OPERATE AS REQUIRED;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Wicket gate grease failure alarm will actuate.
	65-08-03 ---> WICKET GATE STOP NUT SYSTEM	MECHANICAL EQUIPMENT - GENERAL --> FAILS TO OPERATE AS REQUIRED;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Manually set at100%. Nitrogen system will close gates on loss of governor oil pressure. (32-09/p2&4 is out of date)
	65-08-07-SERVO ---> RUNNER BLADE SERVOMOTOR	OPERATING CYLINDER - SERVO --> EXTERNALLY LEAKS; FAILS TO OPERATE AS REQUIRED;	REDUCTION IN PLANT EFFICIENCY;	No	Low failure probability.
	65-08-07-SERVODRAIN ---> RUNNER BLADE SERVOMOTOR DRAIN PUMP	PUMPS --> FAILS TO OPERATE (INCLUDES DEGRADED	POSSIBLE ENVIRONMENTAL EFFECTS;	Yes	

Plant Maintenance Optimizer Version 3.1
Criticality Analysis

Date: 7/31/98 **Page:** 3

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Functional Failure	Component ID	Failure Mode(s)	Failure Effect(s)	Critical?	Remarks
		OPERATION);			
	65-08-65-GATE ---> WICKET GATE ASSEMBLY (INCLUDES LINKAGE & BULL RING) - 20 GATES	WICKET GATE --> FAILS TO POSITION AS REQUIRED;	DEGRADED TRANSIENT RESPONSE CAPABILITY; RESULTS IN UNIT OFF-LINE; POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).; POSSIBLE ENVIRONMENTAL EFFECTS;	Yes	(32-09/p2)
	65-08-65-SERVO ---> WICKET GATE SERVOMOTOR	OPERATING CYLINDER - SERVO --> EXTERNALLY LEAKS; FAILS TO OPERATE AS REQUIRED;	RESULTS IN UNIT OFF-LINE; DEGRADED TRANSIENT RESPONSE CAPABILITY; POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;		Low failure probability.
	65-08-NITROGEN ---> WICKET GATE NITROGEN SYSTEM	MECHANICAL EQUIPMENT - GENERAL --> FAILS TO OPERATE AS REQUIRED;	POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	Yes	Nitrogen system will close gates on loss of governor oil pressure. (32-09/p2&4 is out of date)
03.01 --> FAILS TO PROVIDE TURBINE BRAKING.					
					THIS FUNCTION NOT USED AT McNARY
04.01 --> FAILS TO PROVIDE WATER ISOLATION OF TURBINE.					
	22-02-4WAY ---> 4-WAY SOLENOID VALVE FOR INTAKE GATE HYDRAULICS	SOLENOID VALVE --> FAILS TO OPEN;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	22-20-04-BREAKER ---> HYDRAULIC PUMP MOTOR BREAKER FOR INTAKE GATE HYDRAULICS (2 EACH))	BREAKER - ELECTRICAL --> FAILS TO CLOSE; FAILS TO OPEN;	POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	Yes	Breakers required for circuit protection. Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates

Plant Maintenance Optimizer Version 3.1
Criticality Analysis

Date: 7/31/98

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Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Functional Failure	Component ID	Failure Mode(s)	Failure Effect(s)	Critical?	Remarks
					can now be closed by nitrogen system.
	22-20-04-MOTOR ---> HYDRAULIC PUMP MOTOR FOR INTAKE GATE HYDRAULICS (3)	MOTOR --> FAILS TO RUN (INCLUDES DEGRADED OPERATION);	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	22-20-04-PUMP ---> HYDRAULIC PUMP FOR INTAKE GATE HYDRAULICS (3)	PUMPS --> FAILS TO OPERATE (INCLUDES DEGRADED OPERATION);	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	22-30 ---> HYDRAULIC FLUID TANK FOR INTAKE GATE HYDRAULICS (4)	TANK --> EXTERNALLY LEAKS;	POSSIBLE ENVIRONMENTAL EFFECTS;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	22-CYLINDER/PISTON ---> HYDRAULIC CYLINDER/PISTON FOR INTAKE GATE HYDRAULICS	OPERATING CYLINDER - SERVO --> FAILS TO OPERATE AS REQUIRED;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	22-FILTER ---> FILTER FOR INTAKE GATE HYDRAULICS	FILTER - IN LINE PIPING --> PLUGS;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	22-LATCH ---> LATCH PINS FOR INTAKE GATE HYDRAULICS	MECHANICAL EQUIPMENT - GENERAL --> FAILS TO OPERATE AS REQUIRED;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	66-22 ---> INTAKE GATE (HEAD GATE) UNIT 8, SLOT A	GATE - INTAKE, DISCHARGE,	RESULTS IN NO SIGNIFICANT	No	Removal of gates under study at this time.

Plant Maintenance Optimizer Version 3.1
Criticality Analysis

Date: 7/31/98 **Page:** 5

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Functional Failure	Component ID	Failure Mode(s)	Failure Effect(s)	Critical?	Remarks
		OTHER --> FAILS TO CLOSE;	FUNCTIONAL EFFECT;		Can be raised & lowered by hydraulic system or by crane(32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	66-23 ---> INTAKE GATE (HEAD GATE) UNIT 8, SLOT B	GATE - INTAKE, DISCHARGE, OTHER --> FAILS TO CLOSE;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Can be raised & lowered by hydraulic system or by crane(32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	66-24 ---> INTAKE GATE (HEAD GATE) UNIT 8, SLOT C	GATE - INTAKE, DISCHARGE, OTHER --> FAILS TO CLOSE;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Can be raised & lowered by hydraulic system or by crane(32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
05.01 --> FAILS TO PROVIDE TURBINE OVERSPEED PROTECTION.					THIS FUNCTION NOT USED AT McNARY
06.01 --> FAILS TO PROVIDE INDICATION.					
	22-POSITION ---> INTAKE GATE POSITION INDICATION (MECHANICAL)	CABLES, CABLEWAYS, SAFETY CABLES --> FRAYS;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	65-08-DRAFT ---> DRAFT TUBE PRESSURE INDICATOR	INDICATORS AND GUAGES --> FAILS TO PROVIDE PROPER OUTPUT;	LOSS OF INFORMATION TO OPERATORS;	No	(32-09/p6)
	65-08-SPIRAL ---> SPIRAL CASE PRESSURE INDICATOR	INDICATORS AND GUAGES --> FAILS TO PROVIDE PROPER	LOSS OF INFORMATION TO OPERATORS;	No	(32-09/p6)

