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October 9, 1990

For: The Commissioners

From: James M. Taylor
Executive Director for Operations

Subject: RESULTS OF JOINT NRC/INDUSTRY DEMONSTRATION PROJECT ON MAINTENANCE INDICATORS

Purpose: To inform the Commissioners of the results of the industry/NRC Demonstration Project.

Background: In response to the Commission's direction in June 1989,¹ the staff initiated a "Demonstration Project" with industry to identify and test quantitative indicators for the evaluation of the performance of maintenance programs. The Demonstration Project followed a year of work by the staff to develop indicators of maintenance performance for use by the Commission. The development began in June 1988 with the consideration of candidate indicators. Through cooperation with 13 utilities, the staff narrowed the focus to measures based on component reliability and failure history. The background for the proposed maintenance rule published in November 1988 disseminated this finding, and encouraged industry use of the Nuclear Plant Reliability Data System (NPRDS) to support such measures. The Revised Policy Statement reiterated these same points. The staff developed and validated a proposed indicator based on component failure rates using NPRDS data.² This proposed indicator became the focal point of the Demonstration Project.

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¹ Staff Requirements Memorandum on SECY 89-143/COMLZ-89-21 - Amendment to 10 CFR 50 Related to Maintenance of Nuclear Power Plants, June 26, 1989.

² The development and previous validation efforts regarding the NRC staff's proposed maintenance indicator have been documented in two reports: AEO0/S804B, "Application of the NPRDS for Maintenance Effectiveness Monitoring," issued in January 1989, and EG&G Idaho, Inc. report, "Maintenance Effectiveness Indicator," issued in October 1989.

Contact:
M. H. Williams, AEO0
X24480

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Discussion:

The staff identified candidate utilities for participation in the Project to gain perspective across a broad range of plants and organizations. Through the coordination of the Nuclear Management and Resources Council (NUMARC), six utilities agreed to participate: Commonwealth Edison Company, Lake Power Company, Northeast Utilities, Rochester Gas and Electric, Southern California Edison, and System Energy Resources, Incorporated. NUMARC, representing these industry participants, agreed to a project limited in scope to the review of the NRC staff's proposed maintenance effectiveness indicator. The Institute of Nuclear Power Operations (INPO) provided technical support to NUMARC.

The Demonstration Project included a series of meetings of a Project group, comprised of representatives from the participating utilities, and site visits between September 1989 and March 1990. The elements of the Demonstration Project were: presentation of the proposed indicator to the utilities, data review and analysis by participating utilities and INPO, plant specific discussions of maintenance management and monitoring techniques, and further development activities by the staff. Individual meetings with each of the participating utilities typically took one and one half days and involved their maintenance managers, along with members of their reliability or performance assessment groups. The staff also obtained and reviewed proprietary material used by INPO in its root cause analysis of a sample of component failures reported to the NPRDS.

Enclosure 1 is the staff's detailed report on the Demonstration Project, AEOD/S804C. This report includes, in Appendix A, the previously issued summaries of meetings with individual utility participants. These summaries were agreed to by the utility participant, and provide insight into the technical and maintenance management issues that came to light in the context of discussing indicators during the Demonstration Project. Enclosure 2 provides NUMARC's final report on the industry's perspective of the indicator, dated August 10, 1990.

Because of the agreed upon limited scope of the Demonstration Project, no consensus maintenance indicators were suggested by the industry beyond the existing set of overall INPO and NRC indicators. With regard to the staff's proposed indicator, the industry disagreed with the staff's finding of a strong relationship with maintenance. For example, the NUMARC report states that only 13% of the component failures that comprised the indicator were related to maintenance. The staff reviewed the data that formed the

basis for this report. The industry assigned the cause for about 80% of these failures to wearout, design, manufacturing, or unknown. Typically, using the broad definition of the Policy Statement, the staff would assign about 75% of such failures to maintenance. The staff noted, during the Project, that many of the types of failures deemed by NUMARC to be unrelated to maintenance were addressed by changes to the plant's preventive maintenance program. The inability to reconcile the degree of failures attributed to "maintenance" is a disagreement that is fundamental to industry/regulator communications on the subject of "maintenance". There appears to be, however, a general agreement regarding failure data and its nexus with component or equipment reliability.

During the Demonstration Project, the staff expressed the view that reliable plant equipment was an essential goal of the plant's maintenance program and consequently a measure of that program. However, while some project members agreed on reliability as a program goal, they did not agree that the connection was sufficiently strong to use equipment reliability, or failure rate, as a measure of their maintenance programs. A number of the Demonstration Project members have recognized the need to improve equipment reliability and availability and are taking aggressive actions to achieve these goals. However, the indicator contains a large number of components of varying safety significance. The Project members were concerned about accountability to the staff, and its effect on their resources, for all the underlying factors that govern equipment performance.

The utility participants suggested several improvements to the indicator that were implemented by the staff. These included eliminating the tendency to generate indications in months where no failures were discovered (due to averaging with a prior high failure rate month), and displaying the indicator results by component type as well as by system. The enclosed industry report does not discuss these developments, or suggest other approaches that were discussed during the Project to minimize utility concerns.

The Demonstration Project has identified limitations to the use of the proposed maintenance indicator. Specifically, use must be structured to avoid or minimize the following impacts: disproportionate pressure on the maintenance manager, who does not control the broad maintenance process; diversion of utility resources to immediately respond to indications; disruption of plans to pursue alternative equipment performance management approaches such as

Reliability Centered Maintenance; and disincentive to report voluntarily to the NPRDS.

There was general agreement that NPRDS, with continued broad industry support, is a useful tool for improving industry's overall maintenance. However, the implementation of an NRC plant performance indicator using NPRDS may reduce that support. In addition, the staff noted that there was difficulty in plant to plant comparison using the indicator. This difficulty related to the variability in NPRDS reporting rates and practices throughout the industry as described by Demonstration Project participants. An understanding of a plant's NPRDS reporting practices underlying the indicator is a necessary attribute of any plant comparative analyses, and was not accommodated by the indicator display.

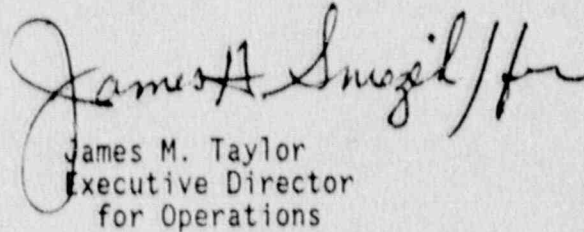
The staff believes that the data does provide useful insights into maintenance trends at an individual plant and that a trend of aggregated data across all plants gives insights into overall industry trends related to maintenance. Although the proposed indicator is consistent with the scope of maintenance in the Commission Policy Statement³, the Demonstration Project discussions confirmed that it is not consistent with the definition generally used at the plant staff level. It follows that the indicator is not, based on the prevailing industry practice, a measure of the effectiveness of their maintenance programs. The indicator captures a much broader view of maintenance, while the programs currently in place use the more traditional limited definition.

Industry's position has been that overall indicators already in use by INPO and NRC best characterize the effectiveness of maintenance programs. The staff proposed an indicator based on component failure history as an additional element for monitoring maintenance effectiveness. However, several impediments to the implementation of that indicator as a formal "Maintenance Effectiveness Indicator" have been identified. The primary technical impediment is the controversy surrounding the assignment of the cause of failures to the maintenance program. Based on the results of the Demonstration Project, the staff does not recommend adoption of the proposed Maintenance Effectiveness Indicator into the set of performance indicators due to the

³ The NRC defines maintenance as the aggregate of those actions which prevent the degradation or failure of, and which promptly restore the intended function of, structures, systems, and components. (Maintenance of Nuclear Power Plants; Revised Policy Statement, December 5, 1989)

limitations in comparing facilities and the potential adverse effects of its use.

The staff plans to continue to use this methodology until April 1991 as an internal tool to give insights into plant equipment reliability at specific plants. The cautions in the use of the data directed by the Commission in response to SECY-90-137⁴ will be observed along with the limitations discussed in this paper. The methodology will be available for subsequent specific application using NPRDS data but the staff does not plan to periodically process and trend the data as a performance indicator.


James M. Taylor
Executive Director
for Operations

Enclosures:
As stated

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⁴ SECY-90-137, "Proposed Criteria To Be Used In Determining When Industry Progress In The Area Of Maintenance Would Be Sufficient To Obviate A Need For Rulemaking"

**MAINTENANCE
INDICATOR
DEMONSTRATION
PROJECT**

August 1990

Report Prepared By:

**U.S. Nuclear Regulatory Commission
Office for Analysis and Evaluation of Operational Data**

EXECUTIVE SUMMARY

In response to the Commission's direction in the Staff Requirements Memorandum on SECY 89-143/COMLZ-89-21 "Amendment to 10CFR50 Related to Maintenance of Nuclear Power Plants," June 26, 1989, the staff initiated a "Demonstration Project" for the development of maintenance performance indicators. This report documents the lessons and results of the Demonstration Project.

Candidate utilities for the Demonstration Project were identified by the staff based upon characteristics such as nuclear steam supply system (NSSS) design, plant age and power rating, utility organizational size or number of plants operated, and location. Through the coordination of the Nuclear Management and Resources Council (NUMARC), six utilities volunteered to participate and provide a member to the Project group. The six utilities were: Commonwealth Edison Company, Duke Power Company, Northeast Nuclear Energy Company, Rochester Gas and Electric, Southern California Edison Company, and System Energy Resources, Incorporated. The utility participants agreed to a project limited in scope to the review of the NRC staff's proposed maintenance effectiveness indicator.

The Demonstration Project was conducted through a series of centralized meetings of the Project group and individual site visits between September 1989 and March 1990. The elements of the Demonstration Project were: presentation of the NRC initiative to the utilities, data review and analysis of the proposed indicator by the participating utilities and INPO, plant specific discussions of maintenance management and monitoring techniques, and further development activities by the staff. Individual meetings with each of the participating utilities typically took one and one-half days and involved their maintenance managers, along with members of their reliability or performance assessment groups. The Project group was well rounded with representation from utility maintenance, operations, licensing, and performance or reliability assessment organizations.

The industry participants did not agree that the NRC staff's proposed maintenance indicator was a measure of maintenance effectiveness. This disagreement arises from the industry's limited definition of maintenance versus the NRC's broad definition of maintenance, as described in the policy statement. The staff believes that consensus was reached on specific improvements to the proposed maintenance indicator. These improvements involve the indicator construction, calculation, and use.

Based upon AEOD's perspective on the issues that arose during the Demonstration Project, the following changes are suggested:

1. Revise the algorithm used in calculating the indicator to eliminate "ghost ticks" and capture "shadow ticks." Two alternative methods developed and being tested by the staff were introduced to the Demonstration Project during the March 1990 joint meeting.

2. Modify the overall indicator to include both system-based and component-based indications. The calculations and displays are being modified to also show component-based indications.
3. Continue to encourage improvement in NPRDS participation and support the initiatives in the Industry Action Plan regarding improving NPRDS data quality.

MAINTENANCE INDICATOR DEMONSTRATION PROJECT

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MAINTENANCE INDICATOR DEMONSTRATION PROJECT

INTRODUCTION

In response to the Commission's direction in June 1989,¹ the Nuclear Regulatory Commission (NRC) staff initiated a "Demonstration Project" for the development of maintenance performance indicators. The staff identified candidate utilities based upon characteristics such as NSSS design, plant age and power rating, utility organizational size or number of plants operated, and location. Through the coordination of the Nuclear Management and Resources Council (NUMARC), the Institute of Nuclear Power Operations (INPO) and six utilities agreed to participate. The six utilities in the Project were: Commonwealth Edison Company, Duke Power Company, Northeast Utilities, Rochester Gas and Electric, Southern California Edison Company, and System Energy Resources, Incorporated. These industry participants agreed to a project limited in scope to the review of the NRC staff's proposed maintenance effectiveness indicator².

The Demonstration Project included the following elements: presentation of the NRC indicator to the utilities; NRC staff preparation of computer files and associated information, including presentations of failure records for which the proposed indicator was used to develop a representation of maintenance effectiveness; data review and analysis by the participating utilities; analysis by INPO; substantive discussions of maintenance management and monitoring techniques with plant staffs; further development activities by the staff; and working discussions of the Project group members to formulate results. Meetings with individual utilities generally involved their maintenance managers and the reliability or performance assessment groups (Appendix A). These meetings, which were typically one and one-half days long, followed the same basic agenda (Appendix B). The Project group was well rounded with representation from utility maintenance, operations, licensing, and performance or reliability assessment organizations.

The Demonstration Project participants worked toward consensus on issues associated with a performance indicator to monitor the effectiveness of maintenance at domestic nuclear power plants. The staff believes that some technical consensus was reached on various methods to improve the NRC staff's proposed indicator. These included changes to the indicator construction and calculation, the identification of potential improvements to the Nuclear Plant Reliability Data System (NPRDS), and, to some extent, use of the indicator. However, fundamental differences in perspectives on what constitutes maintenance functions resulted in disagreement over whether the indicator was a measure of maintenance effectiveness.

¹ Staff Requirements Memorandum on SECY 89-143/COMLZ-89-21 - Amendment to 10 CFR 50 Related to Maintenance of Nuclear Power Plants, June 26, 1989.

² The development and previous validation efforts regarding the NRC staff's proposed maintenance indicator have been documented in two reports: AEO/S604B, "Application of the NPRDS for Maintenance Effectiveness Monitoring," issued in January 1989, and the EG&G Idaho, Inc. report, "Maintenance Effectiveness Indicator," issued in October 1989.

Typically, the maintenance manager does not control all the elements of the broadly defined maintenance process, but feels accountable for anything labeled "maintenance." The proposed indicator is programmatic by design, and is premised on the broad view of maintenance as outlined in the NRC Policy Statement on maintenance and industry guidelines. However, this view of maintenance and the current configuration of the indicator do not match up in a practical way with traditional maintenance line organizations at the sites. Thus, it may be difficult for plant staffs to benefit in a direct way from the proposed indicator in its current form. Variations of the indicator to make it more useful for plant staffs were discussed, including component scopes consistent with reliability-centered maintenance (RCM) programs, and calculating the changes in failures by component type as well as by system. Potential changes to the indicator to address these concerns were also discussed, including both the indicator construction and the calculation technique.

INDICATOR TECHNICAL ISSUES

The technical review by the participating utilities focused on the construction of the indicator, the equipment covered by the indicator, the alignment of the indicator with the utility maintenance program (nexus to maintenance), and the quality of the data that supported the indicator. The staff believes that consensus was achieved on selected improvements to the indicator.

Indicator Construction

The indicator construction issues refer to the calculational technique employed to generate the indications from a plant-specific database. Two issues emerged that are being addressed as a result of the Demonstration Project. These are: (1) ghost and shadowed ticks and (2) failure grouping.

Ghost and Shadow Ticks - In special cases, an indication would occur in a month in which no component failures were discovered, or the number of failures declined from the previous month. This phenomenon was referred to as a "ghost tick." The original algorithm created an indication based upon a change in the average of a month-to-month count of component failures. As a result, a high number of failures discovered in one month would carry over its impact into the average calculation for the subsequent month even though no new failures or fewer failures were discovered in that month. For the case of no new failures, a utility charged with troubleshooting the cause for its indications would find no basis for the indication in the month assigned. Although this feature served as a measure of the magnitude of the first month's component failures, it was misleading. Conversely, the original calculation algorithm also led to the masking of some significant failure changes. These indications which were not generated were known as "shadow ticks." In this case, indications were not generated for significant failure changes because preceding significant increases in failures overshadowed the two-month average associated with the later failure increase. Two alternative calculational techniques were developed and are being tested by the staff. They are described in Appendix C.

Failure Grouping - The issue of failure grouping arose from the consideration that the indicator (clusters of failures that caused an indication) should be amenable to root cause analysis by the utility. The original indicator was calculated based on the change in the failures of a selected set of

components (Outage Dominating Equipment [ODE]) within a system. This method produced indications that were, in many cases, due to the failure of different types of components (e.g., circuit breakers, pumps). This arrangement was consistent with the maintenance approach of some utilities in the Demonstration Project since systems were often made available for maintenance during a certain chronological interval, and the discovery of failures would tend to cluster (indicate) by system. In addition, the approach provided a usable tool that enhanced accountability for plants with systems engineers. However, other members of the Project group noted that this method would result in complicating the cause analysis. They requested a second version of the indicator that grouped indications by type of component. This method enhanced the root cause evaluation.

