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NRC Regulatory Activities on Maintenance of Nuclear Power Plants

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General Safety Considerations

Edited by J. R. Buchanan

NRC Regulatory Activities on Maintenance of Nuclear Power Plants

By M. Dey^a

Abstract: *The Nuclear Regulatory Commission (NRC) has initiated efforts for and focused attention on maintenance of nuclear power plants since 1980. A comprehensive survey and review of industry maintenance practices in the United States and abroad led to the publication of a Final Policy Statement on Maintenance of Nuclear Power Plants which defined the composition and elements of an effective maintenance program. The NRC has initiated efforts for the establishment of a maintenance rule and standard to provide guidance to the industry on its expectations for maintenance in nuclear power plants and to define in more detail the implementation of an effective maintenance program. Various studies have been conducted to support NRC's rulemaking effort and have provided a number of findings regarding effective maintenance practices; one major conclusion is that a performance-oriented systems approach would lead to increased effectiveness of maintenance programs. These findings have been used for the development of a proposed and draft final rule and a draft Regulatory Guide.*

The importance of good maintenance in ensuring safe and reliable plant operation has been widely recognized for a long time. In recent years, with the rapid growth of the number of operating plants in the United States, the approaching end of the nuclear construction era in the United States, and the accumulation of significant reactor operating experience, maintenance has become the focus of increasing attention both from the Nuclear Regulatory Commission (NRC) and from the industry.

Historically, NRC regulatory attention to maintenance has been based, to a considerable extent, on the quality assurance requirements of 10 CFR 50, Appendix B (Ref. 1), the surveillance requirements in 10 CFR 50.36 (Ref. 2), and the in-service inspection requirements in 10 CFR 50.55a (Ref. 3). Although requirements such as these, along with related guidance, cover some of the major elements of nuclear power-plant maintenance, the regulations do not explicitly state NRC's expectations on the full range of activities that form the basis of a maintenance program. In the early 1980s, a series of studies and programs undertaken by NRC, the Institute of Nuclear Power Operations (INPO), and others began to focus increased attention on maintenance and led to the development of NRC's Maintenance and Surveillance Program Plan in 1985 (Ref. 4). The Plan was designed to address five principal maintenance safety issues that were found to exist at some plants. The Plan summarized these issues, and the corresponding Maintenance and Surveillance Program (MSP) objectives, as follows:

1. There is indication that needed maintenance is not being accomplished or is not performed effectively. The objective is to determine the effectiveness of current nuclear power-plant maintenance programs, to detect the causes and effects of equipment performance degradation, and to identify correc-

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tive action to minimize equipment failures and unavailability.

2. Many failures result from improper performance of maintenance. The objective is to reduce failures from improper maintenance by identifying the fundamental causes of human maintenance errors and by identifying practices which reduce the error rate and which increase the probability of error detection prior to system demand and to assess the effectiveness of licensee strategies for improved maintenance performance.

3. The interface between maintenance and operations is presently inadequate. The objective is to determine the causes of poor coordination among activities to assure proper integration of maintenance, operations, and other organizational interfaces for maintenance activities.

4. The number of maintenance-related challenges to safety systems is excessive. The objective is to determine the causes of the high rate of challenges and improve the effectiveness of nuclear power-plant maintenance programs in assuring operability of safety systems.

5. A major portion of occupational radiation exposure (over 75%) and many radiological hazards occur to personnel performing maintenance activities (NUREG-0713) (Ref. 5). Improved planning and control of maintenance activities may significantly reduce occupational exposure to as much as half that at present. The objective is to assure that, by performing preventive and corrective maintenance in a planned and optimized manner, the unnecessary and unanticipated radiological exposure of maintenance personnel will be reduced.⁴

The MSP Plan, Phase I, was implemented beginning in 1985. Results from Phase I were published in June 1986 in a two-volume report.⁶

NUREG-1212 (Ref. 6) reported the in-depth findings and conclusions of Phase I. Several principal conclusions were stressed. First, overall industry reliability and plant performance were found to be improving, as indicated by declining forced outage and scram rates. However, Phase I also confirmed that the five maintenance safety problems identified in the MSP were evident to varying degrees across the U.S. nuclear industry. Wide variations were found in maintenance practices and effectiveness. Industry initiatives to improve maintenance were noted, but definitive assessments of the effectiveness of these programs were not yet possible. In summary, Phase I confirmed the existence of safety concerns related to

maintenance and concluded that further NRC and industry attention was needed to address these concerns.

POLICY STATEMENT

In response to the findings of Phase I, the Commission directed the NRC staff to develop a policy statement to formalize the Commission's position on maintenance. The Final Commission Policy Statement on Maintenance of Nuclear Power Plants⁷ was published in the *Federal Register* on Mar. 23, 1988. The Policy Statement declared the Commission's intent to proceed with a rulemaking aimed at improving the effectiveness of maintenance programs throughout the nuclear industry. For interim guidance to industry while the rulemaking was under way, the Policy Statement also clarified the Commission's views on various maintenance issues, such as the definition and scope of maintenance and elements of a good maintenance program.