Plant Maintenance Optimizer Version 3.1
Criticality Analysis

Date: 7/31/98

Page: 6

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Functional Failure	Component ID	Failure Mode(s)	Failure Effect(s)	Critical?	Remarks
		OUTPUT;			
	65-08-TI ---> TEMPERATURE SENSORS (RTDs)	RESISTANCE TEMPERATURE DEVICE --> FAILS TO PROVIDE PROPER OUTPUT;	LOSS OF INFORMATION TO OPERATORS;	No	Located in turbine guide bearing. (32-09/p6)
07.01 --> FAILS TO PROVIDE EQUIPMENT PROTECTION.					
	13-03-T30 ---> WICKET GATE GREASE FAILURE ALARM RELAY	RELAY --> FAILS TO ENERGIZE;	POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	No	Relay will energize if grease pump fails to complete its cycle within predetermined time.(32-09/p4) Operator rounds would identify problem before damage occurs.
	20-08-12-T13 ---> TURBINE LOW BEARING OIL LEVEL SWITCH (63 DEVICE)	RELAY --> FAILS TO ENERGIZE;	POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	Yes	Starts DC bearing oil pump on low level and initiates alarm. (32-09/p3)
	20-08-22-SWITCH-ALARM ---> TURBINE HEAD COVER SUMP HIGH LEVEL FLOAT SWITCH	SWITCH --> FAILS TO CHANGE STATE UPON DEMAND;	POSSIBLE DAMAGE TO SIGNIFICANT PLANT COMPONENT(S).;	Yes	Provides top plate high water level alarm (no trip). Will indicate excessive packing leakage.
	22-ALARM-LEVEL ---> INTAKE GATE TROUBLE ANNUNCIATION - LOW OIL LEVEL	ALARM --> FAILS TO OPERATE AS REQUIRED;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	22-ALARM-PRESS ---> INTAKE GATE TROUBLE ANNUNCIATION - LOW OIL PRESSURE	ALARM --> FAILS TO OPERATE AS REQUIRED;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.
	22-ALARM-RUNTIME ---> INTAKE GATE TROUBLE ANNUNCIATION - PUMP EXCESSIVE RUN TIME	ALARM --> FAILS TO OPERATE AS REQUIRED;	RESULTS IN NO SIGNIFICANT FUNCTIONAL EFFECT;	No	Removal of gates under study at this time. Gates can be raised & lowered by crane (32-04/p1). Not required since wicket gates can now be closed by nitrogen system.

Plant Maintenance Optimizer Version 3.1

Date: 7/31/98

Critical Task Selection Summary Report
(Critical Tasks only)

Page: 1

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component ID Type	Recommended Task	Frequency	Resp.Discipl	Recommended Bases
20-08-12-T13 --> TURBINE LOW BEARING OIL LEVEL SWITCH (63 DEVICE)				
RLY --> RELAY				
Failure Mode(s) --> FAILS TO ENERGIZE; Failure Cause(s) --> COIL BURNOUT; CONTACTS; WORN, PITTED, CORRODED; OUT OF CALIBRATION;				
	PERFORM CALIBRATION CHECK	3A	ELEC	
	PERFORM FUNCTIONAL TEST.	1A	ELEC	
20-08-22-SWITCH-ALARM --> TURBINE HEAD COVER SUMP HIGH LEVEL FLOAT SWITCH				
SWE --> SWITCH				
Failure Mode(s) --> FAILS TO CHANGE STATE UPON DEMAND; Failure Cause(s) --> STICKING;				
	PERFORM FUNCTIONAL TEST.	1A	ELEC	
22-20-04-BREAKER --> HYDRAULIC PUMP MOTOR BREAKER FOR INTAKE GATE HYDRAULICS (2 EACH))				
BKR --> BREAKER - ELECTRICAL				
Failure Mode(s) --> FAILS TO CLOSE; FAILS TO OPEN; Failure Cause(s) --> COIL BURNOUT; CONTACTS; WORN, PITTED, CORRODED; LINKAGE BINDING; LOOSE PARTS/DEFECTIVE CONNECTIONS;				
	CYCLE BREAKER	1A	ELEC	
	PERFORM DISASSEMBLE, CLEAN AND INSPECT OF ENTIRE COMPONENT AND CHECK FOR LOOSE CONTACTS.	6A	ELEC	
65-08-07-BLADE --> RUNNER BLADES (KAPLAN TYPE)				
MEC --> MECHANICAL EQUIPMENT - GENERAL				
Failure Mode(s) --> FAILS TO OPERATE AS REQUIRED; Failure Cause(s) --> DEGRADED/LOSS OF LUBRICATION; EROSION;				

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Critical Task Selection Summary Report
(Critical Tasks only)