Equipment Selection

The equipment selection for the proposed indicator was the subject of review during the Demonstration Project. Two aspects are worthy of note. First, the staff's original equipment selection assumptions were relatively good. Second, the utilities preferred that the equipment selection reflect the plant's maintenance approach.

The original equipment selection for the indicator was restricted to achieve maximum reporting consistency across plants. NPRDS reporting is a function of the initiation and processing of corrective maintenance work orders. To accommodate the range of the aggressiveness of the operating crew and organization in work identification, a set of equipment was selected for the indicator that would likely be the subject of timely repair and work order processing. This set of equipment was that needed to support plant operation. In general, the staff's assumption was affirmed regarding the assurance that this set of equipment would be the subject of closer scrutiny, and hence, less reporting variability. Some licensees in the Demonstration Project had created a similar list of components based upon their operating experience. These components were then the subject of special oversight. This visibility helped ensure that the work order flow and information contained on the NPRDS record were better than average. Participating licensees also noted that the same maintenance program and practices are employed on balance-of-plant (BOP) equipment and safety equipment. Therefore, the maintenance quality on this set of equipment would likely be representative of the maintenance on all plant equipment.

The equipment selection for the indicator may not fully reflect the plant's approach to maintenance. The maintenance programs for some components may utilize a "run to failure" philosophy. Under such a philosophy, no systematic preventive maintenance (PM) is applied to the component. Only corrective maintenance is utilized. As a result, some component failures captured by the indicator would be allowed by the plant's maintenance program. Two of the Demonstration Project participants were conducting major RCM programs and viewed this as a major potential difference between the goal of the indicator and the results. RCM methodology, using cost/benefit analysis, may dictate such a philosophy based upon engineering analysis of the impact of the failure (i.e., the local, system, or plant level impact). Redundant components and technical specifications (TS) are among the considerations of that analysis. For example, equipment failures with only a local impact and no TS consequences may permit omission of any PM on the component.

A general comment that was received from the participants was that the impact of each of the individual component failures being counted was, in most cases, not significant. Normal priorities of maintenance may allow some of the failures. The industry would prefer that the staff reduce the scope of monitoring to a smaller and more significant set of equipment, preferably only safety-related equipment. The proposed indicator monitored approximately 600 to 2000 components per plant to reflect a broad scope of the maintenance activities.

Nexus to Maintenance

The nexus of the indicator to maintenance was a major topic during the demonstration project. The staff reviewed selected component failures with each of the participating utilities. The utilities' analyses of these failures and the indicator consumed up to 6000 person hours and used all of the information available, including the memory of individuals. Therefore, their cause analysis went far beyond that afforded the staff through review of the narrative descriptions of the causes contained in the NPRDS failure record. Based upon a review of the NPRDS records, the staff had found that 84% of the component failures that comprised the indicator were related to maintenance, under the NRC's perspective of maintenance. During the Demonstration Project, the utilities found that about 14% of such failures were due to maintenance (primarily errors of commission), under their perspective. The major differences between these failure categorizations were associated with failures that the staff assigned to maintenance but which the industry assigned to wearout, design/manufacturing/application, random, or unknown causes.

Many problems that arise from design or application deficiencies are responded to through preventive maintenance measures. The industry asserted that the indicator did not measure maintenance effectiveness since the root cause for the failures comprising the indication was not maintenance-related, under their definition. For example, a utility would argue that charging pump failures or feedwater pump seal failures were due to the original design of the equipment. However, during the discussions, the staff noted that the solution to the problem was through the plant's maintenance program; that the occurrence or disappearance of the failures was a direct result of the preventive maintenance program; and that the indicator was measuring changes in failure frequencies resulting from that program.

Another major cause for failures that, from the viewpoint of the industry, clouds the relationship of the indicator to maintenance is wearout. Specifically, the industry categorized many failures not as maintenance, but as "first of a kind wearout." This category contained many failures that the staff contended could have been detected and repaired at the incipient failure stage through a predictive maintenance program or an aggressive preventive maintenance program. If detected and repaired as incipient failures (prior to the component function being degraded below specification), they would have escaped the indicator. Again, as in the previous example, first failures were frequently addressed by preventive maintenance. If a component (e.g., transmitter) continually failed after three years in a claimed design life of five years, the utility would initiate a preventive replacement at the earlier point, thereby eliminating the failures. The indicator would detect the change as a result of improved maintenance and the dispute regarding the initial cause of the failure is moot relevant to the integrity of the indicator.

This fundamental difference in perspective between the staff and the participating utilities on the nexus of component failures to maintenance came to be referred to in the Demonstration Project as "Big M versus Little m." These differences were graphically illustrated during the Demonstration Project.

During the proof-of-concept phase of the development of the proposed indicator, the staff categorized the causes for approximately 4000 NPRDS failures based on the failure narratives. These narratives were sampled from the periods of ODE component failure history which generated indications. This categorization represented the "Big M" perspective. The results of this categorization can be seen in Figure 1.

The categories shown in Figure 1 should be understood as follows: The failures assigned to this category could be reduced by improvements in that programmatic area. For example, failures associated with the "PM" category were judged to be reducible by either improved implementation of an existing PM program, such as extending the program to cover additional equipment, or by instituting a more extensive PM program, such as using vibration analysis or periodic oil sampling. Two cases drawn from the documentation of recent NRC maintenance inspection results serve to further illustrate this PM assignment. In the first case, four forced outages involved degradation of reactor recirculation pump seals. To address this problem, the licensee initiated a program to collect and analyze reactor recirculation pump shaft vibration data, and has modified the seal replacement frequency.³

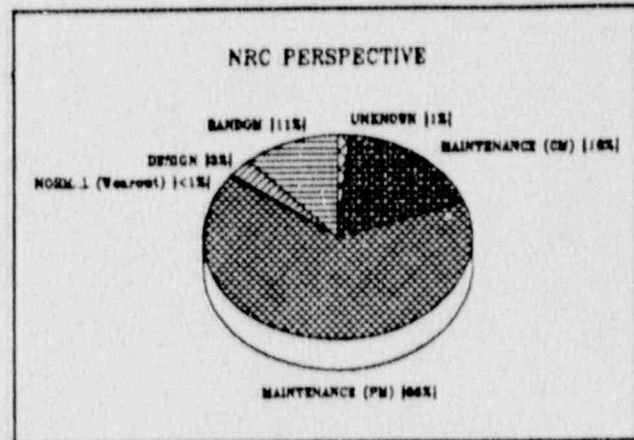


Figure 1. Nexus to Maintenance - NRC Perspective

In the second case, a turbine-driven auxiliary feedwater pump oversped and tripped on start. The cause was traced to lack of a PM program for periodic flushing of the governor as recommended in the vendor technical manual.⁴ In both cases, the staff would assign the failure to the "PM" category.

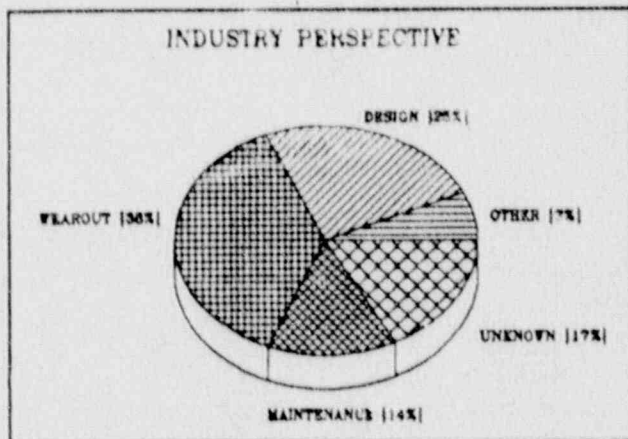


Figure 2. Nexus to Maintenance - Industry Perspective

Figure 2 shows the "Little m" perspective. It was developed during the Demonstration Project by the utility participants with the assistance of INPO and captured distinctions

³ Letter from A. B. Davis, NRC, to C. Reed, CECo, transmitting initial SALP B Report for the Quad Cities Nuclear Plant, February, 2, 1990.

⁴ Letter from L. Reyes, NRC, to J. Goldberg, FPL, transmitting Notice of Violation for the St. Lucie facility, March 14, 1990.

they felt important in determining the nexus to maintenance. These distinctions were also brought out in the review of ODE failures the staff considered related to maintenance during site visits.

"Design" constitutes a large percentage in Figure 2, about eight times larger than the amount assigned by the staff. Such a difference is understandable in that the regulatory perspective of maintenance includes the feedback of experience gained through engineering and design modifications used to eliminate component performance problems, and over time, this process does achieve improvements. Examples of this that were discussed in some detail in the Demonstration Project included the improvement in charging pump performance at Ginna, the improvement in service water pump performance at Grand Gulf, the planned upgrading of charging pumps (replacement of blocks with new design/material) at San Onofre 2&3, and increased surveillance frequency on recirculation pump pressure switches to compensate for drift before their function was impaired. In all these cases, the number of failures experienced decreased or should decrease, thereby reflecting improvement. In other cases, however, failures would continue to occur at about the same rate because, as discussed for Millstone 3, utility studies showed that it was cost-beneficial and safe to simply periodically repair a marginally designed main feedwater pump seal rather than to pursue a design improvement.

NPRDS Data Quality

The utility participants stated that NPRDS data provides information on maintenance, but quality limitations impact its usefulness for a maintenance indicator used by the regulator. There is consensus between the staff and the industry that continued improvement and strengthening of NPRDS is needed.⁵ In particular, the utility participants felt that a source of inconsistency in NPRDS reporting was the determination of the existence of a degraded component state needed to trigger NPRDS reportability. Overreporting of minor or incipient conditions revealed by an aggressive and proactive PM program as degraded failures would result in relatively more failures being used in the indicator, and potentially a greater magnitude in the indicator over time. However, regardless of any overall NPRDS data quality improvements, the data can still be used to determine trends at individual plants.

The proposed indicator itself is designed to be benign to proactive preventive or predictive maintenance. This was accomplished by only including NPRDS failures designated by the utility as "immediate" or "degraded". These terms are defined in NPRDS as follows:

- Immediate - A failure that is sudden and complete.
- Degraded - A failure that is gradual, partial, or both. The component degrades to a level that, in effect, is a termination of the ability to perform its required function. This code should be chosen when a system of component does not satisfy the minimum acceptable performance criteria for a specific function or when a component must be removed from service or isolated to perform corrective maintenance.

⁵ The revised Policy Statement on Maintenance states in part "The Commission encourages the use of the industry-wide NPRDS data ... including improved industry use of and participation in the NPRDS to gauge the effectiveness of maintenance."

Proactive maintenance would identify incipient conditions, defined as an imperfection in the state or condition of a component that could result in a degraded or immediate failure if corrective action is not taken. These incipient conditions would be reversed by PM prior to the component entering a degraded condition where function was impaired, or such impairment was imminent. An incipient designation or code indicates an optional record, since failure has not occurred. This code is also used by INPO to classify records judged not to be failures during the INPO failure audit process. NPRDS documentation provides extensive guidance for making this determination.

The proposed indicator should not penalize proactive preventive and predictive maintenance. It's important that incipient conditions discovered by these programs not be interpreted as degraded failures in the use of the indicator. Improvement of the quality of maintenance work orders appears essential to achieving improvement in NPRDS quality. The utility participants felt that work orders often do not contain enough detail to make a proper determination. The industry also feels that the lack of detail in work orders clouds root cause documentation and impacts the diagnostic value of the indicator. Also, timely maintenance work request close-out and associated NPRDS reporting is needed to capture important details.⁴ These difficulties can be addressed through strengthening the quality of the maintenance work order documentation process, for example as done at Grand Gulf through a dedicated closeout Engineering Review Group (ERG), and through greater rigor in the quality assurance review conducted by INPO.

Grand Gulf has established the ERG to improve the quality and timeliness of maintenance documentation and closeout. The charter of the ERG, as created within the Performance and System Engineering Department, is to perform a final, independent review of maintenance work orders prior to closeout. Grand Gulf has tasked this group with ensuring work orders reflect adequate details of the identified problem, including the overall work scope, root cause, corrective actions taken, and component failures. The ERG represents a plant improvement with the potential for a direct impact on maintenance indicator development, addressing the concerns expressed about the quality of NPRDS reporting and its effect on the indicator. A group such as the ERG provides additional assurance that the failure information documented in the maintenance work orders (MWOs) is accurate and complete. This, in turn, helps assure that the subset being reported to the NPRDS is accurate and complete.

The specific duties of the ERG consist of:

1. Reviewing completed work orders for consistency,
2. Obtaining predictive maintenance data for trending,
3. Providing reports to system engineers for analysis,
4. Maintaining control of the surveillance tracking program,
5. Entering all MWOs into SIMS for component failure trending.

The ERG consists of a supervisor, three full time engineers, two clerical personnel, and two engineering technicians.

⁴ The latest staff assessment of NPRDS is that reporting has become less timely. Failures should be in the system within 90 days of the discovery date.

The Industry Action Plan for improving maintenance identified the need for focused effort on the NPRDS to improve the industry's effectiveness in monitoring and maintaining the reliability of important plant equipment. Specifically, INPO and the utilities will upgrade NPRDS effectiveness by improving data quality and expanding the scope to include additional selected balance-of-plant equipment.

Recommended Approach:

1. Revise the algorithm used in calculating the indicator to eliminate "ghost ticks" and capture "shadow ticks." Two alternative methods developed and being tested by the staff were introduced to the Demonstration Project during the March 1990 joint meeting.
2. Modify the overall indicator to include both system-based and component-based indications. The calculations and displays are being modified to also show component-based indications.
3. Continue to encourage improvement in NPRDS participation and support the initiatives in the Industry Action Plan regarding improving NPRDS data quality.

APPENDIX A
SUMMARIES OF MEETINGS WITH DEMONSTRATION PROJECT
UTILITY PARTICIPANTS

This Appendix contains copies of the NRC minutes for the individual meetings that were held with the six utility participants in the Demonstration Project. The minutes are arranged in the following chronological order:

<u>Utility</u>	<u>Meeting Dates</u>	<u>Page</u>
Commonwealth Edison Company	11/29- 30/1989	A.2
Southern California Edison Company	12/12- 13/1989	A.4
Duke Power Company - Oconee	01/09- 10/1990	A.8
Rochester Gas and Electric Corporation	01/17- 18/1990	A.18
Systems Energy Resources, Incorporated	02/20- 21/1990	A.25
Northeast Utilities	02/28-3/1/1990	A.33

MEMORANDUM FOR: Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

FROM: Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Office for Analysis and Evaluation
of Operational Data

SUBJECT: MINUTES OF COMMONWEALTH EDISON/NUMARC/NRC
NOVEMBER 29-30, 1989 MEETING

On November 29-30, 1989, representatives from the NRC staff met with the Commonwealth Edison staff and a representative from the Nuclear Management and Resources Council (NUMARC) at the Chicago Office of Commonwealth Edison. The meeting was scheduled as part of the Maintenance Indicator Demonstration Project to discuss the staff's proposed Maintenance Effectiveness Indicator (MEI). This meeting was the first in a series of meetings to be held with individual utilities as part of the MEI Demonstration Project. A list of attendees is attached.

The NRC staff presented the detail and logic followed by the staff during the development process for the proposed maintenance indicator. The intent of this presentation was to familiarize utility personnel with all the details necessary for understanding the proposed maintenance indicator.

During the course of the meeting it was determined that Commonwealth Edison is moving toward monitoring equipment (component) performance. Monitoring of component reliability by Commonwealth Edison is in general consistent with the logic being followed by the NRC staff during the development of the proposed maintenance indicator. In addition, it was determined that: 1) utilization of component failures to measure the quality of maintenance is appropriate and useful, 2) utilization of failure rate increase methods is a reasonable way to approach the detection of changes in maintenance effects, and 3) the ODE equipment list/selection for the indicator is generally consistent with Commonwealth Edison's priority listing for equipment availability.

Feedback from Commonwealth Edison was in general positive and constructive. The following recommendations were made: (1) The current methods used to calculate the MEI may have to be revisited to make the indicator more useful to plant staff, e.g., consider grouping failures by component type and by system, (2) the indicator should be sensitive enough to reflect on-going programs to address specific fixes for a given component; i.e., check valves, MOV's, pumps, etc., (3) additional sources of data beyond NPRDS (GADS, Greybook) may be useful to better describe ODE equipment performance.

Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Office for Analysis and Evaluation
of Operational Data

cc: E. Jordan, AEOD
W. Smith, NUMARC
P. Kuhel, CEC
PDR

ATTENDANCE LIST

November 29-30, 1989 Meeting

MAINTENANCE INDICATOR DEMONSTRATION PROJECT

<u>NAME</u>	<u>ORGANIZATION</u>
Paul Kuhel	Commonwealth Edison
Martin G. Kief	Commonwealth Edison
Don Eggett	Commonwealth Edison
Robert Lazon	Commonwealth Edison
Thomas Kovach	Commonwealth Edison
Lee A. Sues	Commonwealth Edison
Walt Smith	NUMARC
Larry Bell	NRC/AEOD
Pat O'Reilly	NRC/AEOD
Mark Williams	NRC/AEOD
Thomas Novak	NRC/AEOD

MEMORANDUM FOR: Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

FROM: Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

SUBJECT: SUMMARY OF DECEMBER 12-13, 1989 MEETING WITH
SOUTHERN CALIFORNIA EDISON COMPANY REGARDING
MAINTENANCE INDICATOR DEVELOPMENT

On December 12-13, 1989, members of the Nuclear Regulatory Commission (NRC) staff met with representatives of Southern California Edison Company (SCE) and the Nuclear Utilities Management and Resources Council (NUMARC) at the San Onofre Nuclear Generating Station (SONGS) site to discuss maintenance indicator development. This meeting was a followup to the October 13, 1989 meeting of the NRC/Industry Maintenance Indicator Demonstration Project.

A list of meeting attendees is enclosed.

The NRC staff presented the detail and logic which the staff followed during the development of the staff's proposed Maintenance Indicator. The purpose of this presentation was to familiarize SCE personnel with all of the detail necessary for understanding the proposed indicator.

SCE explained to the staff that, although they do not have an integrated program for measuring the effectiveness of their maintenance program, they do monitor a number of specific maintenance-related areas (e.g., non-outage productivity, thermal performance, vibration monitoring, rework monitoring, and oil sampling).

The primary issue which was discussed during the meeting was the link between the NRC's proposed indicator and maintenance. This was accomplished by:

- (1) Listing representative cases of component failures comprising the NRC's indicator which the staff had designated as maintenance-related and SCE has not.
- (2) Analyzing the failure narratives for the component failures identified in (1) above. The staff's analysis was based solely on the information contained in the narrative; SCE's analysis was based on all available information (including individual memory) at the site regarding specific failure.
- (3) Discussing the difference in views of "maintenance-related" failures which, in turn, resulted in the following issues:
 - ° SCE expressed the view that the first failure of a component, or the failure of a component after it has been in service for a long time, should not be necessarily considered as related to maintenance. On the other hand, it is not clear that such

failures should be excluded, since lack of maintenance attention or oversight regarding inclusion in a PM program could be the cause of the failure. The number of such failures captured by the indicator and their effect on the indicator has not been determined, but this area should be explored.

- SCE believed that "wearout" was an acceptable characterization of a failure cause, and that "wearout" failures should generally not be considered as related to maintenance. In general, the staff feels that prevention of wearout to the point of loss of function (failure) is the objective of a maintenance program, and thus failures assigned a "wearout" cause should be considered when assessing the performance of a maintenance program. Further, "wearout" may be used too frequently in lieu of more rigorous cause analysis.
- SCE indicated that a reliability centered maintenance (RCM) program could lead to a planned "run-to-failure" strategy for some equipment, and thus failures of that equipment should not be used as part of a maintenance indicator. In particular, condition directed RCM will allow selected components to reach a degraded failure state and thus generate an NPRDS failure report. SCE plans to review the list of equipment used in the candidate indicator and recommend modifications to address this issue. Related to this concern, SCE felt that there is some acceptable level of component failure associated with an effective maintenance program, but the indicator counts all failures in establishing trends, which implies that any failure is a result of maintenance ineffectiveness. The indicator uses failures across a broad spectrum of equipment over time to establish a trend, and in that framework no single failure is used to reach a conclusion about the effectiveness of the program. This concern could also be handled by putting an "error band" around the indicator.
- The concern about reporting incipient conditions as degraded failures to the NPRDS was also discussed. SCE indicated that some utility maintenance tracking systems might allow corrective action to be taken under the umbrella of preventive maintenance, and thus no failure report would be submitted to the NPRDS. This issue related to the completeness and consistency of NPRDS reporting.

Finally, a number of suggestions were made for improving the current indicator which led to the following items for future action:

- (1) SCE will review the specific list of equipment monitored by the indicator for San Onofre Units 1, 2, and 3 and designate those components that should be allowed to run to failure including condition directed cases. Upon staff agreement with such a list, this may have the effect of reducing the number of first failures of a component contributing to the indications. The staff will provide SCE the pertinent engineering records for these three units to facilitate the review.
- (2) The staff will develop a template or peer grouping for use in interpreting the calculated indicator. This will be cycle-based. No comparison across plants would be attempted except within the context of this template. Hence, the template would have the so-called "acceptance bands" mentioned previously.
- (3) For future analyses, the staff will produce the indicator calculated by component type as well as by system. Selection of specific component types will be influenced by the component

types considered in a CFAR run. SCE will provide a list of the CFAR component types for this purpose.

- (4) The staff will modify the indicator algorithm to eliminate the problem of "ghost ticks."
- (5) The staff will determine the extent of the problem of different "levels" of degraded failures - those being discovered during operations versus those discovered during refueling outages (particularly under "open and inspect" conditions).

Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

Enclosure: As stated

cc: E. Jordan, AEOD
W. Smith, NUMARC
M. Rodin, SCE
PDR

ENCLOSURE

List of Attendees

SONGS - NRC MAINTENANCE INDICATOR MEETING

December 12 - 13, 1989

<u>Name</u>	<u>Organization</u>
Brian Katz*	Mgr. NSSSD
Don Evans*	SSSD
Ralph Sanders	SSSD
Robin Baker	Licensing
L.D. Brevig	Licensing
Fred Briggs	Sta. Tech.
A.D. Toth	NRC Region V
R.L. Dennig*	AEOD/NRC
Walt Smith*	NUMARC
Jack Rainsberry	Licensing
Mark Williams*	AEOD/NRC
Loyd Wright*	SSSD, Supv.
R.H. Bridenbecker	VP, Site Mgr.
Harold Ray	VP, NES&L
M.E. Rodin*	SSSD/Reliability
Pat O'Reilly*	AEOD/NRC
Barbara Aden	SSSD
Bob Levline*	SSSD/ERIN

Notes:

* Full time attendees

MEMORANDUM FOR: Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

FROM: Mark H Williams, Chief
Trends and Patterns Analysis Branch
Office for Analysis and Evaluation
of Operational Data

SUBJECT: SUMMARY FROM JANUARY 9-10, 1990 MEETING AT OCONEE

On January 9-10, 1990 we met with representatives of Duke Power and NUMARC to pursue the formulation of maintenance performance indicators. The list of attendees is attached. Discussions followed the agenda provided as Attachment 2, and were limited to the Oconee station since Duke staff indicated that no review had been performed for McGuire or Catawba. The Duke staff did invest a significant amount of time in analyzing the indicator for the Oconee case.

Item 2 of the agenda, the discussion of interim indicator results, raised issues on how the indicator would actually be used, and how much of a resource impact any additional indicator, technical merits aside, would have on Duke general office and plant staffs. The concern expressed by Duke staff was that any new indicator would require resources to respond. At a minimum, they would have to periodically review it and understand its implications. This would detract from other inplant reliability analyses already in process, e.g., CFAR, FATS. Their concern about such an impact is proportional to the degree that this indicator would be used based on its face value, e.g., absolute magnitude, without additional analysis and interpretation by knowledgeable individuals.

The NRC staff indicated that the proposed indicator was not intended for use without additional information on maintenance, for example, as found in inspection reports, and that use of any indicator alone as a basis for a regulatory decision or perspective on performance was contrary to NRC policy.

Item 3, root cause analysis of individual component failures, was accomplished by reviewing a selection of failures for ODE equipment. Based on the information in the failure narrative the staff classified these examples as maintenance related, while the utility had not. Of a total of 15 cases reviewed, the Duke staff believed that six could be related to maintenance (as they define it) in whole or in part. With the additional information provided by Duke, the staff concluded that 3 of the 15 cases were not related to maintenance (as the staff defines it based on the Commission policy statement). The participants disagreed on the remaining 6 cases, due to the differing definitions of what maintenance encompasses, differing understandings of what the term "maintenance related" means, and the suitability of the NPRDS guidance on what constitutes a degraded failure (which is used in the indicator) and an incipient condition (which is not used in the indicator).

The interpretation of "wearout" is a particular concern. Duke staff contends that wearout is a legitimate cause designation which relates to normal equipment service, and does not necessarily indicate deficient maintenance. On the contrary, Duke staff felt that wearout actually

may indicate proactive and desirable maintenance for either the incipient or degraded degrees of failure. The staff does not take issue with this contention *per se*, but argues only that degraded and immediate failures (where by definition a component cannot adequately perform one or more of its functions) attributed to wearout are relevant to evaluating the effectiveness of maintenance.

In general, the staff indicated that its definitions were consistent with the Commission policy statement on maintenance, with INPO industry guidelines, and current NPRDS reporting guidance on the degree of failure. Duke staff disagreed with the boundaries drawn by the staff in its interpretation of the scope of maintenance. The Duke staff further suggested that the NPRDS guidance on degree of failure, in the context of a proposed maintenance indicator, may be too conservative and result in capturing incipient conditions as degraded failures.

Under Item 5, Duke Power approaches to component failure trending, the Oconee staff provided information on a number of different efforts, either underway or in the formative stages, as described in Attachment 3. One database used for component failure trending purposes is the Failure And Trending module (FAT). This data base contains information for every maintenance work order that indicated a problem. It includes all failures that would be reported to NPRDS, but covers a much greater scope of equipment, and covers problems of a lower severity than those reportable as degraded or immediate failures for NPRDS. When comparing trends under Item 6, Duke staff used the flagging algorithm proposed by the staff in combination with FAT data and generally obtained more flags. No alternative algorithms or thresholds were tried. The Duke staff at Oconee is also making use of CFAR, which is based on NPRDS data and compares a plant against the industry for numerous component groupings and application-coded components using failures per component hour. However, CFAR does not currently provide a trendable indicator.

The Duke staff stated that the proposed indicator provided a measure of component failures, but that as currently calculated it did not line up with the Oconee maintenance organization, and thus would not provide useful feedback to the plant staff. The mechanical maintenance at Oconee is organized by type of component, while the instrumentation and electrical is organized by system. Thus, the system-based calculation underlying the cumulative indicator display, with its mix of different types of components, does not align with the responsibilities of their plant staff. In response, the staff explained that the proposed indicator was programmatic, and not constructed as a detailed feedback tool for taking corrective action. Adverse indicator trends would necessitate a broad review of the maintenance program and its implementation. Nonetheless, the indicator could be made more useful to plant staffs, for example by cutting the data by component type, as suggested earlier by Commonwealth Edison staff. Steps to make the indicator more useful are being pursued by the staff, in addition to eliminating mechanistic problems such as "ghost ticks."

The Oconee staff is also becoming used to interpreting the component failure rates provided by CFAR and prefers that similar statistics, i.e., failures normalized by component population, be used to avoid confusion. Given the preference for the CFAR-type approach, Duke staff indicated that they would try to develop a way to turn CFAR results into a trending tool. The Duke staff offered a number of alternatives for staff use in measuring maintenance effectiveness as presented in Attachment 4.

In summary, a number of issues concerning the indicator raised in previous discussions with the ARAC participants were again raised by the Duke staff.

Ascribing the first failure and wearout failures to maintenance,

The potential for counting failures that are discovered by PM and not severe enough to impact the component's primary function (due to some NPRDS failures being coded as "degraded" in accordance with guidance although they are felt to be incipient),

Not highlighting repeat failures or rework,

The presence of "ghost ticks,"

The degree of usefulness to the plant staff,

The need for multiple indicators to capture all the nuances of maintenance performance.

The Duke staff views the proposed indicator as an equipment trend indicator, and believes that a component failure oriented indicator is needed as part of a set to monitor maintenance. Duke staff maintained that more than one overall indicator was needed to monitor the maintenance process. The NRC staff agreed and noted that monitoring equipment failures, the focus of the NRC staff activities, was one useful and important measure of maintenance effectiveness that should be used with other utility indicators to assess and improve the maintenance process. The scope of equipment covered by the indicator (ODE) contained as a subset the equipment Duke would be concerned with given the same basis for selection. More than in previous discussions the Duke staff expressed concern about resources needed to deal with the indicator for response and diagnosis. In particular they felt that since they were already committed to periodic use of CFAR, the need for an indicator might be met by some modification of CFAR, thus saving engineering resources.

Mark H Williams, Chief
Trends and Patterns Analysis Branch
Office for Analysis and Evaluation
of Operational Data

Attachments: As stated

cc: E. Jordan, AEOD
W. Smith, NUMARC
S. Lindsey, Duke Power
L. Wiens, NRR
PDR

Attachment 1

Attendance
January 9-10, 1990 Meeting with Duke Power Company
Regarding Maintenance Indicators

<u>Name</u>	<u>Office</u>	<u>Telephone Number</u>
Bob Dennig	NRC/AEOD	301-492-4490
Tom Novak	NRC/AEOD	301-492-4484
Wayne Hallman	DPC/GO	704-373-2345
Walt Smith	NUMARC	202-872-1280
Bill Foster	DPC/ONS/MAINT.	803-885-3152
Mark Williams	NRC/AEOD	301-492-4480
Ronnie Henderson	DPC/ONS/MMSU	803-885-3152
Sam Hamrick	DPC/ONS/MMSU	803-885-3519
Stuart Lindsey	DPC/NUC. MAINT.	704-373-8768
Pierce Skinner	NRC/SRI-Oconee	803-882-6927
Dendy Clardy	DPC/ONS/MAINT.	803-885-3160

Attachment 2

AGENDA

JANUARY 9-10, 1990 MEETING WITH DUKE POWER COMPANY

REGARDING MAINTENANCE INDICATORS

- (1) NRC presentation - Performance Indicator Development, Analysis Assumptions and Purpose of Meeting.
- (2) Discussion of Interim Indicator Results.
- (3) NPRDS Reporting of Component Failures Involving Outage-Dominating Equipment.
- (4) Root Cause Analysis of Individual Component Failures of Outage-Dominating Equipment.
- (5) Discussion of Duke Power's Programs/Approaches for Trending Equipment Failures and Failure Causes as They Relate to Maintenance ("FATS")
- (6) Comparison of Maintenance Trend Information
 - (a) Trends Calculated with the NRC's Indicator
 - (b) Trends Calculated with Duke Power's Indicator(s)

Attachment 3

Outline of Trending Approaches at Oconee Nuclear Station

- 1) Communications from Work Execution Technicians and Planners to Maintenance Engineering of component failure trends and repeat actions recognized while planning and/or performing maintenance. This is an ongoing process and serves as an active feedback mechanism in the maintenance-triangle concept. Planners now have the capability to retrieve printed information sheets that show a component's corrective maintenance history while planning each work request. This enables the Planner to look for trends during the planning process. The history sheets are attached with the work request so that Work Execution can review as well.
- 2) Maintenance Engineers are accountable for defining and driving Technical Support Programs for components and systems. The TSP's include component trending activities. The Maintenance Engineers are expected to define and perform programmed maintenance in an "ownership" manner, and they monitor the performance and failures of their components on a regular basis. The Maintenance Engineers supply regular feedback and conduct meetings to inform appropriate Planning, Work Execution, Radiation Protection, Operations and Maintenance Management of actions that are needed for problem components discovered through trending or components that will be monitored closely for trends while operating. Maintenance Engineers maintain trend data in a variety of places ranging from personal files to computer data sets.
- 3) Some examples of Technical Support Programs where trending is ongoing are:
 - a. The Predictive Maintenance and Monitoring Program (PM2). This program includes the acquisition and trending of vibration and oil analysis data for rotating equipment. The responsible Maintenance Engineer monitors the data for adverse trends and prescribes corrective and preventive maintenance when trends indicate actions are necessary.
 - b. The pipe Erosion/Corrosion Control Program. This program includes the acquisition of pipe and fitting wall thicknesses that are maintained in a computer file. The responsible Maintenance Engineer monitors the data for trends that show wall thickness that are decreasing at an adverse rate. When trends are discovered, the Maintenance Engineer prescribes the appropriate actions.
 - c. Instrument procedures provide data sheets for I&E technicians to identify components where malfunctions or exceeded calibration tolerances are discovered. These data sheets are named Component Malfunction/Maximum Tolerance Limit Exceeded sheets. The data sheets are forwarded to the responsible Maintenance Engineers for evaluation, and the sheets are kept in I&E Maintenance Engineering files for trending data. The I&E Maintenance Engineers review the filed data for trends.
 - d. The I&E Maintenance Engineer responsible for the RPS system monitors the Reactor Coolant flow for deviations greater than one-half percent and trends that show increasing deviations. As increasing deviations are discovered, the Maintenance Engineer prescribes the necessary actions to prevent excessive deviations.

