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Report to the Honorable Sam Gejdenson, House of Representatives

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NUCLEAR REGULATION

NRC's Efforts to Ensure Effective Plant Maintenance Are Incomplete

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GAO

United States
General Accounting Office
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Resources, Community, and
Economic Development Division

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The Honorable Sam Gejdenson
House of Representatives

Dear Mr. Gejdenson:

As requested, we examined issues concerning the importance of maintenance to safe nuclear power plant operations, the status of the debate between the Nuclear Regulatory Commission and the nuclear utility industry on the need for regulations concerning maintenance, and the unresolved issues in the debate. This report presents the results of our efforts.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days from the date of this letter. At that time, we will send copies to the appropriate congressional committees; the Chairman, Nuclear Regulatory Commission; and the Director, Office of Management and Budget. We will also make copies available to others upon request.

This work was performed under the direction of Victor S. Rezendes, Director, Energy Issues, who can be reached at (202) 275-1441. Other major contributors to this report are listed in appendix I.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Following the 1979 accident at the Three Mile Island plant in Pennsylvania, the Nuclear Regulatory Commission (NRC) became increasingly concerned about the adequacy of utilities' maintenance programs. As a result of NRC's attention and the industry's initiatives, NRC and the industry both agree that utilities' maintenance activities have improved. However, NRC and industry continue to debate the best way to sustain and build on this success and address the problems that still exist. Resolving this debate will become increasingly important as utilities place greater reliance on aging plants to meet growing electricity demand.

Representative Sam Gejdenson asked GAO to examine the importance of maintenance to safe nuclear plant operations, the status of the maintenance debate, and the remaining issues to be resolved in the debate.

Background

Under the Atomic Energy Act of 1954, as amended, NRC is responsible for protecting public health and safety in the operation of commercial nuclear power plants. NRC establishes enforceable requirements by developing regulations and issuing licenses. Currently, NRC's maintenance requirements are dispersed throughout its regulations and in the technical specifications of each plant's operating license. In 1985 NRC staff concluded that because maintenance activities varied from plant to plant, additional comprehensive requirements were needed. In November 1988 NRC proposed additional regulations but later delayed moving forward with them while it monitors utilities' efforts to implement an Institute of Nuclear Power Operations program (a utility-funded group) to help improve maintenance practices. In June 1991 NRC expects to decide whether additional regulations are needed. (See ch. 1.)

Results in Brief

NRC and the industry agree that maintenance is crucial to safe, efficient, and reliable nuclear power plant operations, but they have not been able to agree on the best method to ensure continued improvement in maintenance. The debate centers on (1) whether NRC needs to establish additional comprehensive maintenance regulations or whether NRC should endorse the industry's program and (2) the specific plant areas and systems that would be included.

NRC staff initially believed that regulations may provide greater assurance that all utilities effectively maintain their plants and that without regulations it may be difficult to take enforcement actions for maintenance-related problems in all plant areas. In the proposed regulations, NRC sought to broaden its oversight over all plant systems, including those where electricity is produced (operating systems in electricity-producing plant areas are often referred to as balance-of-plant systems). Industry does not believe that additional regulations are needed because it has developed a maintenance program. Also, industry opposes NRC's oversight of all plant areas because some have no impact on safety. Utilities want NRC to endorse the industry's program and allow them to identify the plant areas that would be covered by the program. GAO believes that an important consideration in NRC's decision should be the agency's ability to take enforcement actions in the future.

Regardless of the decision made on the need for additional comprehensive regulations, NRC must have a mechanism to ensure effective maintenance at nuclear power plants in the future. To do so, NRC could integrate performance indicators into its regular inspection program or periodically conduct special maintenance team inspections. However, NRC has no plans to take either action.

Principal Findings

Maintenance Is Important to Plant Operations

NRC and the industry agree that maintenance is important to safe, reliable, and efficient plant operations and is important as plants age. In mid-1989 NRC reported that maintenance-related safety events, such as unanticipated plant shutdowns, decreased from 48 percent in 1985 to 42 percent of the almost 4,000 events reported in 1987 and 1988. Although progress has been made in the maintenance area, further improvement is needed. For example, over the past 2 years, NRC inspections of 84 plants showed that most had good or satisfactory maintenance programs, but 26 percent received a lower rating for implementation compared with their program ratings. (See ch. 2.)

Maintenance Regulations: Are They Needed?

In 1988 NRC proposed regulations to establish comprehensive maintenance requirements and in 1989 issued a draft regulatory guide that describes methods utilities could use to comply with the proposed regulations. Utilities do not believe that additional regulations are needed because the industry has undertaken various initiatives, such as conducting seminars, and developed its own maintenance program, which all utilities will strive to meet. GAO noted that the industry's program is almost identical to NRC's draft regulatory guide. For example, both include such elements as planning and scheduling, qualification and training of personnel, and engineering support.

In its proposed regulations, NRC wanted oversight over all systems, including those used to produce electricity (balance-of-plant). NRC took this position because it had previously found that balance-of-plant problems constituted the most frequent reasons for unanticipated plant shutdowns and that equipment failures in balance-of-plant systems were the primary cause of almost 75 percent of such shutdowns. Although the industry's program applies to all plant areas, the industry believes that some balance-of-plant systems have no impact on safety and should not be subject to NRC's requirements and that utilities, not NRC, should determine the plant systems, structures, and components that should be emphasized.

In December 1989 the Commissioners agreed to wait until June 1991 to decide whether additional comprehensive regulations are needed. NRC staff believe that industry performance should be considered in making this decision. A factor that GAO believes should be emphasized is NRC's ability to enforce corrective actions when future maintenance problems occur. One option the Commissioners are considering is endorsing the industry's program through a policy statement. With a policy statement, however, NRC may not be able to enforce corrective actions in areas, such as balance-of-plant, not covered by specific regulations or license requirements. (See ch. 2.)