Date: 7/31/98

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Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component ID Type	Recommended Task	Frequency	Resp.Discipl	Recommended Bases
	CYCLE AND TIME BLADES. ESTABLISH ACTION LEVELS. TREND RESULTS.	9A	MECH	
	INSPECT BLADES, SHEAR PINS, WEAR RING, AND BEARINGS, AND REPAIR/REPLACE AS REQUIRED.	9A	MECH	
65-08-08 --> TURBINE VACUUM BREAKER (AIR CHECK VALVE)				
VLV --> VALVE - GENERAL				
Failure Mode(s) --> FAILS TO OPEN; Failure Cause(s) --> STEM BINDING;				
	PERFORM FULL TIMED STROKE TEST.	1A	MECH	
65-08-18-T15/T16 --> BEARING HIGH TEMPERATURE ALARM AND UNIT TRIP RELAY (38 DEVICE)				
RLY --> RELAY				
Failure Mode(s) --> FAILS TO ENERGIZE; Failure Cause(s) --> COIL BURNOUT; CONTACTS; WORN, PITTED, CORRODED; OUT OF CALIBRATION;				
	PERFORM CALIBRATION CHECK	3A	ELEC	
	PERFORM FUNCTIONAL TEST.	1A	ELEC	
65-08-65-GATE --> WICKET GATE ASSEMBLY (INCLUDES LINKAGE & BULL RING) - 20 GATES				
WKT --> WICKET GATE				
Failure Mode(s) --> FAILS TO POSITION AS REQUIRED; Failure Cause(s) --> DIRT ACCUMULATION; STEM BINDING;				
	CYCLE AND TIME GATES. ESTABLISH ACTION LEVELS. TREND RESULTS.	9A	MECH	
	PERFORM DETAILED CLEAN, INSPECT AND LUBRICATE.	9A	MECH	
65-08-65-POS --> WICKET GATE POSITION SWITCHES (33 DEVICE)				

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Date: 7/31/98

Critical Task Selection Summary Report
(Critical Tasks only)

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Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component ID Type	Recommended Task	Frequency	Resp.Discipl	Recommended Bases
RLY --> RELAY				
Failure Mode(s) --> FAILS TO CLOSE; Failure Cause(s) --> COIL BURNOUT; CONTACTS; WORN, PITTED, CORRODED; OUT OF CALIBRATION;				
	PERFORM CALIBRATION CHECK	9A	ELEC	
	PERFORM FUNCTIONAL TEST	9A	ELEC	
65-08-NITROGEN --> WICKET GATE NITROGEN SYSTEM				
MEC --> MECHANICAL EQUIPMENT - GENERAL				
Failure Mode(s) --> FAILS TO OPERATE AS REQUIRED; Failure Cause(s) --> SUBCOMPONENT FAILURE;				
	PERFORM FUNCTIONAL TEST AND TIME GATE CLOSURE. ESTABLISH ACTION LEVELS. TREND RESULTS.	9A	MECH	

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Non-Critical Component Evaluation Report

Date: 7/31/98 **Page:** 1

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component	Component Type	Failure Modes	Non-Critical Evaluation Criteria	Critical?
13-03 --> WICKET GATE (CENTRAL) LUBRICATION SYSTEM	MEC --> MECHANICAL EQUIPMENT - GENERAL	FAILS TO OPERATE AS REQUIRED;	Causes failure of another significant component? ;Simple maintenance to maintain instrinsic reliability? ;	No
13-03-T30 --> WICKET GATE GREASE FAILURE ALARM RELAY	RLY --> RELAY	FAILS TO ENERGIZE;		No
20-08-11 --> TURBINE BEARING OIL PUMP AC	PMP --> PUMPS	FAILS TO START;FAILS TO RUN (INCLUDES DEGRADED OPERATION);	High repair/replacement cost? ;Simple maintenance to maintain instrinsic reliability? ;	No
20-08-12 --> TURBINE BEARING OIL PUMP DC	PMP --> PUMPS	FAILS TO START;FAILS TO RUN (INCLUDES DEGRADED OPERATION);	High repair/replacement cost? ;Simple maintenance to maintain instrinsic reliability? ;	No
20-08-21 --> TURBINE HEAD COVER SUMP PUMP 1 (TOP PLATE)	PMP --> PUMPS	FAILS TO START;FAILS TO RUN (INCLUDES DEGRADED OPERATION);	High repair/replacement cost? ;Simple maintenance to maintain instrinsic reliability? ;	No
20-08-22 --> TURBINE HEAD COVER SUMP PUMP 2 (TOP PLATE)	PMP --> PUMPS	FAILS TO START;FAILS TO RUN (INCLUDES DEGRADED OPERATION);	High repair/replacement cost? ;Simple maintenance to maintain instrinsic reliability? ;	No
20-08-22-SWITCH-LAG --> TURBINE HEAD COVER SUMP PUMP FLOAT SWITCH LAG	SWE --> SWITCH	FAILS TO CHANGE STATE UPON DEMAND;	Simple maintenance to maintain instrinsic reliability? ;	No
20-08-22-SWITCH-LEAD --> TURBINE HEAD COVER SUMP PUMP FLOAT SWITCH LEAD	SWE --> SWITCH	FAILS TO CHANGE STATE UPON DEMAND;	Simple maintenance to maintain instrinsic reliability? ;	No
22-02-4WAY --> 4-WAY SOLENOID VALVE FOR INTAKE GATE HYDRAULICS	SLV --> SOLENOID VALVE	FAILS TO OPEN;		No
22-20-04-MOTOR --> HYDRAULIC PUMP MOTOR FOR INTAKE GATE HYDRAULICS (3)	MTR --> MOTOR	FAILS TO RUN (INCLUDES DEGRADED OPERATION);	Simple maintenance to maintain instrinsic reliability? ;	No
22-20-04-PUMP --> HYDRAULIC PUMP FOR INTAKE GATE HYDRAULICS (3)	PMP --> PUMPS	FAILS TO OPERATE (INCLUDES DEGRADED OPERATION);	Simple maintenance to maintain instrinsic reliability? ;	No
22-30 --> HYDRAULIC FLUID TANK FOR INTAKE GATE HYDRAULICS (4)	TNK --> TANK	EXTERNALLY LEAKS;		No
22-ALARM-LEVEL --> INTAKE GATE TROUBLE ANNUNCIATION - LOW OIL LEVEL	ALM --> ALARM	FAILS TO OPERATE AS REQUIRED;		No
22-ALARM-PRESS --> INTAKE GATE TROUBLE ANNUNCIATION - LOW OIL PRESSURE	ALM --> ALARM	FAILS TO OPERATE AS REQUIRED;		No