- e. The I&E Maintenance Engineer responsible for the Control Rod Drive breakers monitors the trip times obtained during monthly Preventive Maintenance testing and trends the data for trip times that show increases towards a limit established by the engineer. The engineer prescribes necessary actions when adverse increases are apparent.
 - f. The Performance Group trends leak rate data, valve stroke times, pump performance etc., and notifies Maintenance when adverse trends are discovered.
 - g. Limitorque valve operator MOVATS and lubrication analysis data are trended by the responsible Maintenance Engineers for predictive maintenance purposes.
- 4) The following failure reports are provided to Maintenance Engineers for their use in trending components.
- a. The "Value Report Card" is supplied to the Maintenance Valve Engineer after each Refueling Outage. This failure report identifies any corrective maintenance work requests written within the thirty-day window following the Refueling Outage. The engineer analyzes the identified valve failures for failure trends as well as work execution effectiveness.
 - b. The "Multiple Work Request Report" is supplied to both Mechanical and I&E Maintenance Engineering groups. This report identifies components that encounter multiple failures (not necessarily related) in a selected time period.
 - c. The "Average Failure Frequency Report" is supplied to both Mechanical and I&E Maintenance Engineering groups. This report develops failure rates or frequencies considering component populations, number of corrective maintenance work requests written within a selected time period for respective components and the amount of work hours expended.
 - d. The "Component Failure Analysis Report" (CFAR) is now being supplied to the Maintenance Engineering groups quarterly. CFAR identifies Oconee's NPRDS components that are experiencing higher failure rates than similar component applications throughout the industry. NPRDS reports that are submitted are now being supplied to the corresponding Maintenance Engineers on a monthly basis with a summary sheet being sent to the Maintenance Engineering Manager.
 - e. Special failure reports are supplied to Maintenance Engineers as they request them and as the MMSU group discovers failures that indicate a need for further investigation. These reports are built from maintenance history data and failure data contained in the Equipment Database (EQDB), Nuclear Maintenance Database (NMDB) and the Failure and Trending module (FAT).
 - f. Future capabilities being considered are reports that identify rework, repeat failures, and corrective maintenance required following PMs.
- 5) Examples of other maintenance indicators trended at Oconee:
- a. Oconee's Management Information System Report (MIS Report) is a monthly report that supplies a detailed accounting of work hours expended by types of work, the ratio of

Preventive Maintenance to Corrective Maintenance work hours, the number of high priority work requests written and closed out during the month, the work request backlog greater than 90 days, the status of each open work request and the responsible Planner. Each monthly issue is reviewed and trended by Maintenance Management.

- b. Weekly audits of work requests by Planning Coordinators and Planning Manager for completeness and accuracy. One purpose of the audits is to trend the quality of information documented on work requests.
 - c. Housekeeping reports are used to trend Material Condition.
 - d. The Operations group identifies Control Room Annunciators and Instruments out of service monthly to the Planning Group for corrective action. Planning and Operations trend the monthly reports.
 - e. Others.
- 6) Indicators such as Availability Factor, Safety System Actuations, Forced Outage Rate, Corrective Maintenance Backlog, High Priority Work Requests, Ratio of PM to Total Maintenance, PMs Overdue, Thermal Performance, Capacity Factor and Number of Continuous Days of Operation have shown favorable trends during the past years and indicate that Oconee's Maintenance Programs are effective in managing component failures.

Attachment 4

*** PROPOSED OPTIONS ***

FOR

MAINTENANCE EFFECTIVENESS INDICATOR

OPTION 1: Utilize LER Forced Outage Rate Data

Reasons: * Bo. LER and Forced Outage Rate data are now reported to NRC under familiar reporting guidelines. This data is relatively pure and accessible for NRC use.

* Maintenance-related LER data would provide indications of those maintenance challenges to safety systems or design operating bases for a plant. Forced Outage Rate data captures the challenges to the major outage-causing equipment. Together they provide a good basic picture of a plant's maintenance without constructing another indicator.

Cost/Benefit: * Cost to the NRC and industry would be minimal. This data is well understood and will not require redundant analysis/review which would be necessitated by a new indicator.

Needs: * Better maintenance cause codes need to be defined for LER reporting. In addition, the current LER data would need to be reviewed and reclassified for a prior baseline period (e.g., 3 years backfit would probably give a good track record for trending). Based on a review of Oconee LER data for 3 years, this took about 45 minutes for all 3 units.

Option 2: Utilize some of the important "Maintenance Indicators"

Reasons: * A defined core of these maintenance indicators, when reviewed collectively, do provide a more accurate picture of Maintenance Program Effectiveness than any one indicator could. These are what most utilities use to measure their program effectiveness; therefore, the data is again well defined.

Cost/Benefit: * Cost to the NRC and industry would be minimal. This data is well understood and will not require redundant analysis/defense which would be necessitated by the new indicator.

Needs: * Both the industry and the NRC need to come to a more definitive agreement as to what "Maintenance" means. This will require definition of a core set of indicators that when looked at cumulatively provide indication of Maintenance Program health. Possibly a reliability/availability indicator needs to be added to the "Set" of accepted indicators.

Option 3: Utilize CFAR type report(s) or Reconstructed Indicator(s) based on Failure Data Grouped Component Types

Reasons: * Failure data grouped by system appears to be ineffective in correlating with other program indicators; therefore, any reliability type indicator(s) need to be grouped based on component groups similar to CFAR. This would provide some feedback on repeat failures. In effect, trending CFAR "hits" or failure rates would provide the same type of information and alleviate the extra cost to the industry of trending a duplicate indicator.

Cost/Benefit: * The cost for the NRC to use CFAR would not be as high but CFAR in its present form is still judged inadequate to represent Maintenance Program effectiveness. Thus even if CFAR is provided to the Commission, it will require some additional cost to reconstruct CFAR for the type of analysis desired. However, CFAR data is well understood and will not require redundant analysis/review which would be necessitated by the new indicator.

Needs: * If a new reliability indicator is generated then several major changes need to be incorporated to make it useful:

1. Grouping should be made by major critical component groups mutually agreed upon by the industry and the Commission.
2. Wearout should be allowed as a legitimate separate cause code not strictly maintenance related. Additional definition of legitimate wearout will be needed to satisfy both industry and the Commission.
3. Failure trending should account for population size of the group (i.e., % failures of a given population would provide some benefit for efficiency of maintenance).
4. Failure trending should be strictly plotted as total # of failures, or failure rate, or % failures for given population per quarter. If trigger levels are desired then Alert and Alarm levels should be established based on statistical confidence limits of population functional ability (i.e., something like a 90% confidence of 90% of the population being functionally operable during a given time period). An algorithm which averages failures should not be used.
5. A reliability indicator should not be used unilaterally to measure maintenance program effectiveness, but should be only one of several indicators evaluated. Also, the PM program should be accounted for in any maintenance indicator.
6. Impact of the failure needs to be evaluated and incorporated (e.g., was the failure significant to system operability and safety).

MEMORANDUM FOR: Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

FROM: Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Office for Analysis and Evaluation
of Operational Data

SUBJECT: SUMMARY OF JANUARY 17-18, 1990 MEETING WITH
ROCHESTER GAS & ELECTRIC CORPORATION REGARDING
MAINTENANCE INDICATOR DEVELOPMENT

On January 17-18, 1990, members of the NRC staff met with representatives of Rochester Gas and Electric Corporation (RG&E), their consultant, ATESI, and the Nuclear Management and Resources Council (NUMARC) at the Ginna site to discuss maintenance indicator development. A list of meeting attendees is contained in Enclosure 1. Enclosure 2 contains the overall meeting agenda. Enclosure 3 is the agenda for RG&E presentations that discussed specific portions of the agenda items from Enclosure 2.

This meeting was a followup to the October 13, 1989 meeting of the NRC/Industry Maintenance Indicator Demonstration Project. The composition of the demonstration project represents a broad spectrum of utility organizations and sizes, as well as plant sizes and nuclear steam supply system designs and ages. RG&E was included in the demonstration project to gain insights regarding the monitoring of maintenance from the perspective of a relatively small utility operating a single, older plant - RG&E's Ginna plant. Ginna began commercial operation in 1970 with a two-loop Westinghouse-designed PWR having an electrical output of 470 MWe, and represents roughly one-half of the utility's electric generating capacity.

The NRC staff presented the detail and logic which were followed during the development of the staff's proposed Maintenance Indicator (MI). The purpose of this presentation was to familiarize RG&E personnel with all of the detail necessary for understanding the proposed indicator.

RG&E presented results of their assessment of the NRC's proposed indicator, which involved an RG&E staff effort of approximately 1000 manhours. This assessment, which included mathematical verification of the indicator algorithm and results of their analysis of individual NPRDS component failure narratives, focused on an example system (chemical and volume control system) that, according to the indicator, had equipment problems, and a discussion of the reliability-centered maintenance (RCM) program being implemented at the Ginna plant.

RG&E presented the background behind their RCM project, its system selection criteria, the RCM analysis and task methodology, and the RCM Living Program. The results of the RCM analysis determine which components will receive PM tasks designed to maintain component function.

The following major issues were discussed during the meeting:

- (1) RG&E expressed concern that the staff's proposed indicator did not distinguish critical failures from failures which were not significant. They were concerned that use of this indicator could result in a plant's maintenance program focusing on relatively unimportant individual failures. RG&E stated that significant events which occurred at Ginna over the time span of interest were not tracked by the indicator. The staff explained that, as a programmatic indicator, the proposed indicator was not intended to track significant events. Rather, it was intended to track component failures across a broad spectrum of equipment over time to establish a trend on the premise that no single failure would be used to reach a conclusion about the effectiveness of the maintenance program.
- (2) Definition of Maintenance - comparison of the results of independent reviews of example NPRDS failure narratives performed by RG&E and the NRC staff led to the issue whether failures which involved wearout or were first of a kind were maintenance-related.

RG&E reevaluated all of the NPRDS failures using a jury expertise approach, and, in their view, a low percentage could be attributed directly to "maintenance" (11%), as their organizational structure defines maintenance.

According to RG&E, intrinsic design reliability results in random failures for some components [e.g., components that rely on materials that degrade over time (capacitors, relays, seals)] which are expected and are not a result of ineffective maintenance.

A case in point was a group of failures involving the charging pumps. In these failures, the pump packing was found to be leaking, the packing was replaced, and the events were reported to the NPRDS as degraded failures. After several pump packing failures of this type, RG&E determined that the leaking packing was a wearout problem. The corrective action taken was to prepare a PM procedure to replace the pump packing periodically. Under current NPRDS reporting guidance, RG&E considers the packing replacement a wearout condition, and not a maintenance-related failure. The NRC staff commented that for this case, regardless of the cause of the first failure of the pump packing (wearout or maintenance-related), since the indicator would be tracking the failure history, it would show a valid improvement in the RG&E maintenance program when the new PM procedure for the pump was implemented. Therefore, the indicator in this case would measure a maintenance program improvement, and the question of whether the initial failures were due to wearout or lack of maintenance was moot.

RG&E pointed out that, independent of incipient or degraded reporting, the economic decisions exercised during the selection of the preventive maintenance activities or decisions not to maintain but replace when appropriate are treated negatively by the staff's proposed indicator. The indicator does not consider economic and ALARA considerations. This is related to the concern expressed in other meetings with project participants that there is some acceptable level of component failure rate associated with an effective maintenance program. However, the proposed indicator counts all failures in establishing trends, which implies that any failure is a result of maintenance ineffectiveness. To this concern, the staff has responded that the indicator uses failures across a broad spectrum of equipment over time to establish a trend, and in that framework, no single failure is used to reach a conclusion about the effectiveness of the

program. The staff believes that these concerns could be resolved by putting a band around the indicator which would identify the region of acceptability.

- (3) Reliability-Centered Maintenance - Since the analysis is done on a component basis, this methodology may allow components to run to failure, or to a condition where corrective maintenance is required due to a loss of function, if a redundant component (i.e., another train or path) is available. The analysis used to identify this equipment considers the local impact, system impact, and plant impact of the component failure. There will be no system impact if all of its constituent trains are not taken down by the failure of the component.

RG&E stated that the RCM systems selected are predominately standby systems, whereas the systems monitored by the indicator are outage-dominating systems. The staff's proposed indicator does not currently cover most standby safety systems.

The staff pointed out that the proposed indicator can serve as a check on the adequacy of the RCM program and implementation. To ensure that the indicator maintains consistency across plants to the extent possible, the equipment scope of the RCM program should be included in the selection of equipment to be monitored by the indicator. In this vein, the list of equipment monitored by the indicator may be modified, contingent on recommendations received from the industry during the demonstration project.

From their review of the set of NPRDS failures, RG&E concluded that no PM Program activity at Ginna should be modified as a result of the failures aggregated under the indicator algorithm methodology. Other equipment failures have caused PM Program changes at Ginna.

Since the indicator for the Ginna plant remained below the average for PWRs of its type and size, with no adverse trends, over the entire period of interest, the staff would not have expected any PM Program changes to be made based on the indicator.

RG&E indicated there is significant risk in reliance on a single indicator to measure maintenance effectiveness; the staff's proposed indicator could penalize a good performer by lessening the priority for budgets being applied to maintenance if the indicator showed good performance. RG&E utilizes both process indicators (backlog) and industry performance indicators (i.e., availability) as measures of maintenance effectiveness. RG&E did identify the following two sets of indicators, one qualitative, the other quantitative, which they would propose using to monitor maintenance effectiveness:

Qualitative - plant material condition, repetitive component failures.

Quantitative - forced outage frequency, turbine runback frequency, safety system availability.

RG&E identified the following issues which they consider to be most significant in resolving their concerns about the staff's proposed indicator.

- (1) System and component selection.
- (2) Effects of failure (Local versus system versus plant).
- (3) "Ghost" Ticks-Remove superfluous "Ghost" ticks.

- (4) Multifaceted (other indicators, maintenance team inspections, other inspections).
- (5) Individual NPRDS plant reporter expertise and report completeness - Can significantly affect the quality of the NPRDS data.

The following items were identified for future action:

- (1) RG&E will prepare a list of equipment, based on their RCM experience, that should be monitored with the staff's indicator.
- (2) RG&E will provide the staff access to component data for the systems analyzed to date within the Ginna RCM Program.

RG&E agrees with this summary.

Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Office for Analysis and Evaluation
of Operational Data

Enclosures: As stated.