Indicators Could Strengthen NRC's Oversight

Under its regular inspection program, NRC periodically examines maintenance activities. However, the frequency varies, and maintenance is only one element of many, such as physical security and quality assurance, that may be inspected. Since 1988 NRC has conducted special maintenance team inspections at 84 plants and found common weaknesses with utilities' procedures, corrective actions, and engineering support. NRC plans to inspect the remaining 28 plants by April 1991 and then discontinue the special inspections, relying instead on its regular inspection program.

Recognizing that its inspection program is largely reactive, NRC has been considering quantitative maintenance performance indicators to help identify potential problems before they occur. NRC had developed and validated a single indicator based on component reliability data. According to the industry, the indicator does not appropriately measure maintenance performance because a high rate of part failures could indicate a poorly manufactured or substandard product or improper installation rather than inadequate maintenance. Further, NRC staff found that the indicator does not help identify potential problems before they occur. On October 9, 1990, the staff recommended that the Commissioners not adopt the indicator.

Concurrent with developing the component reliability indicator, NRC examined the usefulness of other indicators, including those used throughout the industry, such as maintenance backlog, staff turnover, and balance-of-plant equipment out of service. GAO believes that NRC could enhance its inspection program and strengthen its oversight by using available indicators to (1) help focus resources, (2) identify specific areas warranting review, and (3) be more proactive in assessing utilities' maintenance efforts. However, NRC has no plans to integrate the indicators with the inspection process. (See ch. 3.)

Recommendations

To ensure the safe operation of commercial plants, NRC must be in a strong position to oversee utilities' commitment to effective maintenance practices. Therefore, GAO recommends that the Chairman, NRC,

- base the decision on the need for additional maintenance regulations, in large measure, on NRC's ability to enforce corrective actions in all plant areas, including balance-of-plant;
- ensure that NRC continually examines utilities' commitment to maintenance either through its regular inspection program or by periodically conducting team inspections after April 1991; and
- integrate performance indicators into the inspection process.

Agency Comments

GAO discussed the facts in this report with NRC and industry officials. Generally, they agreed with the facts but offered some clarifications that were incorporated where appropriate. As requested, GAO did not ask NRC or the industry to comment officially on this report.

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Abbreviations

GAO	General Accounting Office
NRC	Nuclear Regulatory Commission
NUMARC	Nuclear Management and Resources Council
INPO	Institute of Nuclear Power Operations
SALP	Systematic Assessment of Licensee Performance

Introduction

In the years since the 1979 accident at the Three Mile Island, Pennsylvania, plant, the Nuclear Regulatory Commission (NRC) has become increasingly concerned about the impact of maintenance on safe operations. Public concerns over nuclear power plant safety and an increased reliance on aging plants make the issue of maintenance paramount. In 1989, NRC reported that maintenance accounted for 42 percent of about 4,000 safety-related events in 1987 and 1988.[1] Although NRC recognizes the problem, it has not yet determined the most appropriate method to address maintenance now and in the future.

NRC's Requirements and Oversight of Maintenance Activities

Under the Atomic Energy Act of 1954, as amended, NRC is responsible for protecting public health and safety in the operation of nuclear plants. To carry out its responsibilities, NRC in part (1) develops regulations and issues licenses for utilities to operate the plants, (2) conducts routine and special inspections to oversee utility's compliance with the established requirements, and (3) evaluates utility-reported information and plant-specific performance indicators. Once NRC identifies a regulatory violation, it can issue a Notice of Violation; impose a civil (financial) penalty; or issue an order to suspend, modify, or revoke an operating license. Within NRC, the Office of Nuclear Regulatory Research develops regulations, the Office of Nuclear Reactor Regulation oversees licensing and inspection, the Office for Analysis and Evaluation of Operational Data collects and evaluates operational safety data and tracks plant-specific performance indicators, and the Office of Enforcement develops policies to enforce compliance with NRC's requirements.

NRC Has Had Concerns for Almost 10 Years

Following the 1979 Three Mile Island accident, NRC became increasingly concerned about the adequacy of utilities' maintenance programs and practices. After the accident, new plant construction slowed, and NRC's emphasis shifted from reviewing construction applications to inspecting plant operations. Subsequent inspections indicated that some utilities needed to improve their maintenance programs and practices. In 1984, NRC found that maintenance was the root cause of 39 percent of safety-related events at the then more than 85-licensed plants. As a result, NRC identified maintenance as a management issue and initiated a formal maintenance status study in 1985.

[1] Utilities are required to report safety-related events at nuclear plants to NRC. NRC relies on its on-site resident inspectors to monitor plant activities and ensure events are reported.

In response to NRC's interest, the nuclear utility industry, through the Nuclear Management and Resources Council (NUMARC),[2] formed a working group in June 1984 to address needed improvements in maintenance. The group's report supported NRC's findings by concluding that maintenance was the root cause of 38 percent of safety-related events at the plants between 1980 and 1984. Since that time, both NRC and the industry have initiated actions to help improve maintenance.

On the basis of their efforts, NRC staff concluded that maintenance problems stemmed in part from the inconsistent implementation of existing industry guidance coupled with a lack of a comprehensive maintenance regulation. Currently, NRC's enforceable requirements in the maintenance area are dispersed throughout its regulations and in the technical specifications of each plant's operating license. As a result, in a March 1988 policy statement NRC announced its intention to develop additional, comprehensive maintenance regulations; NRC issued proposed regulations in November 1988. Also, in 1988 NRC initiated special inspections that solely focused on utilities' maintenance programs and practices.