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Non-Critical Component Evaluation Report

Date: 7/31/98 **Page:** 2

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component	Component Type	Failure Modes	Non-Critical Evaluation Criteria	Critical?
22-ALARM-RUNTIME --> INTAKE GATE TROUBLE ANNUNCIATION - PUMP EXCESSIVE RUN TIME	ALM --> ALARM	FAILS TO OPERATE AS REQUIRED;		No
22-ALARM-START --> INTAKE GATE TROUBLE ANNUNCIATION - PUMP ON TOO SOON	ALM --> ALARM	FAILS TO OPERATE AS REQUIRED;		No
22-CYLINDER/PISTON --> HYDRAULIC CYLINDER/PISTON FOR INTAKE GATE HYDRAULICS	SVO --> OPERATING CYLINDER - SERVO	FAILS TO OPERATE AS REQUIRED;	Simple maintenance to maintain instrinsic reliability? ;	No
22-FILTER --> FILTER FOR INTAKE GATE HYDRAULICS	FLT --> FILTER - IN LINE PIPING	PLUGS;	Simple maintenance to maintain instrinsic reliability? ;	No
22-LATCH --> LATCH PINS FOR INTAKE GATE HYDRAULICS	MEC --> MECHANICAL EQUIPMENT - GENERAL	FAILS TO OPERATE AS REQUIRED;		No
22-POSITION --> INTAKE GATE POSITION INDICATION (MECHANICAL)	CAB --> CABLES, CABLEWAYS, SAFETY CABLES	FRAYS;		No
65-08-03 --> WICKET GATE STOP NUT SYSTEM	MEC --> MECHANICAL EQUIPMENT - GENERAL	FAILS TO OPERATE AS REQUIRED;		No
65-08-07-SERVO --> RUNNER BLADE SERVOMOTOR	SVO --> OPERATING CYLINDER - SERVO	EXTERNALLY LEAKS;FAILS TO OPERATE AS REQUIRED;	Simple maintenance to maintain instrinsic reliability? ;	No
65-08-11 --> TURBINE PACKING (SHAFT SEAL)	RNG --> RING - SEAL, ETC.	FAILS TO OPERATE AS REQUIRED;	Simple maintenance to maintain instrinsic reliability? ;	No
65-08-18-BRG --> TURBINE BEARING TEMPERATURE THERMOMETER AND ALARM (DIAL TYPE)	IND --> INDICATORS AND GUAGES	FAILS TO PROVIDE PROPER OUTPUT;		No
65-08-18-OIL --> TURBINE BEARING DISCHARGE OIL THERMOMETER AND ALARM (DIAL TYPE)	IND --> INDICATORS AND GUAGES	FAILS TO PROVIDE PROPER OUTPUT;		No
65-08-18-T14 --> TURBINE DC BEARING PUMP RUNNING CONTACTOR (42 DEVICE)	SWE --> SWITCH	FAILS TO CHANGE STATE UPON DEMAND;		No
65-08-18-T26 --> TURBINE STOP NUT RAISE ALARM LIMIT SWITCH	SWE --> SWITCH	FAILS TO CHANGE STATE UPON DEMAND;		No

Plant Maintenance Optimizer Version 3.1
Non-Critical Component Evaluation Report

Date: 7/31/98 **Page:** 3

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component	Component Type	Failure Modes	Non-Critical Evaluation Criteria	Critical?
65-08-22 --> TURBINE BEARING ASSEMBLY	BRG --> BEARING	FAILS TO PROVIDE ALIGNMENT;	High repair/replacement cost? ;Simple maintenance to maintain instrinsic reliability? ;	No
65-08-24 --> TURBINE RUNNER HUB ASSEMBLY	RUN --> RUNNER - TURBINE	FAILS TO RUN (INCLUDES DEGRADED OPERATION);	Simple maintenance to maintain instrinsic reliability? ;	No
65-08-24-PRESS --> TURBINE RUNNER HUB PRESSURE SYSTEM	MEC --> MECHANICAL EQUIPMENT - GENERAL	FAILS TO OPERATE AS REQUIRED;		No
65-08-DRAFT --> DRAFT TUBE PRESSURE INDICATOR	IND --> INDICATORS AND GUAGES	FAILS TO PROVIDE PROPER OUTPUT;		No
65-08-SPIRAL --> SPIRAL CASE PRESSURE INDICATOR	IND --> INDICATORS AND GUAGES	FAILS TO PROVIDE PROPER OUTPUT;		No
65-08-TI --> TEMPERATURE SENSORS (RTDs)	RTD --> RESISTANCE TEMPERATURE DEVICE	FAILS TO PROVIDE PROPER OUTPUT;	Simple maintenance to maintain instrinsic reliability? ;	No
65-08-VIB --> TURBINE SHAFT VIBRATION DETECTORS	SWE --> SWITCH	FAILS TO CHANGE STATE UPON DEMAND;		No
66-22 --> INTAKE GATE (HEAD GATE) UNIT 8, SLOT A	GAT --> GATE - INTAKE, DISCHARGE, OTHER	FAILS TO CLOSE;	Simple maintenance to maintain instrinsic reliability? ;	No
66-23 --> INTAKE GATE (HEAD GATE) UNIT 8, SLOT B	GAT --> GATE - INTAKE, DISCHARGE, OTHER	FAILS TO CLOSE;	Simple maintenance to maintain instrinsic reliability? ;	No
66-24 --> INTAKE GATE (HEAD GATE) UNIT 8, SLOT C	GAT --> GATE - INTAKE, DISCHARGE, OTHER	FAILS TO CLOSE;	Simple maintenance to maintain instrinsic reliability? ;	No

