RISK BASED MAINTENANCE: RESOURCE REQUIREMENTS AND ORGANIZATIONAL CHALLENGES

S.D. WEERAKKODY
Northeast Utilities,
Berlin, Connecticut,
United States of America

Abstract

10 CFR 50.65 "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants" required licensees to monitor the performance or condition of structures, systems, or components (SSCs) against licensee established goals, in a manner sufficient to provide reasonable assurance that such SSCs are capable of fulfilling their intended functions. The goals were required to be commensurate with safety significance and operating experience. Northeast Utilities relied upon PRAs to implement 10CFR 50.65, which is also referred to as the "Maintenance Rule." The Maintenance Rule changed some aspects of maintenance of structures, systems, and components (SSC) at nuclear power plants. One objective of the rule was to focus the maintenance resources based on risk significance of components. This paper will discuss the organizational challenges and resource requirements associated with implementation of the Maintenance Rule at nuclear facilities that are supported by the Northeast Utilities Services Company (NUSCo). The paper will discuss (a) how these challenges were addressed, (b) the resources required for ongoing efforts to support the Maintenance Rule, and (c) several key safety benefits derived from the implementation of the Maintenance Rule.

A. PURPOSE

10 CFR 50.65 "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants" required licensees to monitor the performance or condition of structures, systems, or components (SSCs) against licensee established goals, in a manner sufficient to provide reasonable assurance that such SSCs are capable of fulfilling their intended functions. The goals were required to be commensurate with safety significance and operating experience. Northeast Utilities relied upon PRAs to implement 10CFR 50.65, which is also referred to as the "Maintenance Rule." The Maintenance Rule changed some aspects of maintenance of structures, systems, and components (SSC) at nuclear power plants. One objective of the rule was to focus the maintenance resources based on risk significance of components. This paper will discuss the organizational challenges and resource requirements associated with implementation of the Maintenance Rule at nuclear facilities that are supported by the Northeast Utilities Services Company (NUSCo). The paper will discuss (a) how these challenges were addressed, (b) the resources required for ongoing efforts to support the Maintenance Rule, and (c) several key safety benefits derived from the implementation of the Maintenance Rule.

B. DEPARTMENTS SUPPORTING SAFETY RELATED MAINTENANCE

The Maintenance Rule was published in July 1991. The licensees were given five years to fully implement this rule. The rule implementation required interfaces among several functions within the licensees to work closely. They are:

- System Engineers
- PRA Engineers
- Operations
- Work Planning and Outage Management (WP&OM)
- Unit Maintenance Rule Coordinator
- Expert Panel

At NUSCo, the plant system engineers have ownership of specific plant systems. They are cognizant of day-to-day activities associated with those systems. The system engineers are located onsite and they are expected to possess an in-depth understanding of operating history and characteristics of the systems which they take ownership. At NU, the PRA engineers support all of the nuclear units from a central office. The Operations Department has the primary responsibility for the control of the operating equipment. The WP&OM Department is responsible for planning and scheduling test and maintenance activities. The unit Maintenance Rule Coordinator is a position created to support the implementation of the rule. Finally, an Expert Panel was established to support the Maintenance Rule. This panel consisted of at least five members with representatives from Operations, PRA, Plant Engineering, Safety Analysis (Design Basis Analysis), and Work Management. In addition to this, during the Maintenance Rule initial development phase, a Maintenance Rule Working Group supported the resolution of issues and maintained consistency among the nuclear units.

C. PRA's ROLE AND INTERFACES WITH OTHER DEPARTMENTS

PRA's primary role in implementation of the Maintenance Rule are represented by its contribution to the following tasks:

- Determination of Risk-Significance
- Participation in the Expert Panel
- Development and Review of Unavailability Performance Criteria
- Development and Review of Reliability Performance Criteria, and
- Risk Assessment of Work Schedule

In order to support each of the above tasks, PRA interacted with other function within the organizations. While task completion (e.g, Development of a list of Risk-Significant systems) was necessary for initial implementation, the long-term success relies upon an effective exchange of information between PRA engineer and the interfacing functions. Management endorsement of PRA training activities is a key contributor to the long-term success of the Maintenance Rule implementation.