The industry also took actions to improve maintenance. For example, in January 1990 NUMARC identified key industry initiatives in a maintenance action plan. Some initiatives, such as conducting maintenance seminars, have been completed while others, such as the inclusion of maintenance supervisors and managers on plant evaluations, will continue. The industry opposes NRC's proposed maintenance regulations believing they could adversely affect ongoing initiatives by redirecting resources and attention to comply with additional and unnecessary regulations. The industry argues that regulations are not needed because all nuclear utilities have committed to meet or strive to meet an Institute of Nuclear Power Operations (INPO)[3] maintenance program.

NRC has recognized the industry's initiatives and its commitment to maintenance and in a December 1989 revised policy statement delayed proceeding with regulations for 18 months (until June 1991) while it monitors the utilities' efforts. Also, in a December 1989 policy modification NRC instituted a policy to increase the amount of civil penalties by up to 50 percent if a maintenance program deficiency is determined to

[2]NUMARC represents all domestic nuclear utilities and serves as an interface between the industry and NRC.

[3]INPO, a utility-funded group, was organized to improve the safe and reliable operation of nuclear power plants and, among other things, evaluate nuclear utility performance.

be the root cause of a significant regulatory violation, thereby putting utilities on notice about the seriousness with which NRC regards maintenance. In June 1991 NRC expects to decide on the most appropriate option for ensuring effective maintenance at nuclear power plants in the future.

Objectives, Scope, and Methodology

Representative Sam Gejdenson asked us to examine the importance of maintenance to safe plant operations, the status of the maintenance debate between NRC and the industry, and unresolved issues in the debate.

To obtain the information for this report, we reviewed the Atomic Energy Act of 1954 and Energy Reorganization Act of 1974, as amended, pertinent sections of NRC's regulations; NRC's proposed regulations and some comments received on them; escalated enforcement policy, June 1986 report, Status of Maintenance in the U.S. Nuclear Power Industry: 1985; May 1989 report, Maintenance Problems at Nuclear Power Plants, and August 1989 draft regulatory guide on maintenance. We also reviewed a January 1987 MITRE Corporation report, Analysis of Balance-of-Plant Regulatory Issues, prepared for NRC. In addition, we met with NRC staff in the Offices of Nuclear Reactor Regulation, Nuclear Regulatory Research, Enforcement, and Analysis and Evaluation of Operational Data as well as Advisory Committee on Reactor Safeguards officials. We also attended NRC's May 1990 Regulatory Information Conference and a May 1990 public meeting between NRC and utility executives on the industry's maintenance program.

In addition, we spoke with officials from industry-funded groups, such as NUMARC, INPO, the Electric Power Research Institute that conducts research for about two-thirds of the nation's utilities, and five nuclear utilities (Commonwealth Edison, Duke Power, Texas Utilities, Southern California Edison, and Northeast Utilities) that are actively involved in the maintenance issue. Further, we obtained documents to support the oral positions given, such as INPO's March 1990 report, Maintenance Programs in the Nuclear Power Industry, that sets out the industry's maintenance program.

We discussed the facts presented in this report with NRC and NUMARC officials. They generally agreed with the facts but offered some clarifications that were incorporated where appropriate. As requested, we did not ask NRC or the industry to officially comment on this report. We conducted our work between October 1989 and August 1990 in accordance with generally accepted government auditing standards.

Maintenance Regulations: Are They Needed?

Maintenance is an important contributor to safe and reliable nuclear energy production. Both NRC and the industry agree that nuclear utilities have improved in the maintenance area, but they have not been able to agree on the most effective mechanism to sustain and improve this success and address the problems that still exist. The debate centers on (1) whether NRC should establish additional comprehensive maintenance regulations or endorse the industry's program and (2) the specific plant areas and systems that would be included.

NRC initially believed that regulations may provide greater assurance that all utilities will effectively maintain their plants. Also, NRC initially proposed that the regulations apply to all plant areas, including those where electricity is produced, often referred to as balance-of-plant. However, NUMARC officials believe that INPO's maintenance program makes regulations unnecessary; therefore, NRC should endorse the industry's program. In addition, industry opposes NRC's oversight of all plant areas because some have no impact on safety and wants NRC to allow utilities to identify the plant areas that would be covered by their programs.

Maintenance Is Important to Safe and Reliable Operations

In 1988 industry estimated that maintenance accounts for about 70 percent of nuclear power plant activities and is essential for sustained plant operations. Specifically, good maintenance practices contribute to safe and affordable electricity supply to meet growing demand. The Energy Information Administration's 1990 Energy Outlook estimated that the equivalent of about 234 new base load plants will be needed by 2010, yet most utilities are not planning to add any significant new capacity, including coal- or oil-fired plants. Greater energy demand, without the addition of new plants, will increase pressure on existing plants to operate efficiently.

In addition, maintenance is important to sustaining existing plants as they age. Over the next 25 years, about 45 percent of the 112 current plants will reach the end of their 40-year operating licenses—the Yankee Rowe plant in Massachusetts will be the first operating license to expire in 2000. The utility expects to apply for a license extension from NRC in 1991. According to NRC documents, operating risks due to wear, corrosion, and fatigue increase as plants age, thereby necessitating greater emphasis by utilities to effectively maintain their plants. Also, NRC noted that plants with better maintenance programs tend to perform better, resulting in less reliance on costly power from outside sources. In 1989 NRC's Office for Analysis and Evaluation of Operational

Data estimated that the cost of replacement power for all maintenance-related unplanned outages was as much as $960 million in 1987.