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Non-Critical Task Selection Summary Report
(Non-Critical Tasks only)

Date: 7/31/98

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Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component ID Type	Recommended Task	Frequency	Resp. Discipline	Recommended Bases	Critical?
13-03 --> WICKET GATE (CENTRAL) LUBRICATION SYSTEM					
MEC --> MECHANICAL EQUIPMENT - GENERAL					
Evaluation Criteria --> Causes failure of another significant component?; Simple maintenance to maintain instrinsic reliability?;					
	INSPECT FOR LEAKS, CHECK GREASE AND ADD/REPLACE AS REQUIRED	1A	MECH		No
	INSPECT GREASE PIN POSITION TO VERIFY PROPER OPERATION	ROUNDS	OPS		No
13-03-T30 --> WICKET GATE GREASE FAILURE ALARM RELAY					
RLY --> RELAY					
Evaluation Criteria -->					
	PMO has determined that this Non-Critical component should be run-to-failure and corrective maintenance performed				No
20-08-11 --> TURBINE BEARING OIL PUMP AC					
PMP --> PUMPS					
Evaluation Criteria --> High repair/replacement cost?; Simple maintenance to maintain instrinsic reliability?;					
	PERFORM VISUAL INSPECTION AND MONITOR COMPONENT PERFORMANCE.	ROUNDS	OPS		No
20-08-12 --> TURBINE BEARING OIL PUMP DC					
PMP --> PUMPS					
Evaluation Criteria --> High repair/replacement cost?; Simple maintenance to maintain instrinsic reliability?;					
	PERFORM VISUAL INSPECTION AND MONITOR COMPONENT PERFORMANCE DURING FUNCTIONAL TEST OF LOW BEARING OIL LEVEL SWITCH.	1A	ELEC		No

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Non-Critical Task Selection Summary Report
(Non-Critical Tasks only)

Page: 2

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component ID Type / Recommended Task	Frequency	Resp. Discipline	Recommended Bases	Critical?
20-08-21 --> TURBINE HEAD COVER SUMP PUMP 1 (TOP PLATE)				
PMP --> PUMPS				
Evaluation Criteria --> High repair/replacement cost?; Simple maintenance to maintain instrinsic reliability?;				
PERFORM VISUAL INSPECTION AND MONITOR COMPONENT PERFORMANCE WHEN SWAPPING BETWEEN LEAD AND LAG PUMP.	1M	ELEC		No
20-08-22 --> TURBINE HEAD COVER SUMP PUMP 2 (TOP PLATE)				
PMP --> PUMPS				
Evaluation Criteria --> High repair/replacement cost?; Simple maintenance to maintain instrinsic reliability?;				
PERFORM VISUAL INSPECTION AND MONITOR COMPONENT PERFORMANCE WHEN SWAPPING BETWEEN LEAD AND LAG PUMP.	1M	ELEC		No
20-08-22-SWITCH-LAG --> TURBINE HEAD COVER SUMP PUMP FLOAT SWITCH LAG				
SWE --> SWITCH				
Evaluation Criteria --> Simple maintenance to maintain instrinsic reliability?;				
PERFORM FUNCTIONAL TEST	1A	ELEC		No
20-08-22-SWITCH-LEAD --> TURBINE HEAD COVER SUMP PUMP FLOAT SWITCH LEAD				
SWE --> SWITCH				
Evaluation Criteria --> Simple maintenance to maintain instrinsic reliability?;				
PERFORM FUNCTIONAL TEST	1A	ELEC		No
22-02-4WAY --> 4-WAY SOLENOID VALVE FOR INTAKE GATE HYDRAULICS				

Plant Maintenance Optimizer Version 3.1
Non-Critical Task Selection Summary Report
(Non-Critical Tasks only)

Date: 7/31/98

Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component ID Type	Recommended Task	Frequency	Resp. Discipline	Recommended Bases	Critical?
SLV --> SOLENOID VALVE					
Evaluation Criteria -->					
	PMO has determined that this Non-Critical component should be run-to-failure and corrective maintenance performed				No
22-20-04-MOTOR --> HYDRAULIC PUMP MOTOR FOR INTAKE GATE HYDRAULICS (3)					
MTR --> MOTOR					
Evaluation Criteria --> Simple maintenance to maintain instrinsic reliability?;					
	LUBRICATE IF BEARINGS ARE NOT SEALED.	1A	MECH		No
22-20-04-PUMP --> HYDRAULIC PUMP FOR INTAKE GATE HYDRAULICS (3)					
PMP --> PUMPS					
Evaluation Criteria --> Simple maintenance to maintain instrinsic reliability?;					
	LUBRICATE IF BEARINGS ARE NOT SEALED.	1A	MECH		No
22-30 --> HYDRAULIC FLUID TANK FOR INTAKE GATE HYDRAULICS (4)					
TNK --> TANK					
Evaluation Criteria -->					
	PMO has determined that this Non-Critical component should be run-to-failure and corrective maintenance performed				No
22-ALARM-LEVEL --> INTAKE GATE TROUBLE ANNUNCIATION - LOW OIL LEVEL					
ALM --> ALARM					