ENCLOSURE 1
ATTENDANCE LIST
JANUARY 17-18, 1990 MEETING
WITH ROCHESTER GAS & ELECTRIC CORPORATION

<u>NAME</u>	<u>AFFILIATION</u>
John Fischer	RG&E
Mark Flaherty	RG&E
James Huff	RG&E
Tom Marlow	RG&E
Bob Smith	RG&E
Herb Van Houte	RG&E
Gerald Wahl	RG&E
Joe Widay	RG&E
Bill Zornow	RG&E
Walt Smith	NUMARC
Jim Huzdovich	ATESI
John Wilson	ATESI
Victor Benaroya	NRC/AEOD
Bob Dennig	NRC/AEOD
Pat O'Reilly	NRC/AEOD
Mark Williams	NRC/AEOD

ENCLOSURE 2

AGENDA

JANUARY 17-18, 1990 MEETING WITH ROCHESTER GAS & ELECTRIC CORPORATION

REGARDING MAINTENANCE INDICATORS

- (1) NRC presentation - Performance Indicator Development, Analysis Assumptions and Purpose of Meeting.
- (2) Discussion of Interim Indicator Results
- (3) NPRDS Reporting of Component Failures Involving Outage-Dominating Equipment.
- (4) Root Cause Analysis of Individual Component Failures of Outage-Dominating Equipment.
- (5) Discussion of RG&E's Programs/Approaches for Trending Equipment Failures and Failure Causes as They Relate to Maintenance
- (6) Comparison of Maintenance Trend Information
 - (a) Trends Calculated with the NRC's Indicator
 - (b) Trends Calculated with RG&E's Indicator(s)

ENCLOSURE 3

RG&E AGENDA FOR MAINTENANCE
INDICATOR DEVELOPMENT MEETING

- | | |
|---|----------|
| Introduction | (Marlow) |
| NRC Presentation of Agenda Items 1-4 | |
| 1) RG&E Assessment of NRC Data | |
| a) RG&E mathematical verification. | (Zornow) |
| b) 57 reports. | (Zornow) |
| 2) Analysis of Validity of MEI | |
| a) Concerns with MEI data. | (Marlow) |
| b) Example of a specific Ginna system
which had ticks - CVCS. | (Wahl) |
| c) Matrix. | (Marlow) |
| d) Present graphs, charts. | (Marlow) |
| (5) Discussion of RG&E's Programs/Approaches
for Trending Equipment Failures and
Failure Causes as They Relate to Maintenance | |
| a) RCM system selection vs. MEI system
selection. | (Wilson) |
| b) RCM analysis and RCM task evaluation. | (Wilson) |
| c) RCM Living Program - Tells if we did not
have the right system, critical
component, dominant failure modes,
or frequency. | (Wilson) |
| (6) Comparison of Maintenance Trend Information | |
| (a) Trends calculated with the NRC's
proposed indicator. | |
| (b) Trends calculated with RG&E's indicator. | |
| RG&E's Recommendation for an MEI | (Marlow) |
| a) Qualitative. | |
| b) Quantitative. | |
| Conclusions | (Marlow) |

MEMORANDUM FOR: Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

FROM: Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

SUBJECT: SUMMARY OF FEBRUARY 20-21, 1990 MEETING WITH SYSTEMS
ENERGY RESOURCES, INCORPORATED REGARDING
MAINTENANCE INDICATOR DEVELOPMENT

On February 20-21, 1990, members of the NRC staff met with representatives of Systems Energy Resources, Incorporated (SERI), the licensee for the Grand Gulf plant, and the Nuclear Management and Resources Council (NUMARC) at the Grand Gulf site to discuss maintenance indicator development. A list of meeting attendees is contained in Enclosure 1. Enclosure 2 contains the meeting agenda.

This meeting was a followup to the October 13, 1989 meeting of the NRC/Industry Maintenance Indicator Demonstration Project.

The NRC staff presented their proposed Maintenance Indicator (MI). The purpose of this presentation was to familiarize utility personnel with all of the detail necessary for understanding the proposed indicator.

Two unique programs at Grand Gulf are particularly relevant to the work on the Demonstration Project. They are the Engineering Review Group (ERG) and the NPRDS Trend Report, both of which are discussed in detail below.

An Engineering Review Group has been formed within the Grand Gulf Performance and System Engineering Department to perform a final, independent review of work orders prior to closeout. Grand Gulf management has tasked this group with ensuring work orders reflect adequate details of the identified problem, including the overall work scope, cause, corrective actions taken, and component failures. The ERG represents a plant improvement with the potential for a direct impact on maintenance indicator development, since one of the concerns expressed about a component failure-based indicator has been the quality of NPRDS reporting. A group such as the ERG provides additional assurance that the failure information documented in the MWOs (and of the subset being reported to the NPRDS) is accurate and complete.

The specific duties of the ERG consist of :

- (1) Reviewing completed work orders for consistency,
- (2) Obtaining predictive maintenance data for trending,
- (3) Providing reports to system engineers for analysis,
- (4) Maintaining control of the surveillance tracking program,
- (5) Entering all MWOs into SIMS for component failure trending.

The NPRDS Trend Report, which has been prepared and issued periodically since 1987, contains a listing and evaluation of the component failures at Grand Gulf which were entered into the NPRDS database over the previous period. This report: (1) flags repetitive failures, (2) tracks corrective actions, (3) plots the failure rate for components which have experienced major repetitive failures (e.g., radial well pumps, diesel-generator starting air compressor), (4) trends reporting times, and (5) tabulates data for easy reference.

Grand Gulf staff described their maintenance organization and explained their maintenance philosophy. Basically, the responsibility for equipment at the Grand Gulf station is structured around the systems engineering concept. For this reason, they preferred the systems perspective of the NRC's proposed indicator, as opposed to the component type perspective. As far as quality of maintenance is concerned, no distinction is made between safety systems and balance-of-plant systems. The only difference in the maintenance of the two types of systems is that maintenance on safety systems receives a higher priority. Their maintenance program is predicated on the premise that its primary objective is to ensure that the plant operators have available the equipment necessary to operate the plant in a safe manner in accordance with the Technical Specifications. Grand Gulf tries to perform as much of the maintenance tasks as possible during normal plant operation, as opposed to accumulating work for outages. For that work which is performed during a refueling outage, timely closeout of maintenance work during a refueling outage, timely closeout of maintenance work orders (MWOs) and timely reporting to the NPRDS are stressed.

Grand Gulf staff described how the Grand Gulf outage planning and scheduling group interfaces with the regular maintenance organization. Outage planning at Grand Gulf starts as a "seed" that pulls in line management to actually manage the outage. During an outage, the Grand Gulf plant is run by this specially constituted outage organization, and the normal plant organizational lines do not exist during this time. The transition to this outage organization begins about two months before the start of a refueling outage. Following the refueling outage, a formal report is prepared which documents any lessons learned during the outage that can be considered in the planning and scheduling for the next refueling outage. The plant staff stated that they determine whether a refueling outage has been successful from the amount of work completed during the outage and how the plant operates after the outage is completed.

In keeping with the systems perspective, Grand Gulf looks one quarter ahead and tries to consolidate all preventive maintenance (PM) and surveillances for a particular system into, for example, a one-week period, and get all (corrective maintenance, as well as PM) of the work done within this time frame - called a "system outage." The purpose of this approach is to minimize the total time that the system is out of service.

Grand Gulf has actively continued a Maintenance Improvement Program since June 1987. A key element of this program is the installation and implementation of the Station Information Management System (SIMS). This system allows Grand Gulf management the opportunity to closely monitor planned work activities at Grand Gulf. In addition, SIMS provides more space for documenting detailed descriptions of problems and the corrective actions taken. SIMS has the capability for electronically providing the input for NPRDS failure reports. Although this capability is currently not being used, Grand Gulf has future plans to use this system for NPRDS report preparation.

The Grand Gulf staff stated that verbatim compliance with written procedures is stressed at all times with maintenance and operations staff, and personal accountability is emphasized. They

instill a feeling of "ownership" in their operations, maintenance, and engineering support personnel.

Another part of the maintenance philosophy at Grand Gulf is the stated policy that contractors are not employed to perform routine maintenance tasks.

Another key element of the Maintenance Improvement Program at Grand Gulf is its Predictive Maintenance Program. Grand Gulf staff presented a discussion of this program. Basically, it consists of the following:

- (1) Vibration monitoring of rotational equipment.
- (2) Lube oil analysis program.
- (3) Motor-operated valve testing.
- (4) Pump and valve testing program.
- (5) Local leak rate testing.
- (6) Check valve performance monitoring.
- (7) Leakage reduction program.
- (8) Relief valve testing program.
- (9) Scram frequency reduction program.
- (10) Human performance evaluation system (HPES).
- (11) Plant performance monitoring.
- (12) NPRDS.
- (13) Erosion/corrosion program.

Consistent with a stated management goal to make Grand Gulf a top performer, SERI has pursued cross-fertilization between Grand Gulf and those U.S. plants, as well as plants outside the U.S., which are considered among the best performing units in the country. This exchange of technical expertise has taken place at all levels of plant management.

Discussion of the results of root cause analyses of a selected set of Grand Gulf NPRDS failure narratives and the indicator trend led to the identification of a number of issues regarding the NRC staff's proposed maintenance indicator.

- (1) Grand Gulf staff expressed concern that the indicator can be skewed by just a few problem components and thereby show maintenance problems. The NRC staff pointed out that high maintenance equipment can result in indications, but that the indicator looks across a broad spectrum of equipment and a few problems will not make a plant stand out.
- (2) Grand Gulf staff expressed concern about the usage of the staff's proposed indicator. How it will be used and by whom are major concerns which have been voiced in previous project meetings. The NRC staff explained that it would be used by the NRC staff to monitor the industry's progress in maintenance and to provide input to senior management regarding plant performance through the following process. The indicator for a given plant would be compared against the average of its peers, and the indicator trends would also be examined. If a plant's indicator is consistently higher than the peer group average and displays an adverse trend, the plant operational data for the period(s) where the indicator exhibits the unfavorable characteristics would be examined in detail to determine the driving forces behind the component failures experienced during the period. Also, the staff would check into the plant's NPRDS reporting history to determine whether this had

an influence on the indicator. The indicator would be used as a screening tool to trigger a more detailed review of plant data and experience obtainable from many sources (e.g., regional office inspections, maintenance team inspections, diagnostic evaluations, SALPs).

- (3) Grand Gulf staff expressed concern about the characterization of the indicator. In this respect, they were concerned that each individual indicating flag, or even each individual component failure, could be construed as a sign of maintenance ineffectiveness. The NRC staff explained that the indicator was designed as a programmatic indicator, and as such, was not intended to track individual events.
- (4) Discussion of the failure history for the radial well pumps at Grand Gulf led to identification of a case very similar to that of the charging pumps at San Onofre 2 and 3 (i.e., a case where original design engineering support, and traditional maintenance have played roles over time in the performance of equipment). In the case of the radial well pumps, Grand Gulf staff explained that the pumps have had a history of seal failures, in part caused by suspended mud intake from the river water. As river level varied, so did mud intakes. Over a period of time, systems engineering and maintenance staff have formulated an improved maintenance approach, employing PM to "get ahead" of the failures as much as possible, and they expect the pump failure rate to decrease, at which point the proposed indicator would reflect improved performance resulting from a maintenance program improvement. They also plan to erect a building over the pumps to protect them from the elements and facilitate detection of seal failures at the incipient stage. Extensive maintenance had not coped with detecting early failures in the past. However, they pointed out that some random pump failure rate will persist due to "bursts" of sediment in the wells. Complicating the situation is the fact that, at certain times of the year, work cannot be performed on the pumps because of the danger to personnel from the high level of the Mississippi River. Therefore, the Grand Gulf staff was concerned that individual failures of this nature would be considered as caused by ineffective maintenance, and that some failure rate would always be present, since cost-benefit would not support a zero-failure approach to this problem.

The NRC staff explained that for these pumps, the way to demonstrate improvement in the maintenance process was to track the failures before and after those improvements. In this sense, the failures are related to maintenance, especially within the broad context of the Commission's policy statement. Individual failures are also filtered through the indicator algorithm, which tends to screen random failures. However, the staff is exploring additional ways to address the existence of a residual inherent failure rate, such as the use of a tolerance band around the indicator trend.

- (5) Discussion of the failure narratives associated with the Grand Gulf LPRM system led to identification of another similar case. In this situation, the LPRM detectors (which are the first of a kind and unique to the BWR/6 design) were failing with an NPRDS failure description of "out of calibration," and a cause category of "dirty connections." The Grand Gulf staff explained that this condition was not caused by dirty connections as indicated, but actually was a design peculiarity unique to these specific detectors. The detectors were not field repairable, since the internals were not accessible. After much interaction between the NSSS vendor and SERI, it was found that the root cause of the detector going out of calibration was a buildup on the internal connections in the instrument. The corrective action recommended for the problem was a capacitive discharge test which would burn off the buildup on the connections. Since there was no way to anticipate this

type of failure, the Grand Gulf staff eventually implemented a PM task that performs the test before the performance of the instrument progresses to the degraded stage. Grand Gulf staff maintained that failures of this type should not be tracked by the indicator since there was no way that the first failure of the detectors could have been prevented, and then the uniqueness of the design and inaccessibility of the detector internals made it impossible to perform any sort of preventive maintenance until a failure history of the instruments could be compiled over a long enough span of time upon which to base appropriate PM.

- (6) A number of cases were discussed which consisted of the reporting of incipient conditions as degraded failures. The Grand Gulf staff explained that past NPRDS reporting practices may have been somewhat conservative, and commented that incipients would today be recognized and categorized more readily.
- (7) "Ghost ticks" should be eliminated.

The Grand Gulf staff uses the following activities and documents at the frequency indicated to assess maintenance at the Grand Gulf plant.

Daily

- (1) Plant Status Report.
- (2) Plant Tours to monitor maintenance activities and housekeeping/plant material conditions.

Weekly

- (1) Work Order Status Report.
- (2) Plant Contamination Report.
- (3) Maintenance Task Tracking.
- (4) Quality Deficiency Status Report.
- (5) Material Nonconformance Report.

Monthly

- (1) Maintenance Performance Report.
- (2) Performance Monitoring Report.
- (3) Thermal Performance Report.
- (4) Operational Analysis Report.
- (5) Health Physics Summary Report.

Quarterly

- (1) Quality Programs Status and Trend Analysis Report.
- (2) NPRDS Trend Report.

Of particular interest is the Maintenance Performance Report, which is issued on a monthly basis, and is made available to all maintenance personnel for their review. This report tracks the following maintenance-related information: (1) maintenance goals versus actual achievements, (2) major work items during the month, (3) safety report, (4) occupational injury and illness, (5)

LERs, (6) violations (7) radiological deficiency reports, (8) personnel contamination report with details, (9) personnel exposure, (10) quality deficiency reports, (11) security response to insecure doors, (12) maintenance outages, (13) maintenance work status, (14) task tracking, (15) department overtime, and (16) budget.

Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Office for Analysis and Evaluation
of Operational Data

Enclosures: As stated

ENCLOSURE 1

ATTENDANCE LIST

FEBRUARY 20-21, 1990 MEETING

WITH SYSTEMS ENERGY RESOURCES, INCORPORATED

<u>NAME</u>	<u>AFFILIATION</u>
Bill Angle	SERI
W. T. Cottle	SERI
Joel P. Dimmette, Jr.	SERI
Chuck Dugger	SERI
Norman G. Ford	SERI
Randy Hutchinson	SERI
M. A. Krupa	SERI
Ron Moomaw	SERI
Jerry C. Roberts	SERI
Steve Saunders	SERI
Warren J. Hall	SERI
H. O. Christensen	NRC/RII-SRI
Bob Dennig	NRC/AEOD
J. L. Mathis	NRC/RII-RI
T. M. Novak	NRC/AEOD
Patrick O'Reilly	NRC/AEOD
Mark Williams	NRC/AEOD

ENCLOSURE 2

AGENDA

FEBRUARY 20-21, 1990 MEETING WITH SYSTEM ENERGY RESOURCES, INCORPORATED
REGARDING MAINTENANCE INDICATORS

- (1) NRC presentation - Performance Indicator Development, Analysis Assumptions and Purpose of Meeting.
- (2) Discussion of Interim Indicator Results
- (3) NPRDS Reporting of Component Failures Involving Outage-Dominating Equipment.
- (4) Root Cause Analysis of Individual Component Failures of Outage-Dominating Equipment.
- (5) Discussion of SERI's Programs/Applications Trending Equipment Failures and Failure Causes as They Relate to Maintenance
- (6) Comparison of Maintenance Trend Information
 - (a) Trends Calculated with the NRC's Indicator
 - (b) Trends Calculated with SERI's Indicator(s)

MEMORANDUM FOR: Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

FROM: Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

SUBJECT: SUMMARY OF FEBRUARY 28 - MARCH 1, 1990 MEETING WITH
NORTHEAST UTILITIES REGARDING MAINTENANCE INDICATOR
DEVELOPMENT

On February 28 - March 1, 1990, staff from AEOD, Northeast Utilities (NU), NU's operating companies, and NUMARC met at the Northeast Utilities offices in Berlin, Connecticut to exchange information on maintenance indicators. This meeting was part of the NRC/Industry Maintenance Indicator Demonstration Project. A list of meeting attendees is contained in Enclosure 1. Enclosure 2 provides the meeting agenda. On March 1, 1990, the staff also toured the Haddam Neck nuclear plant.

The NRC staff presented the detail and logic which were followed during the development of the staff's proposed maintenance Indicator (MI). The purpose of this presentation was to familiarize utility personnel with all of the detail necessary for understanding the proposed indicator.