Progress Has Been Made, but Problems Still Exist

As a result of NRC's interest and the industry's initiatives conducted since 1985, both NRC and the industry agree that utilities have improved in the maintenance area. For example, in mid-1989 NRC found that maintenance-related safety events declined from 48 percent in 1985 to 42 percent of the almost 4,000 events reported in 1987 and 1988. Likewise, industry found that between 1979 and 1985 about 12.6 percent of the plants received a rating of 3 in maintenance under NRC's Systematic Assessment of Licensee Performance (SALP) program compared with 7.7 percent of the plants between 1985 and 1988.[1]

Despite the progress made, both NRC and industry recognize that maintenance problems still exist. NRC maintenance team inspections conducted between August 1988 and May 1990 of 84 plants showed that most had good or satisfactory programs, but 26 percent received a lower rating for implementation compared with their written program ratings. Table 2.1 shows the results of NRC's maintenance team inspections as of May 1990.

[1] In 1979 NRC implemented SALP to periodically assess utilities' performance in up to 11 technical areas. For each area, NRC rates the utility as follows: management attention and involvement are readily evident and resources are ample and effectively used such that the level of performance substantially exceeded regulatory requirements—rating 1; management attention to safety is good such that the level of performance is above that needed to meet regulatory requirements—rating 2; or insufficient management attention and resources in safety activities and performance do not significantly exceed minimal requirements—rating 3. NRC issued revised definitions on September 28, 1990.

Table 2.1: Results of NRC's Maintenance Team Inspections as of May 1990

Plants	State	Inspection completed	Rating program/ implemented[a]
Arkansas 1 and 2	Arkansas	12/16/88	Sat/Sat
Beaver Valley 1 and 2	Pennsylvania	10/13/89	Good/Good
Braidwood 1 and 2	Illinois	05/18/90	Good/Good
Browns Ferry 1, 2, 3	Alabama	02/09/90	Sat/Sat
Brunswick 1 and 2	North Carolina	02/10/89	Good/Sat
Byron 1 and 2	Illinois	03/30/90	Good/Good
Calvert Cliffs 1 and 2	Maryland	03/16/90	Good/Good
Clinton	Illinois	04/14/89	Sat/Sat
Cook 1 and 2	Michigan	01/09/90	Sat/Sat
Cooper	Nebraska	12/22/89	Good/Sat
Davis Besse	Ohio	10/21/88	Sat/Sat
Diablo Canyon 1 and 2	California	08/05/88	Sat/Sat
Dresden 2 and 3	Illinois	02/24/89	Good/Sat
Duane Arnold	Iowa	12/16/88	Sat/Sat
Farley 1 and 2	Alabama	05/26/89	Sat/Good
Fermi	Michigan	12/01/89	Sat/Sat
Fort Calhoun	Nebraska	04/14/89	Sat/Poor
Grand Gulf	Mississippi	11/18/88	Good/Sat
Hatch 1 and 2	Georgia	03/31/89	Good/Good
Hope Creek	New Jersey	10/27/89	Good/Good
Indian Point 2	New York	05/19/89	Poor/Sat
Indian Point 3	New York	04/21/89	Good/Good
Lasalle 1 and 2	Illinois	06/02/89	Good/Sat
Limerick 1	Pennsylvania	02/24/89	Good/Good
Maine Yankee	Maine	11/25/88	Sat/Sat
McGuire 1 and 2	North Carolina	07/07/89	Good/Good
Millstone 1, 2, 3	Connecticut	06/30/89	Good/Good
Nine Mile Point 1 and 2	New York	12/23/88	Good/Good
North Anna 1 and 2	Virginia	05/26/89	Sat/Sat
Oconee 1, 2, 3	South Carolina	08/05/88	Good/Sat
Palisades	Michigan	10/28/88	Sat/Sat
Palo Verde 1, 2, 3	Arizona	09/15/89	Sat/Sat
Peach Bottom 2 and 3	Pennsylvania	08/05/88	Good/Good
Prairie Island 1 and 2	Minnesota	02/09/90	Good/Good
Quad Cities 1 and 2	Illinois	10/27/89	Good/Sat
Rancho Seco[b]	California	03/03/89	Sat/Sat
River Bend	Louisiana	10/20/89	Sat/Sat
Salem 1 and 2	New Jersey	05/11/90	Sat/Sat
San Onofre 1, 2, 3	California	08/04/89	Good/Sat

(continued)

Plants	State	Inspection completed	Rating program/ implemented[a]
Shearon Harris	North Carolina	09/01/89	Good/Good
South Texas 1 and 2	Texas	02/23/90	Good/Sat
St. Lucie 1 and 2	Florida	11/18/89	Good/Good
Surry 1 and 2	Virginia	04/13/90	Sat/Sat
Three Mile Island	Pennsylvania	01/09/90	Good/Good
Trojan	Oregon	10/21/88	Sat/Sat
Turkey Point 3 and 4	Florida	12/30/88	Sat/Poor
Vermont Yankee	Vermont	03/24/89	Sat/Good
Waterford	Louisiana	02/17/89	Good/Sat
Wolf Creek	Kansas	11/11/88	Sat/Sat
Zion 1 and 2	Illinois	08/04/89	Sat/Sat

[a]NRC assigns a rating of good, satisfactory, and poor. Good indicates that the utility has made more than minimal efforts and only a few areas require improvement. Satisfactory indicates that the utility has developed and effectively implemented a program, and areas requiring improvement are offset by better performance in other areas. Poor indicates that the utility has made no or inadequate effort in the maintenance area.

[b]In June 1989 Californians voted to close Rancho Seco.