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Non-Critical Task Selection Summary Report
(Non-Critical Tasks only)

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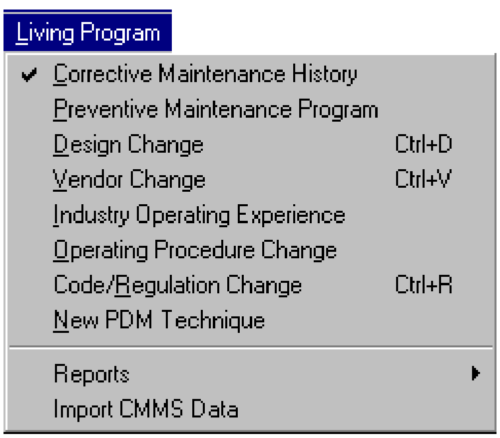
Plant: McNARY HYDRO STATION - UNIT 8
System: TURBINE - KAPLAN TYPE

Component ID	Type	Recommended Task	Frequency	Resp. Discipline	Recommended Bases	Critical?
	Evaluation Criteria -->					
		PMO has determined that this Non-Critical component should be run-to-failure and corrective maintenance performed				No
22-ALARM-PRESS --> INTAKE GATE TROUBLE ANNUNCIATION - LOW OIL PRESSURE						
	ALM --> ALARM					
	Evaluation Criteria -->					
		PMO has determined that this Non-Critical component should be run-to-failure and corrective maintenance performed				No
22-ALARM-RUNTIME --> INTAKE GATE TROUBLE ANNUNCIATION - PUMP EXCESSIVE RUN TIME						
	ALM --> ALARM					
	Evaluation Criteria -->					
		PMO has determined that this Non-Critical component should be run-to-failure and corrective maintenance performed				No
22-ALARM-START --> INTAKE GATE TROUBLE ANNUNCIATION - PUMP ON TOO SOON						
	ALM --> ALARM					
	Evaluation Criteria -->					
		PMO has determined that this Non-Critical component should be run-to-failure and corrective maintenance performed				No
22-CYLINDER/PISTON --> HYDRAULIC CYLINDER/PISTON FOR INTAKE GATE HYDRAULICS						
	SVO --> OPERATING CYLINDER - SERVO					

B

LIVING PROGRAM MODULE

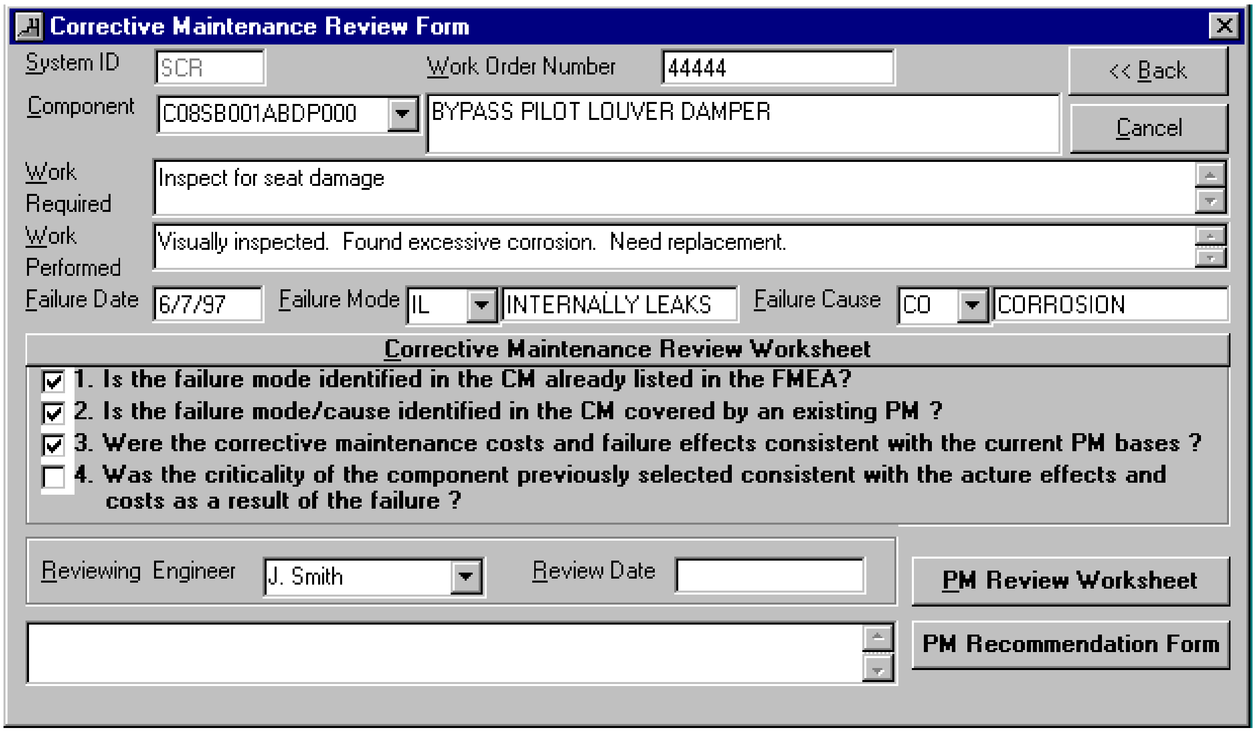
The primary objective of a streamlined RCM program is to ensure cost-effective and applicable tasks are implemented to prevent equipment failure deemed undesirable. It is also the intent to ensure a cost effective maintenance program is in place for the life of the plant. The Living Program is intended to provide a process for a utility to routinely review their maintenance program and make continuous improvements. The Living Program Module software is designed to provide a tool to more easily make the necessary reviews of plant and industry experiences, regulatory changes, design changes, and other sources of maintenance changes.