In their opening remarks, NU discussed their management approach for the Millstone and Haddam Neck sites. Each unit at each site is operated as an independent entity under the direction of the unit superintendent. Within this framework of independence, each unit has its own maintenance staff and facilities, and tracks cents per kilowatt at the bus bar. However, certain major aspects of the maintenance policy are established at the corporate level. For example, it is NU's policy that their nuclear plants are not allowed to enter a limiting condition for operation (LCO) solely for the purpose of performing planned maintenance. NU also has established a system-wide Production Maintenance Management System, or PMMS.

PMMS, which was first placed into operation almost ten years ago on a phased implementation basis, is now almost completely implemented, and is used to track maintenance at all of their electrical generating stations, fossil as well as nuclear. It is a computerized maintenance tracking system with fairly extensive capabilities. NU has used PMMS to: (1) identify plant equipment by means of a system-wide common nomenclature, (2) establish a dedicated planning function at each of their generating facilities, (3) establish a common maintenance work order mechanism across facilities (4) provide a uniform work priority system, (5) provide resource forecasting and tracking on a consistent system-wide basis, and (6) provide a database of production-related information in support of management decisions.

There is an important difference between PMMS and the staff's proposed indicator. PMMS tracks work orders and associated information. The staff's proposed indicator tracks equipment failures. In order to extract failure data from PMMS, engineering analysis supported by standardized guidance, such as found in NPRDS, is required.

NU employs PMMS to generate the PMMS Performance Report on a quarterly basis. This report trends a number of indicators which NU uses to monitor maintenance performance at their plants. The contents of the PMMS Performance Report are as follows: (1) Preventive Maintenance Percentage, (2) Corrective Maintenance Backlog, (3) CM Backlog Indicator, (4) Preventive Maintenance Performance, (5) Twenty Most Worked on Components, (6) Ten Most Worked on Systems, and (7) Rework Percentage. Performance indicators have been used in the NU organization as management tools for about five years.

NU considers items (1), (3), and (7) above their primary maintenance indicators. The Preventive Maintenance Percentage displays a trend of the preventive work accomplished by a task department as a percentage of the total maintenance work. The CM Backlog Indicator is an indicator which was developed internally by NU. This indicator displays a curve of CM work that indicates the condition of the work backlog and the clearing rate time constant. This consists of the number of priority 3 non-outage CM work orders that are open at a point in time. This process indicator is not used to provide diagnostic feedback to the organization at the working level. The Rework Percentage displays a trend of CM and other work orders that failed a retest by operations by quarter.

NU also produces a quarterly Utility Performance Report for NU management which contains (1) capacity factor, (2) forced outage rate, (3) thermal performance (unit heat rate), (4) LERs, (5) unplanned automatic reactor trips, (6) plant design change evaluation status, (7) plant design change request status, (8) solid radioactive waste generated, (9) collective man-rem exposure, (10) total skin and clothing contaminations, (11) PMMS Indicators #1 and #3, (12) NRC inspections - violations and severity level, (13) outstanding INPO recommendations, (15) NE&O contractors, and (16) Enforcement conferences.

During a discussion about maintenance during outages, NU stated that each of its four units (Haddam Neck, Millstone Units 1, 2, and 3) prepares an outage report 30-60 days after the completion of a refueling outage which documents lessons learned during the outage. Within the NU organization, outage planning is done on a unit level, as opposed to the corporate level. Usage of the NPRDS database by the NU organization was also discussed. Currently, there is a task force within the organization evaluating how NPRDS could best be used to enhance plant operations. In the past, the NU organization has not used NPRDS data very much, and since it is prepared at the corporate level, unit maintenance managers are generally not familiar with the NPRDS data for their units.

Prior to the meeting NU was provided with examples of NPRDS-reported failures, used in constructing the proposed indicator, that the staff categorized as maintenance-related. The discussion of the history behind these failures indicated that plant staff were aware of component performance problems and had often made various adjustments to the maintenance programs in response. However, the utility determination that the performance problem originated in a marginal application of a component design resulted in their concluding that the failures were not related to maintenance. Several examples are discussed below. Since the frequency of such failures is being controlled by the maintenance program, the staff believes an increase or decrease in such failures is a measure of maintenance effectiveness.

There were a number of failures of a reactor recirculation pump pressure switch at Millstone 1 that the utility had attributed to wearout in the NPRDS failure records. On other occasions, the same switch had drifted out of specification due to unknown causes. The NU staff explained

that this particular switch was a design problem that had existed since the plant was built. It was essentially a misapplication of design which utility management had made a decision to live with, and had charged the maintenance department to keep the equipment operating, given this deficiency. NU stated that a temporary solution to the problem had been implemented. This consisted of an increased surveillance frequency which was established to catch the instrument drift while it was still in the incipient stage before the instrument's function became degraded.

Another example consisted of three failures of main feedwater pump seals at Millstone 3. In this case, according to the utility, the original pump seal design was marginal, especially at low flow conditions, when flashing led to overheating of the seal and subsequent failure. As explained, this was a misapplication of design, for which utility management had decided that continuing to fix seal failures was more cost-effective than making a major design modification. The maintenance organization was then faced with the responsibility of keeping the pumps in operating condition in spite of the seal problem. These failures were either categorized as due to unknown causes or attributed to design problems.

During the meeting, NU staff expressed a number of concerns about the usefulness of the proposed indicator. The need for resources to respond to another indicator (fielding questions from the NRC and various PUCs), with the likely outcome that these resources would be diverted from existing staff now devoted to utility performance trending, was a major concern. In the NRC staff's view, the intended use of the proposed indicator should help allay this concern. The utility staff also felt that the proposed indicator was difficult to interpret, and offered little diagnostic information for corrective action. As a programmatic indicator, diagnostic capability was not a prime concern originally, but comments from other Demonstration Project participants have resulted in modifications, such as cutting the indicator by component type, to enhance its usefulness to plant staff.

The utility staff also felt that the quality of NPRDS reporting may not be high enough for this important use. The tendency for NPRDS data to show concentrations of failures discovered in outages, and the potential for penalizing proactive maintenance if incipient conditions were reported as degraded failures were raised as issues. NRC staff actions to adjust indicator interpretation based on various segments of the fuel cycle, and examination of reporting patterns in interpreting the indicator were cited by the staff as potential remedies for these concerns.

Lastly, NU staff were concerned about use of a single indicator to track maintenance. The staff explained that no indicator is used in the absence of other information, including other indicators and information from various types of inspections. Further, the proposed indicator was developed as an example of the type of indicator needed, and was not intended to be the only indicator based on component failure data.

Mark H. Williams, Chief
Trends and Patterns Analysis Branch
Office for Analysis and Evaluation
of Operational Data

Enclosure: As stated

ENCLOSURE 1
ATTENDANCE LIST
FEBRUARY 28-MARCH 1, 1990 MEETING
WITH NORTHEAST UTILITIES

<u>NAME</u>	<u>AFFILIATION</u>
Bob Dennig	NRC/AEOD
T. M. Novak	NRC/AEOD
Patrick O'Reilly	NRC/AEOD
Mark Williams	NRC/AEOD
Thomas Laats	EG&G-Idaho
Howard Stromberg	EG&G-Idaho
Peter M. Austin	Northeast Utilities
Mike Ciccone	Northeast Utilities
Tom Dente	Northeast Utilities
Neil Herzig	Northeast Utilities
William J. Nadeau	Northeast Utilities
Wayne D. Romberg	Northeast Utilities
Jere LaPlatney	Connecticut Yankee Atomic Power Company
Neil Bergh	Northeast Nuclear Energy Company
Peter J. Przekop	Northeast Nuclear Energy Company
Ron Rothgeb	Northeast Nuclear Energy Company
Walt Smith	NUMARC
Tom Tipton	NUMARC

ENCLOSURE 2

AGENDA

FEBRUARY 28-MARCH 1, 1990 MEETING WITH NORTHEAST UTILITIES

REGARDING MAINTENANCE INDICATORS

- (1) NRC presentation - Performance Indicator Development, Analysis Assumptions and Purpose of Meeting.
- (2) Discussion of Interim Indicator Results
- (3) NPRDS Reporting of Component Failures Involving Outage-Dominating Equipment.
- (4) Root Cause Analysis of Individual Component Failures of Outage-Dominating Equipment.
- (5) Discussion of Northeast Utilities' Programs/Approaches for Trending Equipment Failures and Failure Causes as They Relate to Maintenance
- (6) Comparison of Maintenance Trend Information
 - (a) Trends Calculated with the NRC's Indicator
 - (b) Trends Calculated with Northeast Utilities' Indicator(s)

APPENDIX B**MAINTENANCE INDICATOR DEMONSTRATION PROJECT DETAILS**

This Appendix discusses the details of a typical meeting with one of the utility participants in the Demonstration Project. It also contains a roster of all the utility staff and consultants that participated in these meetings, along with copies of the NRC standard presentation slides used during each of these individual meetings.

APPENDIX B

MAINTENANCE INDICATOR DEMONSTRATION PROJECT DETAILS

The second meeting of the NRC/Industry Maintenance Indicator Demonstration Project took place on October 13, 1989. At this meeting, each of the six project utility-participants presented their preliminary comments regarding the NRC staff's proposed Maintenance Indicator and summarized the results of their reviews of the plant-specific set of NPRDS component failures which the NRC staff had provided to each utility-participant at the first meeting of the project on September 12, 1989. In order to obtain more details concerning each utility's review, the NRC staff held a series of two-day meetings with each of the six project utility-participants over the five-month period November 1989-March 1990. These meetings were held either at the utility's headquarters office or at one of the utility's plant sites. Table B-1 shows the date and location for each of the six meetings. Prior to each of the six meetings, the NRC staff sent a letter to the senior management of the respective utility-participant acknowledging the meeting date and transmitting a proposed agenda for the meeting. To ensure consistency in the information discussed during the meetings, a standard agenda was used for the series of six meetings. Table B-2 contains the standard meeting agenda. Table B-3 identifies the participating utility staff and consultants who participated in the six meetings.

Typically, each meeting began with introductory remarks by the utility's Senior Vice President - Nuclear or his designated representative. The NRC staff then gave a detailed presentation on the development and validation of the staff's proposed Maintenance Indicator. Using a standard set of slides (Table B.4), the NRC staff described the proposed indicator concept, explained how the indicator was constructed, discussed the indicator validation process, and for illustrative purposes, presented the indicator for a typical plant. The staff's presentation was designed to familiarize utility personnel with all of the details necessary for understanding the indicator.

Next, the NRC staff presented the indicator for the utility's plants. In the discussion that ensued, the NRC staff related to the utility staff their interpretation of the specific plant's indicator; whether the indicator for the plant was higher than, below the average, or average relative to the average for that plant's peer group, and whether any adverse trends in the indicator were noted. In turn, the utility staff provided their comments on the proposed indicator based on their review of the failure data which were monitored by the indicator. This discussion of the indicator was usually followed by a discussion of the NPRDS - the utility's NPRDS reporting philosophy (tendency to over report vs. under reporting), how the reporting is handled (on a unit basis or at the corporate level), and who determines what information from the work orders is reported to NPRDS.

The NRC staff and the utility staff then embarked on a detailed discussion of the root cause of a specific group of NPRDS failure records that contributed to the indicating flags generated by the NRC staff's proposed indicator. A sample set of failures used in this discussion is shown in Table B.5. The records discussed consisted of failures which the utility had categorized as attributable to causes other than maintenance (e.g., engineering/design, wearout, unknown, random failure), but the NRC staff, applying the scope of the Commission's definition of maintenance as specified in its Revised Maintenance Policy Statement issued December 4, 1989, had classified as maintenance-related. Generally, the staff's review of the NPRDS failure narratives for the records in question had resulted in about 70-80% of the failures reviewed being ascribed to maintenance. In contrast, the utility's review of the same set of failure records, using all of the detailed information about the

individual failures at the utility's disposal and applying the industry's much narrower view of the definition of maintenance, usually resulted in a much smaller percentage (5-15%) being characterized as maintenance-related. Typically, the majority of the failures were attributed to wearout or to unknown causes.

Out of these discussions arose issues such as whether first failures or failures of components that had been in service for relatively long periods of time should be classified as maintenance-related. Another issue that was identified during these discussions was whether the failure of a problem component for which a management decision had been made to continue to maintain the component in operable condition as opposed to implementing a major (and, therefore expensive) design modification (e.g., the charging pumps at San Onofre 2 and 3) should be captured as a maintenance-related failure.

A related issue which originated from these discussions was the discovery that, in the interest of conservatism, most of the utilities in some cases had reported what were apparently incipient conditions as degraded failures. Such over reporting would have a direct adverse effect on the NRC staff's proposed indicator, since the indicator was originally designed to consider only degraded and immediate failures, not incipient conditions.

These discussions enabled each of the two parties to better understand the other's perspective of maintenance. Sometimes the utility staff changed their position on a given failure, and agreed with the NRC staff that the failure was maintenance-related. In other cases, the NRC staff agreed with the utility's position. The end result of these discussions was generally that the percentage of the total number of failures attributed to maintenance-related causes might change by as much as 10%. However, as far as the NRC staff was concerned, the majority of the component failures that comprised the indicator was still maintenance-related, and their original conclusion on this issue was still valid.

The utility staff then discussed their programs for monitoring trends in maintenance. For the most part, these consisted of plant level performance indicators which track the maintenance process (termed process indicators in AEOD/S804A and S804B). Included in this category are the three INPO performance indicators that are related to maintenance. These are Corrective Maintenance Backlog, Ratio of Preventive Maintenance to Total Maintenance, and Percentage of Preventive Maintenance Missed. Some utilities track these indicators in a separate formal report which the plant staff prepares for senior management on a regular basis. Other utilities include the maintenance-related indicators in the overall plant performance indicator report that is issued periodically to management. One utility has developed its own maintenance indicator which it tracks in a special maintenance performance report that is issued on a periodic basis. Another utility did not have any formal report which tracked maintenance indicators.

Finally, the last item on the meeting agenda was a comparison of maintenance trend information calculated with the NRC staff's proposed indicator and the maintenance trend information calculated with the utility's indicator(s). In this case, the only available trend information was that provided by the NRC staff's proposed indicator. None of the utilities visited have a programmatic indicator that is used to routinely monitor equipment performance and feed back that information to the organization at the working level. Consequently, the only discussions which took place with each utility regarding this agenda item were primarily qualitative.

Following all of the meetings except one, the NRC staff was given a tour of the plant site conducted by the utility staff.

Table B-1

NRC Staff Meetings with Individual Project Utility-Participants

<u>Meeting Dates</u>	<u>Project Utility-Participant</u>	<u>Meeting Location</u>
11/29-11/30/89	Commonwealth Edison Company	Commonwealth Edison Office - Chicago, IL
12/12-12/13/89	Southern California Edison Company	San Onofre Plant Site
01/09-01/10/90	Duke Power Company	Oconee Plant Site
01/18-01/19/90	Rochester Gas and Electric Corporation	Ginna Plant Site
02/20-02/21/90	Systems Energy Resources, Inc.	Grand Gulf Plant Site
02/28-03/01/90	Northeast Utilities	Northeast Utilities Office - Berlin, CT

Table B-2

Agenda Used in Meetings with Six Project Utility-Participants

- (1) NRC Presentation - Performance Indicator Development, Analysis Assumptions and Purpose of Meeting.
- (2) Discussion of Interim Indicator Results.
- (3) NPRDS Reporting of Component Failures Involving Outage-Dominating Equipment.
- (4) Root Cause Analysis of Individual Component Failures of Outage-Dominating Equipment.
- (5) Discussion of Project Utility-Participant's Programs/Approaches for Trending Equipment Failures and Failure Causes as They Relate to Maintenance.
- (6) Comparison of Maintenance Trend Information.
 - (a) Trends Calculated with the NRC's Indicator.
 - (b) Trends Calculated with the Utility-Participant's Indicator(s).