During the inspections shown in table 2.1, NRC found that overall maintenance had improved but more could be done, particularly in the balance-of-plant (discussed later). Utility executives with whom we spoke agreed that the inspections were very helpful in confirming some of their own findings. NRC found common weaknesses, including that some utilities did not always (1) use or follow maintenance procedures, (2) appropriately determine the root cause of component failures, (3) have sufficient engineering support, (4) have adequate spare part procurement practices, and (5) make timely repairs throughout the plants.

As a result of the inspections, NRC issued notices of violations against 63 plants. In addition, although Waterford received a good program rating, NRC imposed a $50,000 civil penalty against the plant because NRC identified problems with a high pressure injection pump that could have represented a safety hazard. By April 1991 NRC plans to complete maintenance team inspections for the remaining 28 plants and reinspect 10 to 12 plants to determine whether improvements have occurred.

INPO evaluations have identified findings similar to NRC's team inspections. Following the 1979 Three Mile Island accident, the industry established INPO to assist utilities in improving plant operations. Among other things, INPO periodically evaluates nuclear power plant performance and operating safety. INPO has no legal authority to enforce compliance but rather relies on utilities to voluntarily take needed corrective actions.

INPO believes that all nuclear utilities are affected by the actions of any one utility, which is a strong motivation for compliance with INPO recommendations. However, INPO does not routinely provide copies of its evaluation reports to NRC, but the Vice President for Government Relations told us that all nuclear utilities make their reports available to NRC's resident inspectors.

NRC Had Proposed Maintenance Regulations

On the basis of its 1986 report, Status of Maintenance in the Nuclear Power Industry: 1985, NRC staff concluded that one reason for the inconsistency in utility program implementation was the lack of comprehensive regulations applicable to maintenance. Subsequently, in March 1988 NRC issued a policy statement that first defined maintenance and listed 17 activities that utilities should include in a maintenance program. In November 1988 NRC proposed regulations that required utilities to develop and implement a maintenance program based on the activities listed in the policy statement. Specifically, NRC

- defined maintenance as any action that prevents the degradation or failure, or restores the function, of all structures, systems, and components, including those in the power conversion side of the plants, often referred to as balance-of-plant, and
- identified 17 activities in a maintenance program, such as corrective, preventive, and predictive maintenance, recordkeeping, and maintenance training.

NRC received 123 comments on the proposed regulations, primarily from NUMARC and nuclear utilities, who opposed the regulations. NUMARC took the lead in responding to NRC on behalf of the industry. NUMARC opposed the regulations stating that (1) the industry already had various maintenance initiatives, (2) NRC's including all balance-of-plant systems would dilute attention from the safety-related portions of the plant, and (3) NRC did not have guidance that utilities could use to establish acceptable maintenance programs. The industry also stated that NRC did not define specific program elements, such as corrective, preventive, and predictive maintenance in the proposed regulations.

In August 1989 NRC released a draft regulatory guide that staff believe met the criteria set out in the proposed regulations. In the guide, NRC stated that each utility program should extend to all structures, systems, and components, including those in the balance-of-plant. Again, the industry noted that NRC's draft regulatory guide included the entire plant, including those systems that NRC has not previously regulated.

Although the industry agrees that NRC's oversight should extend to all plant areas that could affect safety, including balance-of-plant, NUMARC believes that utilities, not NRC, should determine the structures, systems, and components that would be subject to the maintenance requirements. NUMARC noted that the Electric Power Research Institute is developing a method that would allow utilities to do so. NUMARC also points out that some systems have little relationship to operational or radiological safety, and too broad of a maintenance focus will dilute NRC and utility resources by focusing on those areas that are not as important to safe plant operations. According to NUMARC officials, the industry's program applies to the entire plant, and each utility determines the plant areas that should be emphasized in its program.

NRC Has Reexamined the Scope of Its Requirements

NRC defines equipment as safety-related or nonsafety-related and has traditionally relied on utilities to ensure that nonsafety-related balance-of-plant systems function properly.[2] Over the past several years, NRC has been reexamining its requirements concerning such systems. In a January 1980 report on the 1979 Three Mile Island accident, a special inquiry group stated that the classification of systems and equipment into safety- and nonsafety-related was unsatisfactory, and utilities rather than NRC made the designation. Where NRC disagreed with the utility, the final determination was often made on an ad hoc basis. The report concluded that the arbitrary nature of the safety- and nonsafety-related distinction as a boundary of NRC's regulatory attention was paramount at Three Mile Island because a nonsafety-related system played a critical role in the accident initiation.

Also, on June 9, 1985, the Davis-Besse, Ohio, plant experienced a series of equipment failures and operator errors such that the utility could not activate feedwater pumps needed to supply water to the plant. In a May 1986 position paper to the Commission, NRC staff in part indicated that the utility had made an artificial distinction between safety-related and nonsafety-related features that led to inadequate maintenance of equipment necessary to ensure safe operations. NRC stated that some balance-of-plant systems may actually be more significant than safety-related equipment because balance-of-plant failures can needlessly challenge

[2]Safety-related equipment ensures the integrity of the reactor vessel, its coolant, and the pressure boundary associated with its operation. This equipment is needed to shut down the reactor and prevent or mitigate an accident and the escape of radiation if an accident occurs. In contrast, systems and components defined by NRC as nonsafety-related do not have a direct safety protection function. Although the failure of nonsafety-related equipment can lead to an accident, safety-related equipment exists to prevent or mitigate an accident.

safety-related systems and aggravate conditions under which such systems must respond.