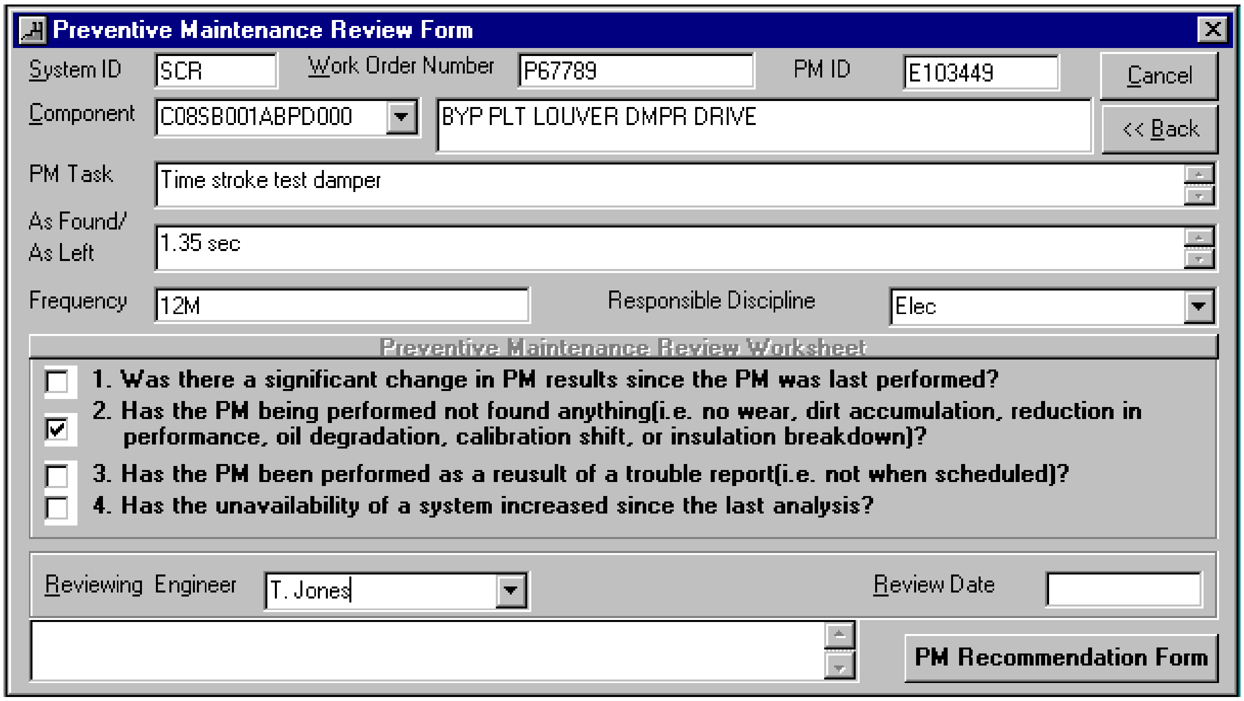
The Living Program Module software is an integral part of the PMO software in order to more easily evaluate possible sources of maintenance changes with respect to the streamlined RCM analysis results that were the basis for the existing program. This integration provides a utility with the ability to easily analyze possible sources for maintenance program changes, review and update where necessary the appropriate streamlined RCM analysis, and document the reviews and maintenance change recommendations in one process.

The Living Program Module software provides the tool to review a maintenance program and make continuous improvements by utilizing review forms in the computer for the various types of input being reviewed. These screens provide questions designed to prompt the reviewer to consider if changes should be made either to the streamlined RCM analysis basis or to the maintenance tasks for any component that was analyzed in the system. The Living Program software allows immediate reference to the SRCM analysis of the component being reviewed to facilitate making changes.

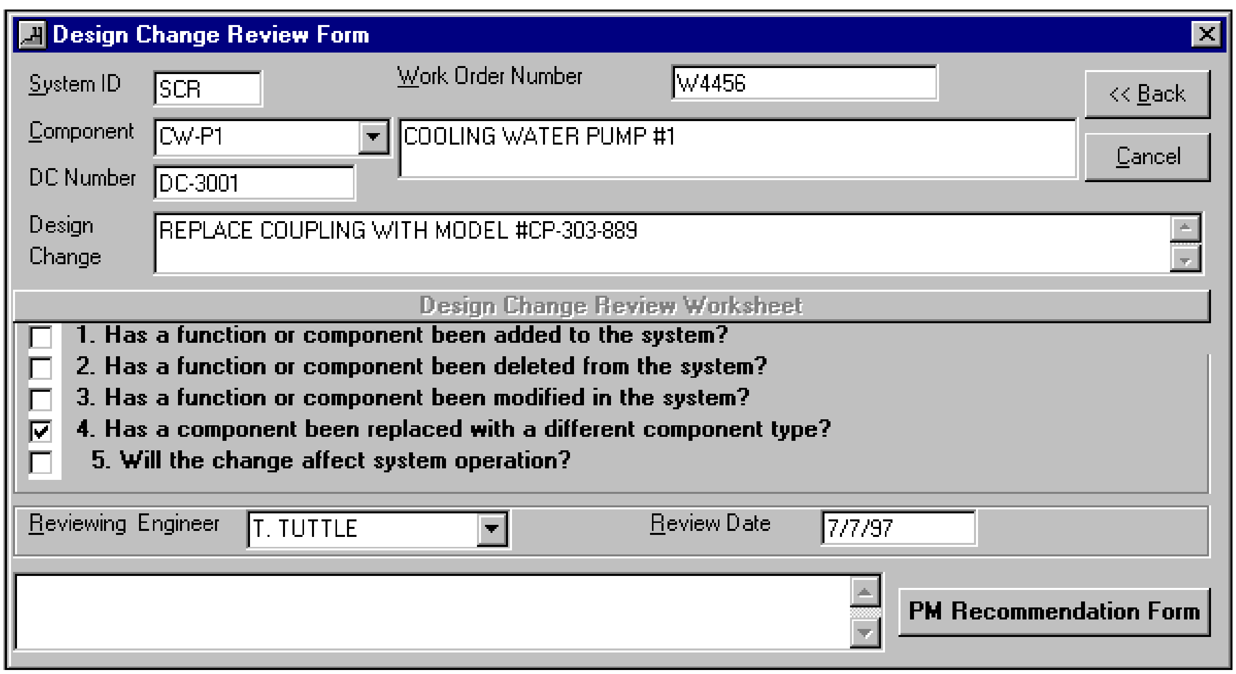
The following shows a few of the review screens selected from the Living Program dropdown list shown above that would be used to effectively execute a living program procedure.