The NRC Policy Statement states that all commercial nuclear power plants:

...should develop and implement a well-defined and effective program to assure that maintenance activities are conducted to preserve or restore the availability, performance and reliability of plant structures, systems, and components. The program should clearly define the components and activities included, as well as the management systems used to control those activities. Further, the program should include feedback of specific results to ensure corrective actions, provisions for overall program evaluation, and the identification of possible component or system design problems.⁷

The Policy Statement lists the following 15 activities that form the basis of an adequate maintenance program:

- Technology in the areas of
 - corrective maintenance
 - preventive maintenance
 - predictive maintenance
 - surveillance
- Engineering support and plant modifications
- Quality assurance and quality control
- Equipment history and trending
- Maintenance records
- Management of parts, tools, and facilities
- Procedures
- Postmaintenance testing and return-to-service activities

- Measures of overall program effectiveness
- Maintenance management and organization in the areas of
 - planning
 - scheduling
 - staffing
 - shift coverage
 - resource allocation
- Control of contracted maintenance services
- Radiological exposure control (ALARA)
- Personnel qualification and training
- Internal communications between the maintenance organization and plant operations and support groups
- Communications between plant and corporate management and the maintenance organization

PROPOSED RULE AND SUPPORTING DOCUMENTS

On Nov. 28, 1988, the NRC published a notice of proposed rulemaking to require commercial nuclear plant licensees to implement effective maintenance programs.⁸ A major workshop, with over 300 participants, was conducted to discuss rulemaking options and key maintenance issues and practices. The discussions at the workshop are documented in Ref. 9. The proposed rule followed the framework of the Policy Statement requiring the implementation of a maintenance program, including the preceding 15 activities, regular assessments of the program, and the execution of corrective actions based on these assessments.

Toward determining and further defining effective maintenance practices, the NRC published draft NUREG-1333 (Ref. 10). The review of foreign and other U.S. industry maintenance programs showed that certain practices are emphasized in these programs and have been found to contribute significantly to effective maintenance. These are discussed in the following text.

1. *Systems Approach.* A systems approach may be described as containing the following elements:

- Systematic evaluation of the functions and objectives of plant systems, components, and structures to determine maintenance activities and requirements.
- A focus on long-term maintenance objectives and establishing a proactive maintenance program as opposed to reactive maintenance.

- Use of a reliability-centered approach to maintenance, including consideration of the human-machine interface.
- The deriving of planning and scheduling from overall program objectives.

2. *Effectiveness Monitoring.* The programs reviewed consisted of major efforts for the monitoring of maintenance effectiveness, which included the following:

- The collection and engineering evaluation of failure data (root-cause analysis).
- The use of an integrated information system for collecting data and monitoring the effectiveness of a maintenance program.

3. *Technician Qualifications and Motivation.* The programs reviewed placed emphasis on the role of the maintenance technician and his ability to perform assigned duties. The programs were oriented to the following:

- The use of maintenance technician training/certification programs.
- Enhancement of the environment and motivation of maintenance technicians.

4. *Maintenance Organization.* A key element of the foreign programs was a clear definition of interfaces between maintenance and other activities (engineering support, operations, quality assurance, quality control, corporate offices, and safety review). An important aspect of the interface is the adequate and timely engineering support that includes the evaluation of failure data.

NRC MAINTENANCE INSPECTIONS AND MAINTENANCE PERFORMANCE INDICATOR PROGRAMS

As part of NRC's overall focus on maintenance and to update previous assessments of U.S. nuclear power-plant maintenance programs, maintenance has been chosen as an area of emphasis in the inspection program for fiscal years 1989 and 1990. The inspections being conducted use a maintenance inspection tree, which consists of the essential elements of an effective maintenance program. To date, about 30 sites have been inspected; the remaining sites will be inspected by the end of 1990. Results of the limited inspections to date indicate that, although maintenance programs are adequately documented, implementation of the programs is

lagging. The inspections indicate a need for continued improvement in maintenance activities, particularly in the areas of equipment performance/reliability trending and monitoring, and root-cause analysis and engineering support. The maintenance inspection guidance (based on an inspection tree) and results of the inspections have also been used toward the development of a draft Regulatory Guide.

The monitoring of maintenance effectiveness has been identified as an area of interest and importance and one in which substantial improvements can be achieved. Therefore, in 1988 the NRC initiated a specific program for the development of maintenance performance indicators. In a trial program that included extensive site visits, actual operational data from commercial power-reactor plants was used and the ability of selected indicators to determine maintenance effectiveness was assessed. A major conclusion of the program is that plants should use quantitative indicators that are based on actual component reliability and failure history to provide the best measure of maintenance effectiveness. These recommendations have been used in the development of the relevant sections of the draft Regulatory Guide.