As a result of the findings at Davis-Besse, NRC contracted with MITRE Corporation to examine NRC's regulatory oversight related to the balance-of-plant. The January 1987 study indicated that operating safety may be jeopardized by elements that lie outside NRC's strictest purview and a significant portion of a plant (balance-of-plant) falls into this category.[3] MITRE found that during 1984 and 1985 balance-of-plant problems constituted the most frequent reason for unanticipated plant shutdowns—70 percent for pressurized water reactors and 67 percent for boiling water reactors.[4] The report also stated that 10 percent of the problems were associated with safety system failures, which MITRE considered excessive given the potentially serious consequences of such failures. The report concluded that NRC needs to view the total plant as a system and provide the same level of attention to reducing balance-of-plant challenges to safety systems as it does to responding to and mitigating those challenges.

In addition to the Davis-Besse event and MITRE study, NRC sought to broaden its oversight over balance-of-plant in the proposed regulations for several other reasons. First, without specific regulatory requirements or license specifications, NRC must prove that balance-of-plant concerns have a significant safety impact before NRC may take enforcement actions against utilities. According to NRC staff, this can be difficult if a history of balance-of-plant problems does not exist. Second, in 1988 NRC found that equipment failures in balance-of-plant systems were the primary cause (75 percent) of unplanned plant shutdowns. Third, NRC's maintenance team inspections found that some utilities needed to improve maintenance for balance-of-plant systems. Fourth, other experiences had shown that failures in the balance-of-plant can challenge the safety-related systems. For example, the December 1986 pipe rupture at the Surry, Virginia, nuclear power plant occurred in the

[3] Although information in this report is dated, it demonstrates an independent review of the issue.

[4] Pressurized water reactors are cooled by water that is kept at a high pressure to prevent it from boiling. The water passes across the nuclear fuel and transfers energy to a secondary system where steam is produced. Boiling water reactors are cooled by water that is allowed to boil as it passes through the nuclear fuel. The water is used directly to produce steam that generates electricity.

nonsafety-related portion of the plant that is not regulated by NRC. However, its effects cascaded across several regulated systems causing additional accident management problems.[5]

Despite these concerns, in a December 1989 revised policy statement the Commission stated that each utility's maintenance program should cover those balance-of-plant systems that could significantly impact safety or security but did not specify the systems that meet this criteria. Thus, it is unclear which plant areas would be subject to either NRC's maintenance requirements or the industry's program. At the same time, the Commission decided to delay proceeding with regulations until June 1991. In the interim, NRC expects to monitor utilities' actions to implement the industry program and escalate the amount of civil penalties by up to 50 percent if a maintenance program deficiency is the root cause of a significant regulatory violation, thereby putting utilities on notice about the seriousness with which NRC regards maintenance. As of August 1990, NRC had not applied the escalation factor to any civil penalty.

According to NRC staff, they have provided the Commission a number of criteria that should be considered when deciding whether additional comprehensive regulations are needed. The staff proposed, for example, that utilities' commitment to effectively implement an acceptable maintenance program and trends in utilities' maintenance performance should be considered. The staff did not address the issue of NRC's ability to enforce compliance with maintenance requirements in all plant areas, including balance-of-plant. In response, the Commission said that it would consider the issues raised by the staff as well as NRC's ability to enforce compliance.

The enforcement issue continues to be a crucial area of concern. For example, the Department of Energy's Defense Nuclear Facilities Safety Board contracted for a study that compared the Department's and NRC's safety requirements. The August 1990 contractor report stated that NRC's maintenance requirements present a concern for the nonsafety-related or balance-of-plant equipment because such equipment is not as strictly regulated as the safety-related portion of commercial plants. The report concluded that NRC's maintenance requirements are not well integrated into its regulations.

[5]Nuclear Regulation: Action Needed to Ensure That Utilities Monitor and Repair Pipe Damage (GAO/RCED-88-73, Mar. 18, 1988).

Industry's Program Is Almost Identical to NRC's

In March 1990 INPO provided NRC the industry's maintenance-related performance objectives and criteria, Maintenance Programs in the Nuclear Power Industry. The program sets out 37 performance objectives that nuclear utilities commit to or strive to meet and describes criteria to meet the objectives. For example, one objective is that the material condition of the plant is maintained to support safe and reliable operations; one criterion is that temporary repairs are minimized and permanent repairs are made when conditions permit.

INPO, NUMARC, and nuclear utilities want NRC to endorse the document as the industry's maintenance program and recognize industry efforts to meet the performance objectives. The Commission could decide to endorse the industry's program through a policy statement. NRC has used this approach in the past.[6] However, with a policy statement, NRC may not be able to enforce corrective actions in areas, such as balance-of-plant, not covered by specific regulations or license requirements. On the other hand, regulations could ensure a standardized program with uniform application throughout the industry, provide for direct NRC oversight, and ensure a well-defined mechanism for NRC to require corrective actions promptly and effectively.

We noted that NRC's draft regulatory guide and the industry's program are almost identical. For example, INPO's definition of maintenance is almost identical to NRC's. Also, INPO's document sets out a broad range of similar activities that should be included in an effective program, including maintenance procedures, planning and scheduling, qualifications and training of personnel, and engineering and corporate support. However, NUMARC recognizes that this broad view of maintenance must be accepted by each utility.

NUMARC and INPO recognize that many maintenance activities shown in INPO's program are identical to NRC's regulatory guide. NUMARC told us, however, that the industry has traditionally taken a narrower view of maintenance; that is, the actual repair of systems, components, and equipment; and plant maintenance staff may have difficulty translating activities such as training or replacement parts problems as "maintenance related" because these types of activities are outside their span of control. The industry has indicated that the broader view of maintenance must be more visible at the staff level for the industry's program to work.

[6] Nuclear Regulation: NRC's Security Clearance Program Can Be Strengthened (GAO/RCED-89-41, Dec. 20, 1988) provides one example.