C.1 System Engineering and PRA

Prior to the Maintenance Rule, there was no regulatory requirement to motivate the system engineers to understand the reliability models (Fault trees) associated with their systems.

However, the Maintenance Rule required the system engineers to gain an understanding of the reliability models and the risk significance of the systems that they own. Management support was obtained to transfer the PRA knowledge to the system engineers. Information exchange sessions between PRA engineers and system engineers enhance the system engineers' understanding of the reliability aspects of their systems. These information exchanges also benefit the PRA engineers by enhancing their understanding of system operations.

C.2 Operations and PRA

Prior to the Maintenance Rule, PRA had provided periodic training to the operators primarily focused on keeping them informed of dominant core-damage sequences and risk-significant operator actions. With the Maintenance Rule, the focus of operator training shifted to understanding the risk associated with removing equipment from service and the monitoring process implemented to manage risk. The need for this training had to be communicated to the Training Department which is responsible for scheduling operator training. Even though the risk management concept provided to the operators was in some respect additional requirements which operators needed to follow, there was near unanimous agreement on its value and contribution to public health and safety. The credibility of the risk assessment and monitoring principles (e.g, prohibition to perform high risk test with key decay heat removal system trains out of service) led to full acceptance by the operators.

C.3 WP&OM and PRA

10CFR 50.65 (Maintenance Rule) requires the licensee to assess the overall risk impact associated with on-line maintenance. The PRA function provides the expertise to assess this overall impact. However, prior to Risk Monitoring and Maintenance rule, PRA had almost no experience or involvement in the area of Work Planning. Similarly, prior to the Maintenance Rule the work planners had almost no experience with the concept of risk assessment. In order to meet part (a)(3) of the Maintenance Rule, PRA and WP&OM had to start working together and share information. WP&OM personnel had to be informed of the subset of systems and tests which are of interest to PRA. WP&OM had to expend resources to accommodate PRA information needs. They had to summarize the detailed work plans so that the PRA engineers could interpret the schedules. There was a significant resource burden on the PRA since the weekly work schedules had to be reviewed in order to provide timely feedback to the units.

D. RESOURCE REQUIREMENTS

D.1 PRA Resource Requirements

During the initial implementation phase, the PRA engineers provide critical input to the following activities: Risk Significance determination and Performance Criteria development. In addition, PRA engineers participated in the development of the risk management process by generating risk matrices, reviewing the work planner's schedules, and transferring the risk monitoring knowledge and principles to operators. As PRAs were periodically updated, some of these activities had to be repeated.

While the Rule was put into place between 1990 and 1996, PRA resources per nuclear unit was approximately 6 person-months (PM) per unit per year. Even though the rule is fully in place, PRA spends significant resources to adjust methods and processes based on lessons learned. The ongoing PRA support for the rule include the following tasks:

(i) Periodically update PRA Models
(ii) Review risk significance and performance criteria decisions when PRA models are updated
(iii) Participate in Expert Panels
(iv) Provide periodic training to System Engineers, Operators, and Work Planners, and
(v) Review maintenance and test schedules to support risk management process

Item (i) above requires significant resources. However, those resources are required to support all PRA related efforts. Item (v) can be resource intensive unless proper state-of-the-art tools (computer software) are used. Items (ii)-(v) can be supported with about 3 PM/unit/year.

D.2 System Engineering Resource Requirements

During the implementation stage of the Maintenance Rule, the system engineers expended a significant amount of resources to perform a multitude of tasks such as examining the past operating history, preparing system basis documents, establishing performance criteria, learning the Rule, and failure definitions. The unit Maintenance Rule coordinator provides extensive support to the system engineers during this phase The total effort to support these activities were estimated at 6PM/Unit/Year. Now that the Rule is fully implemented, the system engineer is expected to continue to track and trend the system performance. If the system is a bad performer (referred to as an (a)(1) system in the Maintenance Rule space), then additional ongoing support is needed for goals setting and monitoring. If one assumes, 20 systems at 2 hours per month per system, the ongoing resource burden is approximately 3 person-months/unit/year.