DRAFT REGULATORY GUIDE

A draft Regulatory Guide has been prepared with the use of findings and recommendations of the preceding studies and programs. The draft Regulatory Guide has been published for public comment and defines an effective maintenance program to involve a systems approach whereby overall policy, goals, and objectives are established; maintenance is conducted on the basis of these goals and objectives; the effectiveness of maintenance is monitored and assessed; and, on the basis of the monitoring and assessment activities, timely feedback and corrective actions are executed. The incorporation of these steps in the maintenance program is considered essential to ensuring that an effective maintenance program is achieved and maintained. The following items summarize the key elements of each of the preceding steps described in the Regulatory Guide and shown schematically in Fig. 1.

1. *Establish Overall Policy, Goals, and Objectives.* The maintenance program should define the overall policy and objectives for maintenance that are consistent with safe operation and security of the plant. The maintenance required on various structures, systems, and components should be directed

toward achieving these objectives. Quantitative goals related to these objectives should be established as one means to measure the progress of the maintenance program in achieving its objectives.

2. *Conduct Maintenance.* The conduct of maintenance activities in the plant should be documented, as necessary, to provide for implementation in a systematic, coordinated, and accurate fashion consistent with the goals and objectives defined in item 1. These activities include the management, coordination, communication, quality assurance, training, surveillance, and technical tasks, including postmaintenance testing, associated with performing maintenance. An effective maintenance program need not require extensive documentation but rather must be understood and effectively implemented by all involved personnel in a consistent manner.

3. *Monitor and Assess Effectiveness and Performance.* The effectiveness of maintenance activities should be evaluated by assessing the performance of the plant against the goals and objectives established in item 1 and by other quantitative means. In addition, qualitative assessments of maintenance (audit and inspection) should be used. On the basis of these assessments, the need for corrective action should be determined.

4. *Obtain Feedback and Take Corrective Actions.* A feedback mechanism should be an integral part of the maintenance program to ensure that timely corrective actions are taken if the effectiveness of the program is not consistent with the established goals and objectives or if the other quantitative and qualitative assessments indicate that improvement is needed. The feedback process should also ensure that any direct or supporting activity, associated with the maintenance program and needing improvement, is identified and corrected in a timely manner.

FUTURE ACTIVITIES

The NRC staff submitted for Commission approval a final rule,¹¹ similar to the proposed rule except clarifying the scope of equipment and activities, and the draft Regulatory Guide discussed previously.

The NRC has decided to postpone the promulgation of the final maintenance rule until the completion of an adequate and effective final Regulatory Guide and until further assessments of improvement in plant maintenance programs have been completed and recommendations made regarding the need for a rule.

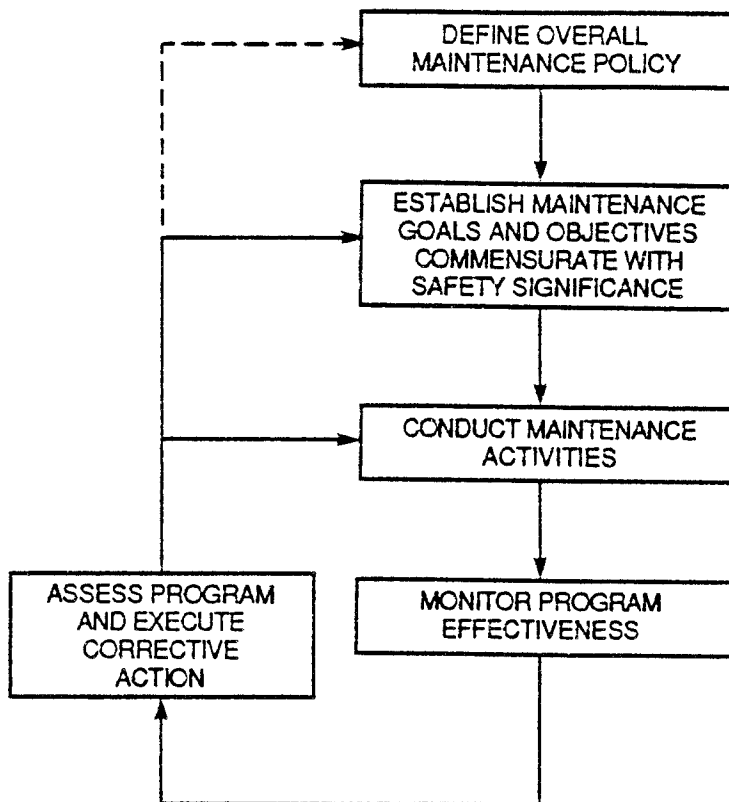


Fig. 1 Schematic of systems approach in draft regulatory guide.

The draft Regulatory Guide has been published for public comment. Further study, confirmation, and elaboration of the findings discussed in this paper and a workshop and peer review of the Regulatory Guide are planned. The NRC seeks to develop and establish a standard which has received extensive review and comments and which, if implemented, would lead to effective maintenance at nuclear power plants and enhanced safety of the U.S. nuclear power program.

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