Conclusions

The first step in ensuring effective maintenance is to establish requirements for what constitutes good maintenance. NRC is considering additional comprehensive regulations and a regulatory guide to provide greater assurance that all domestic nuclear utilities will maintain their plants effectively. The industry believes that it can more appropriately develop a program to improve maintenance and guarantee utilities' commitment to the program established. As a result, utilities want NRC to endorse the industry's program. However, NRC's issuing a policy statement allowing utilities to voluntarily adopt INPO's program could limit NRC's ability to require prompt and effective corrective actions for deficiencies in the future. Although industry can establish a maintenance program, no legal authority exists for it to enforce compliance—this responsibility rests solely with NRC.

NRC admits that operating risks increase as nuclear plants age, and effective maintenance is paramount for continued safe operations. Over the next 25 years, about 45 percent of the operating licenses for the current 112 plants will expire—one utility expects to seek a license extension in 1991. As part of this process, NRC will have to decide the plant areas that should be examined before granting an extension. Therefore, the time may be right for NRC to view the total plant as a system and remove the artificial distinction between safety- and nonsafety-related systems.

In its proposed regulations, NRC wanted maintenance requirements to apply to all plant systems, including balance-of-plant. The lessons of Three Mile Island and Davis-Besse and NRC's inspections of 84 plants validate NRC's concerns and highlight the importance of NRC's having this ability. NRC found common weaknesses with some utilities' maintenance practices in the balance-of-plant. Despite its own staffs' concerns and evidence that balance-of-plant problems can lead to safety-related events, the Commission responded to industry's opposition and stated that each utility's maintenance program should cover those balance-of-plant systems that could impact safety but did not identify those systems. Thus, it is unclear the plant areas that would be subject to the maintenance requirements.

Recommendation

To provide the foundation for ensuring utilities' future commitment to effective plant maintenance, we recommend that the Chairman, NRC, base the decision on the need for additional regulations, in large measure, on NRC's ability to enforce corrective actions in all plant areas, including balance-of-plant.

Indicators Could Strengthen NRC's Inspection Program

NRC must have a mechanism to ensure effective maintenance and enforce corrective actions in the future. To achieve these goals, NRC could complement its regular inspection program with performance indicators or periodically conduct special maintenance team inspections. NRC and the industry use a wide variety of indicators, such as maintenance backlog and balance-of-plant equipment out of service, that NRC could use in conjunction with inspections to help identify problems before they occur and provide effective oversight of utilities' maintenance practices. However, NRC does not plan to integrate the indicators into its inspection program. In addition, NRC plans to discontinue the special team inspections after April 1991, relying instead on its regular inspection program.

NRC Must Ensure That Utilities Have Effective Maintenance Programs

Periodically, NRC inspects each operating plant to ensure that the utility operates the plant safely and in accordance with NRC's regulations. NRC carries out its inspection responsibilities using a three-tiered approach. NRC headquarters develops policies and guides, provides technical assistance to the five regional offices; and conducts special investigations. NRC's regional offices have overall responsibility to implement the policies and to conduct special investigations of maintenance, surveillance, and quality assurance programs. Finally, NRC has at least one resident inspector assigned full-time at each of the 112 operating plants to monitor day-to-day activities.

NRC does not have specific standards applicable to all aspects of plant operations. As a result, NRC inspects only a selected sample of utility operations, evaluates the sample for compliance, and extrapolates the results to make a judgment about the entire plant. To carry out its responsibilities, NRC has five different types of inspections, including regular (core) and special team inspections. In part, the core program requires the resident inspectors to periodically assess plant operations against 21 procedures, such as physical security and quality assurance—only 1 procedure specifically applies to maintenance. The maintenance inspections require an average of 150 hours annually at each plant but are not as detailed or extensive as the special team inspections.

In 1988, NRC began team inspections to determine the adequacy of utility maintenance programs. As discussed in chapter 2, NRC conducted team inspections at 84 plants. Although NRC gave the highest rating to 56 percent for their written programs, 63 percent of the plants did not receive the same rating for implementation. NRC plans to inspect the remaining

28 plants by April 1991 and then discontinue the special team inspections, relying instead on its regular inspection program. On the basis of NRC's information, the team inspections took an average of about 285 hours at each plant.

Further, under SALP, NRC periodically (about every 12 to 18 months) evaluates utility operations in up to 11 plant areas, including maintenance. SALP reports generally summarize the inspections that NRC made during the assessment period and show trends in the plants' performance. The purposes of the program include encouraging utility improvement programs and allowing NRC to determine where to use inspection resources. However, SALP is limited in providing timely information for making resource decisions and has missed poor performance in the past. For example, the Calvert Cliffs plant in Lusby, Maryland, was rated above the level needed to meet NRC requirements in every plant area in a March 1988 SALP review. By December 1988, Calvert Cliffs was one of nine problem plants warranting increased attention. NRC recognizes that a great deal can change in the 12 to 18 months covered by SALP reviews and would like to be more proactive and predictive concerning maintenance and identify potential problems before they occur. To meet these goals, NRC has been developing quantitative indicators.

Indicators Could Improve Maintenance Inspections

NRC could enhance its inspection program by using available performance indicators to help focus resources and identify specific areas for review.[1] For many years, NRC and the industry have used such indicators as availability and unplanned outage rates to assess plant performance.[2] In 1986, NRC initiated a program to produce quarterly reports on these and other indicators, such as significant events, safety system failures, forced outage rates, and radiation exposures. According to NRC staff, the program was intended to be more predictive by detecting symptoms of declining performance and provide more objective input into NRC inspections.