D.3 Operations Resources

The operators need to be cognizant of risk-management guidance. In order to accomplish this, additional training was incorporated into the operator training curriculum. If 1 hr/operator/year is estimated as the training burden to the operators, assuming 60 operators/unit, the total ongoing burden is approximately 0.5 person-month/Unit/Year.

D.4 Expert Panel

The resource requirements to support the expert panel are estimated as follows. During the Maintenance Rule implementation phase, the Expert Panel met approximately once a week. The panel consists of at least 5 people. If each panel meeting has a 3 hour burden per participant and one assumes 6 participants per meeting, this equates to approximately 6 PM/unit/year. For on-going rule compliance, it is likely the expert panel will only meet monthly or quarterly. The Expert Panel burden is estimated to be about 2 PM/year/Unit.

D.5 Unit Maintenance Rule Coordinator

From 1991 to 1996, until the Maintenance Rule was fully in place, a new full time position was created to support all Maintenance Rule related tasks. In addition, 4 full-time contractors and a program manager provided support for 2 years to support 4 nuclear plants. That is, during this phase, the resources expended was approximately 18 person-months/Unit/Year. However, now that the rule fully implemented, the Maintenance Rule Coordinator will likely be able to assume other responsibilities as well. Assuming a 50% reduction, the resource needs to support the ongoing efforts associated with the Maintenance Rule by the unit coordinator is estimated to be 9 PM/Unit/Year.

D.6 WP&OM

In order to meet paragraph (a)(3) of Maintenance Rule to assess risk when removing equipment from service, NUSCo relies upon WP&OM. During the implementation stage, the PRA and WP&OM had to learn the capabilities of their respective disciplines. PRA had to understand the processes and procedures applicable to work planning and identify their information needs to WP&OM. WP&OM had generate the information that was needed by PRA in a format that was usable by PRA. The implementation burden associated with WP&OM is estimated at 1 PM/Unit/Year based on a weekly work load of 3 hours for WP&OM to produce the necessary documentation for PRA review. In addition, 1 PM/Unit/Year was added to accommodate the learning curve. Since the WP&OM and PRA information exchange has to continue on a daily basis, the WP&OM resource will continue to be needed, however, at a slightly reduced levels.

D.7 Total Resources

Function	Resources needed to Support Implementation of Rule (Person-months per unit per year)	Resources to support Ongoing Tasks (Person-months per unit per year
PRA	6	3
Expert Panel	6	2
Maintenance Rule Coordinator	18	9
System Engineers	6	3
WP&OM	2	1
Operations	0.5	0.5
Total	**38.5**	**18.5**

E. SIGNIFICANT SAFETY BENEFITS

Maintenance Rule implementation has resulted in reductions in risk associated with nuclear plant operations. Perhaps the most profound safety benefits will be gained from risk assessment and monitoring when removing equipment from service. The Technical Specifications did not always prevent the operators from entering high risk configurations. However, the shortcomings of the Technical Specifications in this area were eliminated by the implementation of risk assessment processes. The Maintenance Rule highlighted the need to control unavailability for several critical safety systems. In addition to meeting the specific objectives associated with the Maintenance Rule, the activities associated with the Maintenance Rule set a strong foundation for a future risk-informed safety culture at nuclear utilities.

F. CONCLUSIONS

Implementation of the Maintenance Rule, 10CFR 50.65, at nuclear plants has many organizational as well as technical challenges. The organizational challenges had to be overcome by generating appropriate procedures and processes that requires interactions among different organizations and processes. In the short-term, the ability to create these processes and procedures relied upon management support. The long-term success will rely on continuing training and information exchanges between functions (e.g, work planning and PRA, system engineering and PRA). Since the Maintenance Rule is performance based rather than prescriptive, technical challenges were addressed by generating internal guidelines. In addition to providing the benefits of improved maintenance, the Maintenance Rule has set a strong foundation for future risk-informed regulations. The implementation burden was extensive at the beginning. However, if the state-of-the-art tools are used, the ongoing burden minimized.