Sample Corrective Maintenance Review Form Screen



Sample Preventive Maintenance Review Form Screen

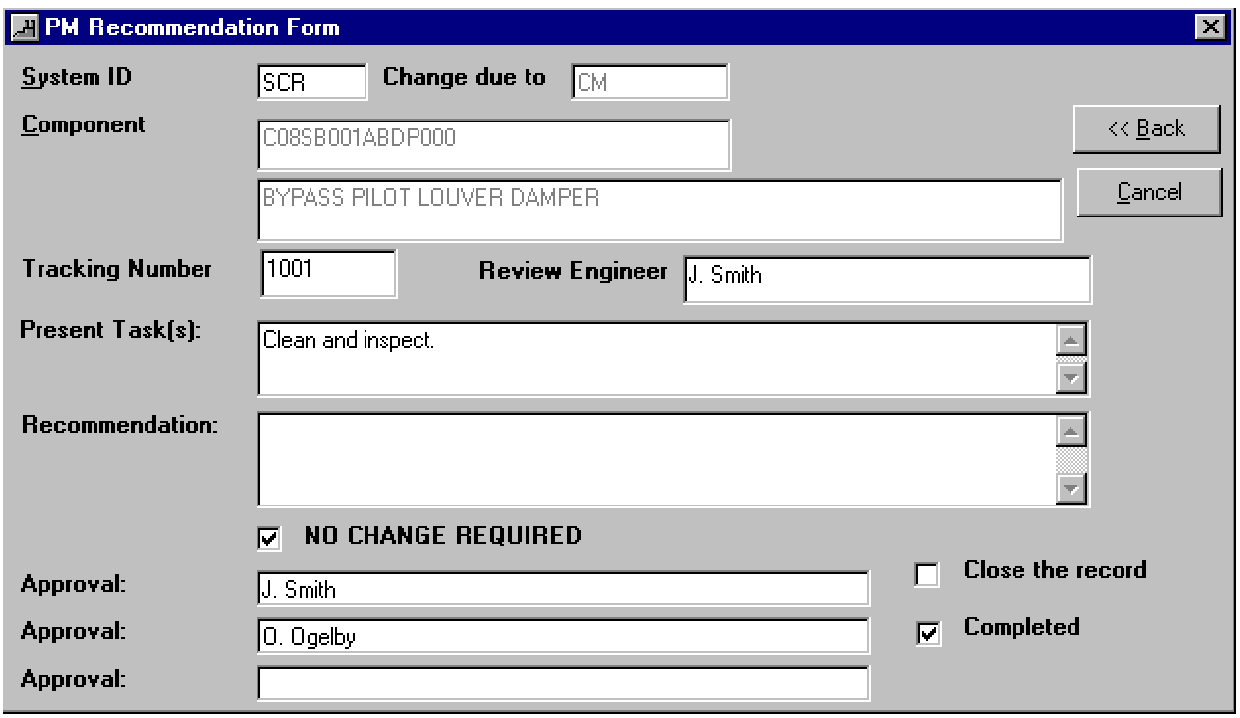


Sample Design Change Review Form Screen

The information that is to be reviewed using the Living Program Module, or in a living program review in general, is available from the plant's Computerized Maintenance Management System (CMMS) and other sources. For Corrective Maintenance History and Preventive Maintenance History reviews, the Living Program Module provides a method to use electronic data downloaded from the CMMS which will simplify the review process greatly. Other reviews, such as the Design Change review, may require hand entering the information into the Living Program Module databases, but it is expected that these types of reviews would only constitute a small fraction of the corrective and preventive history reviews made more easy through electronic data transfers.

After any given item is reviewed, a corrective maintenance action for example, the analyst would then use the Living Program Module's PM Recommendation Form to define new tasks that were determined to be necessary, or to report that no PM changes are required. Using the PM Recommendation Form this way provides a complete record of the actions necessary to take in response to the item reviewed.

The PM Recommendation Form below shows the type of information required and reported on the form.


PM Recommendation Form
System ID: SCR
Change due to: CM
Component: C08SB001ABDP000
BYPASS PILOT LOUVER DAMPER
<< Back
Cancel
Tracking Number: 1001
Review Engineer: J. Smith
Present Task(s): Clean and inspect.
Recommendation:
NO CHANGE REQUIRED
Approval: J. Smith
Approval: O. Ogelby
Approval:
Close the record
Completed

Sample PM Recommendation Form Screen

Note that the form includes approvals. The software would allow either a printout of the form to be reviewed and signed by those responsible for the program or the approval could be done electronically using passwords. This electronic process would allow easier approval by allowing those responsible to access the program on-line thus eliminating the need to print documents, route them for signature, and file them for records.

The Living Program Module provides a tool for easing the records management of a Living Program procedure at any plant by keeping track of which items have been reviewed and completed, including approvals, and an electronic data file for record keeping.