As part of the program, NRC spent about $573,000 and 7 staff years since mid-1988 developing and testing potential maintenance indicators, including those that the industry uses. After conducting analyses on 13

[1] In Aviation Safety: Management Improvement Needed in FAA's Airworthiness Directive Program (GAO/RCED-90-94, Feb. 16, 1990), we noted that indicators could help focus the Federal Aviation Administration's inspection efforts.

[2] Availability compares the hours a plant was available to operate to actual hours operated; unplanned outages reflect power outages caused by plant shutdowns other than for normal maintenance.

indicators, including maintenance backlog, staff turnover, and balance-of-plant equipment out of service, NRC concluded that the 13 indicators help plant managers but are not useful for predicting and/or explaining maintenance performance.

As a result, NRC developed a component reliability indicator believing it provided the most consistent measure of effective maintenance performance. To develop the indicator, NRC relied on data that utilities have voluntarily provided to INPO since 1981. NRC staff selected between 600 and 2,000 components and found that 84 percent of the component failures were related to maintenance as defined by NRC. However, NRC recognized that the indicator is based on incomplete and inconsistent data because utilities were routinely reporting only about 65 percent of equipment failures to INPO. NRC also acknowledged that the indicator only predicted equipment-caused plant outages 12 percent of the time. Despite these problems, NRC indicated that INPO's data are the best available information, and actions could be taken to ensure more consistent reporting and enhance its reliability.

To address industry's concerns about overemphasizing one indicator, NRC has examined the usefulness of risk-based and programmatic indicators. The risk-based indicator would estimate the probability of failure of particular plant components and the resulting safety risks. Two programmatic indicators under consideration include challenges to safety systems from maintenance errors and overall thermal (heat) efficiency. We noted that the January 1987 MITRE report recommended that NRC develop separate indicators to monitor balance-of-plant performance. The study concluded that such indicators could help NRC evaluate utilities' commitment to improve plant performance and that the balance-of-plant indicators should be used in conjunction with other tools, such as inspections, to assess overall management effectiveness.

Industry Questions the Indicator

The industry does not believe that NRC can develop a single quantitative indicator to predict equipment or system failures resulting from poor maintenance practices and are concerned that, if an indicator is developed, it could be subject to misuse. For example, the public utility commission in Massachusetts has been using NRC's SALP scores in ratemaking decisions. As stated earlier, NRC did not initiate SALP for this purpose.

According to NUMARC officials, INPO has tried for years to develop a maintenance effectiveness indicator without success. They also noted that problems exist with gathering reliable data and are concerned that overemphasizing one indicator could result in utilities' managing data to the detriment of safe plant operations. For example, an emphasis on manual plant shutdowns to measure effective maintenance could put pressure on the utility to avoid necessary shutdowns to improve the indicator results.

They also noted that NRC's component reliability indicator is not an appropriate measure of maintenance because a high failure rate could indicate a poorly manufactured or substandard product or improper installation rather than inadequate maintenance. Both NUMARC and INPO officials said that the component reliability data system was never intended to identify the root cause of failures, and NUMARC disputes NRC's staff conclusion that 84 percent of component failures are related to maintenance. NUMARC also said that many failures are attributable to design problems, and the data base is limited as NRC recognizes. INPO's system contains only a small percent of total components—about 5,000 per plant compared with a total of 30,000 in older and 70,000 in newer plants—and NRC used even fewer components to develop the indicator.

In addition, industry believes that developing a specific maintenance indicator is not necessary because utilities already use their own indicators, and the results are available to NRC. Industry wants NRC to use the long-accepted indicators, such as capacity factor, availability, unplanned outages, safety system failures, and radiation exposures. Industry believes NRC's focus should be on the bottom line—plant performance. INPO notes that overall performance, as reported by NRC and the industry, has improved; therefore, utilities' attention to maintenance has improved.

On October 9, 1990, NRC submitted its own and an industry report on the component reliability indicator to the Commission. NRC recommended that the Commission not adopt the indicator because the results of a 1-year pilot project with six utilities showed that the indicator captures a broader view of maintenance than currently used by the industry and could not be used to compare plants. The industry noted that the indicator did not measure maintenance effectiveness.

Conclusions

Maintenance is an ongoing, day-to-day activity. Although a utility may have an effective maintenance program at a given point of time, no certainty exists that the same would be true in the future. In fact, past experience has shown that a good performing plant can quickly move into the poor performing category. Also, utilities' having good written maintenance procedures does not mean that they will be implemented effectively. To illustrate, 63 percent of the 84 plants NRC inspected did not receive the highest rating for maintenance program implementation.

Therefore, NRC must have a strong oversight mechanism to identify weaknesses and ensure compliance with maintenance requirements. NRC's inspection program plays a crucial role in helping to ensure safe plant operations, and NRC has relied on maintenance team inspections to assess the need for additional regulations and monitor utilities' activities. Although these inspections provide an in-depth examination of the total plant, NRC plans to discontinue them after April 1991, relying instead on its regular inspection program.

On the other hand, NRC wants a mechanism to enhance its inspection efforts, highlight the plant areas warranting greater attention, and identify problems before they occur. To achieve these goals, NRC has been considering performance indicators. We believe that NRC should utilize the many commonly used indicators in conjunction with its inspection program to strengthen its oversight, better use inspection resources, identify specific areas warranting review, and be more proactive in assessing utilities' maintenance efforts. However, NRC has no plans to integrate performance indicators into its inspection program.

Recommendations

To help NRC ensure compliance with the maintenance requirements eventually established, we recommend that the Chairman, NRC,

- ensure that NRC continually examines utilities' commitment to maintenance either through its regular inspection program or by periodically conducting special team inspections after April 1991 and
- integrate performance indicators into the inspection process.

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