Table B-3

Utility Staff and Consultants Participating In Demonstration Project Meetings

<u>Name</u>	<u>Affiliation</u>
Jere LaPlatney	Connecticut Yankee Atomic Power Company
Ron Rothgeb	Northeast Nuclear Energy Company
Neil Bergh	Northeast Nuclear Energy Company
Peter J. Przekop	Northeast Nuclear Energy Company
Tom Dente	Northeast Utilities
Mike Chiccone	Northeast Utilities
Neil Herzig	Northeast Utilities
Peter Austin	Northeast Utilities
William Nadeau	Northeast Utilities
Wayne Romberg	Northeast Utilities
Paul Kuhel	Commonwealth Edison Company
Martin G. Kief	Commonwealth Edison Company
Don Eggett	Commonwealth Edison Company
Robert Lazon	Commonwealth Edison Company
Thomas Kovach	Commonwealth Edison Company
Lee A. Sues	Commonwealth Edison Company
Brian Katz	Southern California Edison Company
Don Evans	Southern California Edison Company
Ralph Sanders	Southern California Edison Company
Robin Baker	Southern California Edison Company
L. D. Brevig	Southern California Edison Company
Fred Briggs	Southern California Edison Company
Jack Rainsberry	Southern California Edison Company
Loyd Wright	Southern California Edison Company
R. H. Bridenbecker	Southern California Edison Company
Harold Ray	Southern California Edison Company
M. E. Rodin	Southern California Edison Company
Barbara Aden	Southern California Edison Company
Bob Levine	Southern California Edison Company
Wayne Hallman	Duke Power Company
Bill Foster	Duke Power Company
Ronnie Henderson	Duke Power Company
Sam Hamrick	Duke Power Company
Stuart Lindsey	Duke Power Company
Dendy Clardy	Duke Power Company
Bill Angle	Systems Energy Resources, Incorporated
W. T. Cottle	Systems Energy Resources, Incorporated
Joel P. Dimmette, Jr.	Systems Energy Resources, Incorporated
Chuck Dugger	Systems Energy Resources, Incorporated
Norman G. Ford	Systems Energy Resources, Incorporated
Randy Hutchinson	Systems Energy Resources, Incorporated
M. A. Krupa	Systems Energy Resources, Incorporated
Ron Moomaw	Systems Energy Resources, Incorporated
Jerry Roberts	Systems Energy Resources, Incorporated
Steve Sanders	Systems Energy Resources, Incorporated

Table B-3 (Continued)

Utility Staff and Consultants Participating In Demonstration Project Meetings

<u>Name</u>	<u>Affiliation</u>
John Fischer	Rochester Gas & Electric Corporation
Mark Flaherty	Rochester Gas & Electric Corporation
James Huff	Rochester Gas & Electric Corporation
Bob Smith	Rochester Gas & Electric Corporation
Tom Marlow	Rochester Gas & Electric Corporation
Herb Van Houte	Rochester Gas & Electric Corporation
Gerald Wahl	Rochester Gas & Electric Corporation
Joe Widay	Rochester Gas & Electric Corporation
Bill Zornow	Rochester Gas & Electric Corporation
Jim Huzdovich	ATESI
John Wilson	ATESI

Table B.4

NRC Standard Presentation Slides

<u>Slide No.</u>	<u>Subject</u>
1	Current Indicators - Simple List
2	P. I. Report page - Finger Charts
3	P. I. Report page - Trend Charts
4	P. I. Report page - Part II event descriptions
5	Commission Direction on Maintenance PIs - Background
6	LER Causes & Corrective Actions - Ind. Avg. w/maintenance
7	MEI Summary Description - Failure rate increase with causes
8	MEI Trend - totals of prior slide portrayed over time for a plant
9	ODE Equipment Selection Basis
10	MEI ODE Systems Selected
11	Key Aspects of the Indicator
12	Indicator Display candidate (with cumulative curve)
13	Validation Activities
14	MEI vs. Cause Code Correlation
15	MEI BWR & PWR Populations (2 yr. totals)
16	MEI Trend for PWRs (2 yr. regression line)
17	Demonstration Project Background
18	Demonstration Project - Utility membership

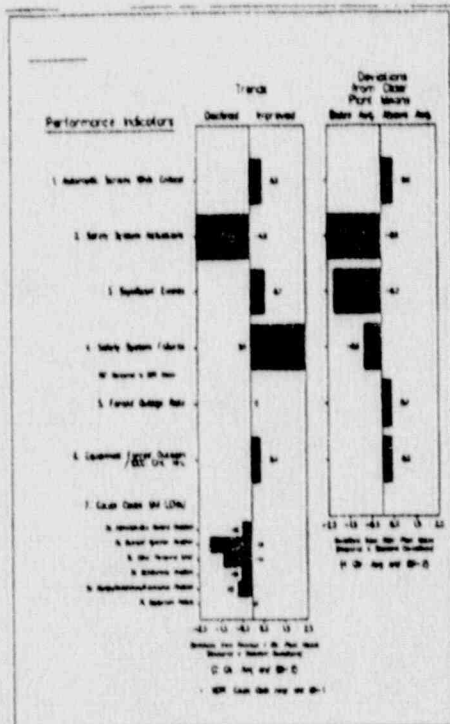
Slide 1

CURRENT INDICATORS

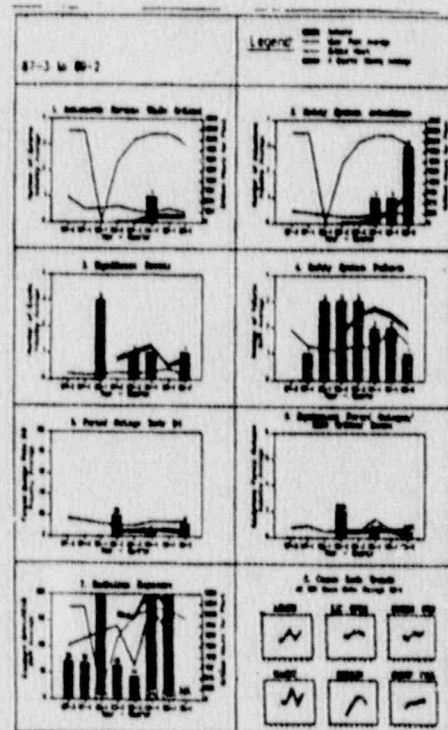
- Automatic Scrams While Critical
- Safety Systems Actuations
- Significant Events
- Safety System Failures
- Forced Outage Rates
- Equipment Forced Outages/1000 Crit. Hrs.
- Collective Radiation Exposure*
- Cause Codes

*Provided by IRPO

Slide 2



Slide 3



Slide 4

PI EVENTS FOR 80-3

803 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 DECK: POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 140000 00 0000

807 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 SYSTEM: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 DECK: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 PLANTED COVER ON SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS
 REPLACED.

807 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 SYSTEM: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 DECK: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 PLANTED COVER ON SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS
 REPLACED.

807 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 SYSTEM: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 DECK: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 PLANTED COVER ON SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS
 REPLACED.

PI EVENTS FOR 80-4

804 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 DECK: SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS IN UPPER STORAGE YARD.
 AVAILABLE TO UPPER STORAGE YARD.

804 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 DECK: SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS IN UPPER STORAGE YARD.
 AVAILABLE TO UPPER STORAGE YARD.

807 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 SYSTEM: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 DECK: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 PLANTED COVER ON SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS
 REPLACED.

807 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 SYSTEM: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 DECK: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 PLANTED COVER ON SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS
 REPLACED.

PI EVENTS FOR 80-5

805 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 DECK: SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS IN UPPER STORAGE YARD.
 AVAILABLE TO UPPER STORAGE YARD.

807 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 SYSTEM: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 DECK: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 PLANTED COVER ON SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS
 REPLACED.

807 01/14/80 LEAF NUMBER 01 700 10701 POWER: 100
 SYSTEM: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 DECK: 2100 POLYMER COVER OVER BLADES OF MULTIPLE SPEC 25 DECKS IN UPPER STORAGE YARD.
 PLANTED COVER ON SPEC 25 DECKS IN UPPER STORAGE YARD. SPEC 25 DECKS
 REPLACED.

Slide 5

MAINTENANCE MONITORING

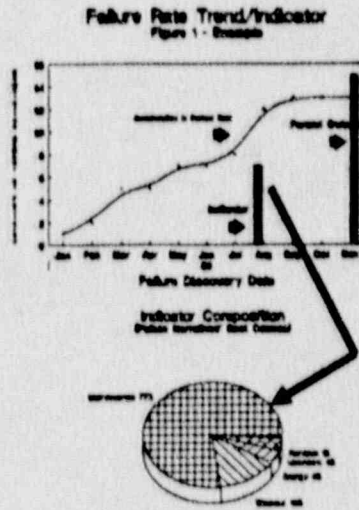
- COMMISSION DIRECTION - MAINTENANCE INDICATORS
 - AEOD 8504A-Process Indicators (10/88)
 - AEOD 8504B-Effectiveness Indicators (2/89)
 - Follow-up development
- MAINTENANCE RULEMAKING ASSOCIATION
 - Monitor and Inspection Function
 - Regulatory Guide and Policy Statement
- 18 MONTH INTERVAL
 - Maintenance Indicator Use
 - Staff Evaluation
- INTERACTION WITH INDUSTRY
 - Commission Intent

Slide 6

**CORRECTIVE ACTIONS
EVENTS WITH MAINTENANCE CAUSES**



Slide 7



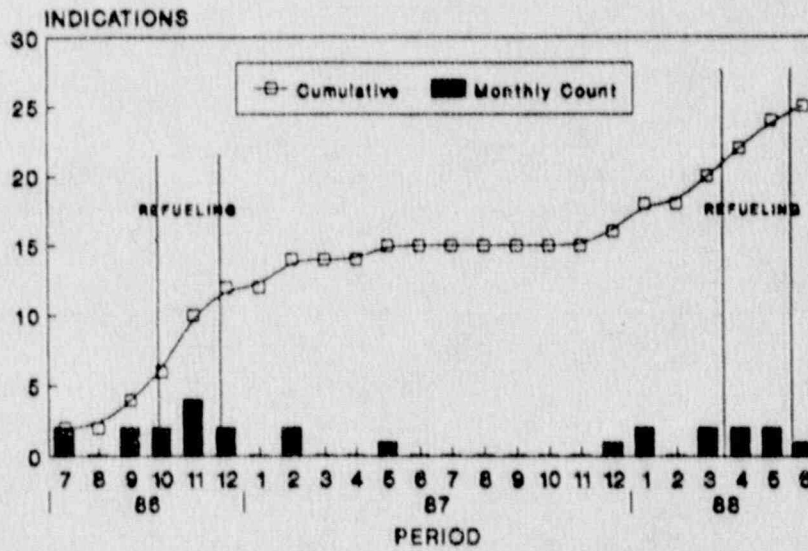
Maintenance Effectiveness Monitoring

Office for the Analysis and Evaluation of Operational Data

U.S. Nuclear Regulatory Commission

Slide 8

MAINTENANCE EFFECTIVENESS INDICATOR (TREND)



Slide 9

ODE SYSTEM AND COMPONENT SELECTION

- SYSTEM AND COMPONENT SELECTION
 - 10 to 12 systems per plant per vendor
 - 800 to 2000 components per plant
 - 28 to 31 percent of reportable components per vendor
- LIST COMPARED AGAINST
 - NUREG-0020 (Gray Book)
 - Stoller report
 - NERC report

Slide 10

MEI SYSTEMS MONITORED

BWR

- Reactor Restrictions
- Reactor Protection
- Control Rod Drive
- Condensate
- Feedwater
- Main Steam
- Reactor Steam Supply Startup -
Normal, Trip, etc.
- Reactor Service Water
- Plant AC Power Distribution
- Instrument AC Power

PWR

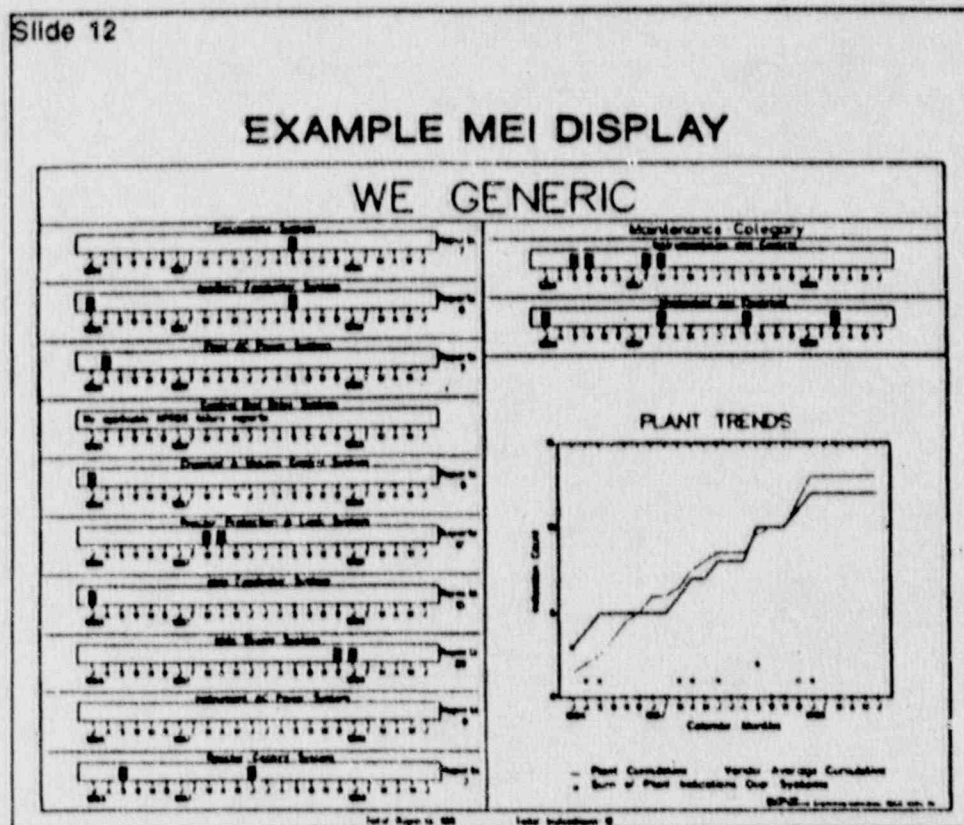
- Reactor Control
- Reactor Protection
- Control Rod Drive
- Condensate
- Feedwater -
Main, Auxiliary/Emergency
- Main Steam
- Plant AC Power Distribution
- Instrument AC Power
- Charging Subsystem

Slide 11

**MAINTENANCE EFFECTIVENESS INDICATOR
(KEY ASPECTS)**

- NORMALIZED TO PLANT REPORTING PRACTICES
 - Not absolute value
(Not detrimental to back reporting)
- MONITORED WITHIN SYSTEM ON A MONTHLY BASIS IS ESSENTIAL
- CONSTRUCTED TO CREATE A RELATIVELY COMPLETE DATA SET FOR EVALUATION
 - Discussion with plant MPROS coordinators
 - Equipment selection criteria
(Major components important to power generation in MPROS scope identified)
 - Included failures not included
(Reduced reporting variability)
(Allow plants to monitor more closely)
- OTHER SYSTEMS AMENABLE TO SAME APPROACH

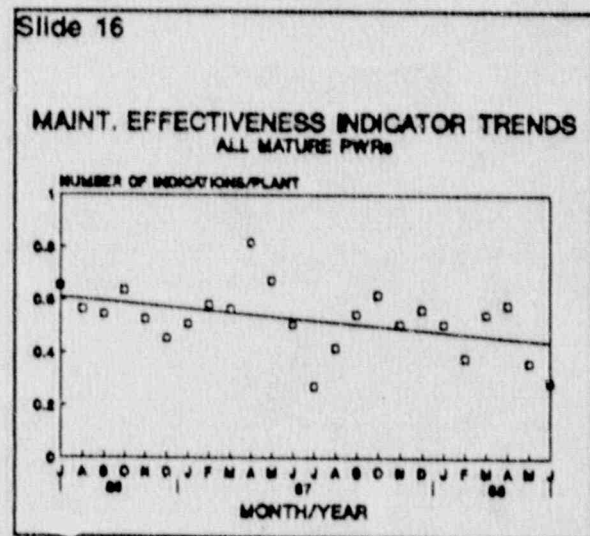
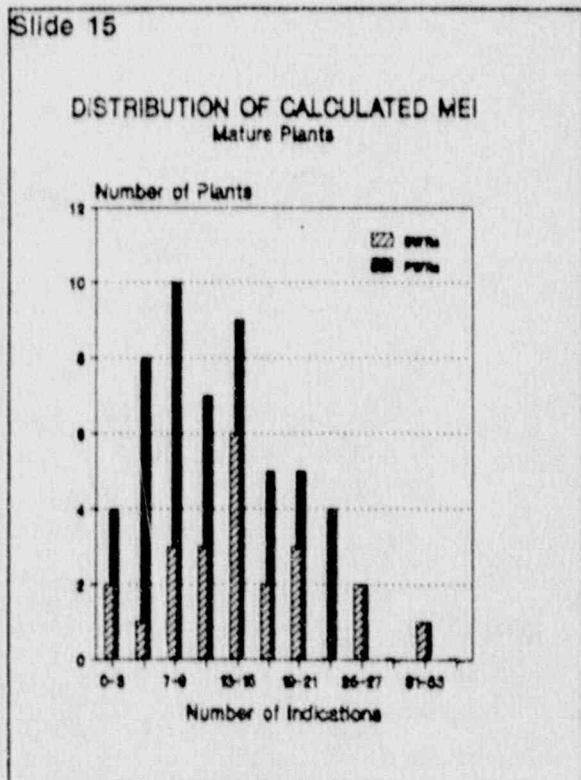
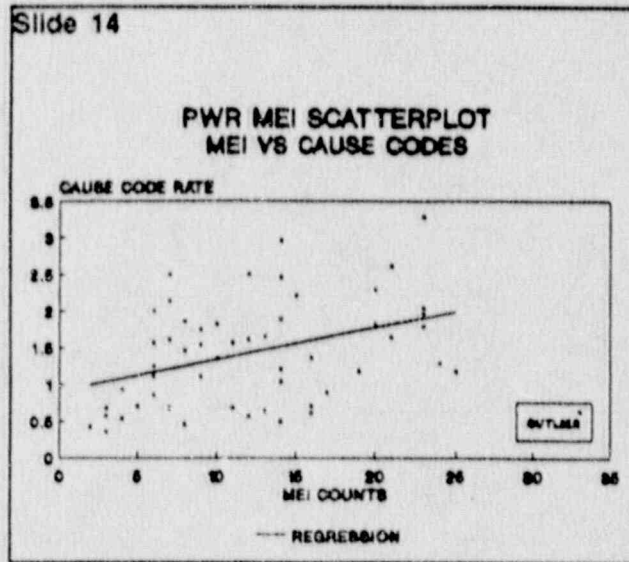
Slide 12



Slide 13

VALIDATION ACTIVITIES

- ROOT-CAUSE ANALYSIS
- LER CORRELATION ANALYSIS
- INSPECTION REPORT ANALYSIS
- OTHER CORRELATION ANALYSES
 - Time Lag
- CORRELATIONS WITH OTHER STUDIES
 - FRV
 - MFP



Slide 17

NRC/UTILITY DEMONSTRATION PROJECT

- **INDUSTRY MEETINGS**
 - Initial meeting - July 19, 1989
NUMARC agreement on coordination
 - Task Group meeting - September 12, 1989
AEOD presents results and provides plant-specific data.
 - October 13, 1989 - Industry feedback
Issues - Definitions and Reporting
 - Utility Visits - Trend Comparison and
evaluation issues in controversy
 - Schedule - Development Completion - 3/90

Slide 18

DEMONSTRATION PROJECT

- **INDUSTRY MEMBERSHIP**
 - Commonwealth Edison
 - Duke Power
 - Mississippi Power & Light
 - Northeast Utilities
 - Rochester Gas & Electric
 - Southern California Edison
 - INPO
 - NUMARC

Table B.5

Examples: Failure Narratives Categorized as Maintenance

1. **Event:** CVCS boric acid blender control isolation valve failure
Discovery Date: 9/4/87
Cause Cat.: Unknown
Cause Desc.: Normal/Abnormal Wear; Corrosion
- Narrative:** The boric acid to boric acid blender control isolation valve was found not fully closed after conducting a procedure. The unit was being cooled down. The valve internals were heavily corroded and eroded. WR 131670. The seat ring, gasket, and bonnet were replaced. Reassembled and tested the valve for proper operation.
- Comment:** This valve had a previous failure on 8/19/87 when the valve plug was discovered broken off and the valve seat was badly eroded; then the plug assembly, seat ring, and cage were replaced.
2. **Event:** CVCS seal water injection filter inlet isolation valve failure
Discovery Date: 11/14/87
Cause Cat.: Unknown
Cause Desc.: Out of Mechanical Adjustment; Previous Repair/Installation Status
- Narrative:** Seal water injection filter 1A inlet isolation valve was leaking. It was found by an operator while the unit was coming up in power after a refueling outage. The valve diaphragm was crushed and the valve disc had wrong measurements; the root cause was unknown. The disc and valve diaphragm were replaced; the valve was reassembled, and proper operation and no leakage were verified. (WR 132854)
- Comment:** The cause description associates this failure with previous repair.
3. **Event:** CVCS charging flow control valve operator failure
Discovery Date: 3/22/87
Cause Cat.: Unknown
Cause Desc.: Out of Calibration
- Narrative:** Chemical and Volume Control charging flow control valve was swinging when pump "A" was placed into service. The valve stabilized when pump "B" was placed into service. The unit was at full power. The cause was improper adjustment of the gain on the control valve controlling circuit card. The circuit card gain was readjusted to the proper value for control valve operation. The operator performed as required. WR 130726
- Comment:** The improper adjustment of the gain indicates this may have been a maintenance-related failure.
4. **Event:** CVCS volume control tank valve operator failed
Discovery Date: 8/16/87
Cause Cat.: Unknown
Cause Desc.: Burned/Burned Out; Mechanical Damage/Binding
- Narrative:** The volume control tank no. 1 outlet control valve would not open after closing for safety injection during startup. The motor burned up opening. The valve operator had a broken drive nut apparently broken when pulling the disc off its seat. The operator had put excessive dose thrust on the valve. The burned up motor and broken drive nut were replaced. The actuator was reset to ensure proper torque output. WR 95103. WR 94986. WR 131717.
- Comment:** The problems described in the narrative of the valve failure suggest that the failure may have been maintenance related.
5. **Event:** CVCS cation bed demineralizer supply valve stem broke
Discovery Date: 3/22/88
Cause Cat.: Unknown
Cause Desc.: Normal/Abnormal Wear; Aging/Cyclic Fatigue
- Narrative:** The cation bed demineralizer 1 in the supply line from the mix bed demineralizer valve was found inoperable by the operator. The unit was at power. The stem broke on the valve and pulled out of the assembly. The valve had worn internals. WR 134361. The bonnet assembly, gaskets, diaphragm, and O-rings were replaced; the valve was torqued and functionally verified as in proper operation.
- Comment:** This valve failed previously on 11/4/87 when a chain link to the valve operator fell off a sprocket; also the valve was leaking due to normal wear of the internals; two master links in the chain were replaced and a new diaphragm stem and bonnet were installed.
6. **Event:** CVCS valve operator on the charging flow control valve failed
Discovery Date: 7/7/87
Cause Cat.: Unknown
Cause Desc.: Out of Calibration
- Narrative:** The charging flow control valve was leaking by. It was found by an operator while the unit was being refueled. The valve operator was not closing fully due to a low air supply pressure. The valve was not seating properly. WR 065861. The air supply pressure was adjusted and set the valve travel. Checked for proper operation.
- Comment:** The improper air supply pressure indicates that this failure may have been maintenance related.
7. **Event:** Reactor Protection and Logic system SG flow transmitter (MCFFT5060) out of calibration
Discovery Date: 3/13/86
Cause Cat.: Unknown
Cause Desc.: Out of Calibration
- Narrative:** Steam generator 1D feedwater flow transmitter for channel #1 failed low. The plant was normally operating. The transmitter was found out of calibration for an unknown reason. The transmitter was recalibrated. W/R 122361.
- Comment:** This transmitter had the same problem twice previously on 3/7/86 and 1/21/86. In each of these cases the transmitter was recalibrated and the cause category was unknown.
8. **Event:** Reactor Protection and Logic system main steam flow transmitter (MSMFT5050) out of calibration and water in junction box
Discovery Date: 9/18/87
Cause Cat.: Unknown
Cause Desc.: Foreign/Incorrect Material; Out of Calibration
- Narrative:** Main steam flow transmitter channel No. 2 from steam generator "C" was found out of calibration during a refueling surveillance test. The flow transmitter had water in the pull junction box below the transmitter. The transmitter was out of tolerance by 6.7% high throughout the range. The flow transmitter pull junction box was drained, all mechanical connectors were tightened, and the transmitter was calibrated for proper operation. WR 065981
- Comment:** The presence of water in the junction box and the need to tighten all connections indicate that this failure may have been maintenance related.

APPENDIX C
INDICATOR TECHNICAL ISSUES

Appendix C contains details of the algorithm methods being explored to address concerns expressed during the Demonstration Project over how the proposed indicator introduced "ghost" indications and suppressed "shadow" indications.

APPENDIX C

INDICATOR TECHNICAL ISSUES

As initially presented in AEOD/S804B, the maintenance indicator used a simple computational algorithm that compared failure counts over a sliding five-month time interval. Only when a selected threshold value was exceeded did it flag the comparative change as being significant. The indicator was based on selected components in selected systems and it trended the summation of the cumulative indicator flags for each system considered based on all component failure indications within these selected systems. All failures of the equipment as reported to NPRDS were included if they were of an immediate or degraded nature, reported incipient failures were excluded. As a result of this initial construction and bases, several compromises were introduced into the indicator's precision and usefulness to utility staffs. These included being a system-based rather than a component-based indicator, tracking of only some of the systems reportable to NPRDS with exclusion of most safety systems, introduction of "ghost" indications and suppression of "shadow" indications. During the Demonstration Project, several methods and modifications have been explored to address these problems.

Algorithm Refinements

The algorithm used in constructing the indicator was very simple. It processed the selected NPRDS failures by first counting the failures by calendar month using the NPRDS failure discovery date. It then looked for a relative increase in the failure frequency within a moving five-month window, comparing the average number of failures in the last two months to the average number of failures in the first three months. When this difference exceeded a fixed threshold value, a marker was assigned to the latest month of the five-month period. If the failure count for the fourth month is high enough, however, the overall average for the fourth and fifth months can be great enough to produce an indication in the fifth month even when there were zero failures in the fifth month. This "ghost tick" phenomena was identified early in the development of the proposed indicator but the formula was not modified since it was felt that sensitivity to the magnitude of a failure jump increase was desirable and the precise placement of indications was not critical.

Conversely, the original calculation averaging also led to some significant failure increases not generating indications. This "shadowing" of indications occurred when significant increases in failures in a preceding month, when included in the three-month average used in the algorithm, overshadowed the two-month average associated with the later failure increase. This phenomenon was also recognized during the indicator development but this lack of indication was considered to not be a problem given the anticipated way that the indicator was meant to be used.

Two revised calculational methods are being explored to eliminate the "ghost ticks" while capturing "shadow ticks", thereby yielding a more precise set of indications. Both of these exploratory calculational methods still employ the same sliding five-month time window used in the original algorithm. They differ from the original algorithm in the methods used to treat the failure information within the five-month window.

Three-month Averaging: In the three-month averaging method, the algorithm is applied to the failure data, as originally proposed. If the average number of failures for the last two months of the five-

month window exceeds the average number of failures for the first three months of the time window by the threshold limit of 1.01, the algorithm calculation is satisfied such that an indication would be generated for the fifth month. At this point, a check of this indication is made to verify that it is not a ghost tick. This check is performed by averaging the values of the failure counts in the first three months of the time window being considered. If the actual failure count value in the fifth month exceeds the first three-month average for this window, the indication is permitted to remain. If the value of the fifth month does not exceed the average value of the first three months then the indication is eliminated.

If the average of the last two months of the five-month window does not exceed the average of the first three months by the threshold limit, checks are made to determine if an indication should be generated but is being "shadowed" by previous recent failure histories. This check is performed by averaging the values of the failure counts in the first three months of the time window and substituting this average value for the highest value in the three-month period. The algorithm is then completed using the actual failure values for the last two months of the five-month period. If the threshold value of the algorithm is now exceeded, an indication is generated and retained for this fifth month.

Five-month Averaging: The five-month averaging method uses the same algorithm and threshold as used in the original indicator. The difference occurs once a failure indication is generated. In the five-month averaging method, once an indication is generated the data values to be used in subsequent calculations are revised. This is accomplished by substituting the average value of the failures for the actual values of the failures in the five-month time window that resulted in an indication being generated for the fifth month. The time frame is then shifted one month and the original algorithm is applied but now the first four months of the five-month window are average failure values, not actual values. If no failure indication is generated for this new time window, the window is shifted another month with the first three months of the window retaining the old average value and the last two months containing actual monthly failure counts. If no indications are generated, the window is shifted again and the process is repeated. This continues until a new indication is generated. Once a new indication is found, the actual failure values for the five-month window involved in the new indication are retrieved, if necessary, and a new five month average is determined. These average values are then substituted for the actual values and the process outlined above is repeated.

These processes are continued for the entire time period under consideration for both the system-based and the component-based sets of NPRDS equipment failures for each plant. Comparative graphs of the cumulative results of these efforts are plotted. The following examples illustrate how the revised algorithms compare with each other and with the original approach. The examples are based on actual NPRDS failure data for plants which were represented in the Demonstration Project. In these examples, an "F" denotes an indication found by all three methods, a "G" represents ghost indications that are eliminated by the revised calculation method, and an "S" notes a shadow indication which is added by a revised calculation method.

In the first example, a plant experienced 57 failures in systems and components used in constructing the original indicator. Of these, 41 failures were experienced in just two systems. These 41 failures resulted in the generation of a total of eight indications, four in each of the two systems, when the original algorithm was applied. The remaining 16 failures were distributed among six other systems and these failures resulted in no additional indications. The distribution of the 41 failures between the two systems is shown in Figure C.1. Included in this figure are the

comparative indications generated when the original and the two revised algorithms are applied to this data.

MONTH	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Failures																												
System A	0	2	0	1	1	0	1	0	0	0	0	0	3	0	2	0	2	0	0	1	0	2	0	5	0	1	1	0
System B	0	1	0	0	2	0	0	2	1	2	0	0	3	1	0	0	0	0	2	1	0	0	0	3	0	0	1	0
ALGORITHM																												
Original																												
System A													F	G										F	G			
System B													F						F					F	G			
3-Month																												
System A													F											F				
System B													F							F				F				
5-Month																												
System A													F											F				
System B													F							F				F				

Figure C.1 Example Application of Various Algorithms

In this example, both of the revised algorithms eliminated three "ghost" indications. The failure distribution was such that neither revised algorithm determined that additional "shadow" indications were present.

In the following example, a different plant experienced 229 failures, with 35 of these failures occurring in one particular system. Applying the original algorithm to these failures resulted in the generation of three indications. In this case, the application of the revised algorithms both eliminated one "ghost" indication but found one "shadow" indication. Figure C.2 illustrates these indications.

MONTH	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Failures																												
System C	0	5	1	0	0	1	1	0	0	3	3	0	1	0	1	0	0	0	7	0	1	3	0	2	2	2	1	1
ALGORITHM																												
Original																												
System C												F							F	G								
3-Month																												
System C												F							F		S							
5-Month																												
System C												F							F		S							

Figure C.2 Additional Example Application of Various Algorithms

Thus for this example, the total number of indications remains the same. However, the revised algorithms yield a different distribution of the indications over the time period being considered. Comparisons of additional examples reveal that the two revised methods are equally sensitive to capturing "shadow" indications but the five-month averaging method is more sensitive and eliminates additional "ghost" indications.

ENCLOSURE NO. 2



NUCLEAR MANAGEMENT AND RESOURCES COUNCIL

1776 Eye Street, N.W. • Suite 300 • Washington, DC 20006-2496
(202) 872-1280

August 10, 1990

Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Novak:

Enclosed for your information is a copy of our final report "Evaluation of the NRC Proposed Maintenance Effectiveness Indicator." As a result of our meeting on June 26, 1990, this report has been changed since the draft version was transmitted to you to clarify the results of the industry analysis as shown on page 9 of the report. The industry appreciates having had the opportunity to interact with the NRC-AEOD staff in the evaluation of the proposed maintenance effectiveness indicator as described in report AEOD/S804B. We believe the interaction has resulted in a good understanding between us even though our conclusions, as described in the enclosed NUMARC report, differ significantly from those published in the NRC draft report AEOD/S804C. In addition to the detailed comments in the enclosure, we offer the following general observations.

The relationship of the proposed indicator to plant safety has not been demonstrated by the data evaluated during this project. Additionally, our review of the failures and their significance leads us to conclude that this proposed indicator is neither a measurement of maintenance effectiveness nor does it provide insight into its nexus to maintenance.

The proposed indicator equates all equipment failures to ineffective maintenance. However, in order to measure maintenance, the proposed indicator should include only those failures that are maintenance related. The NUMARC Ad Hoc Advisory Committee (AHAC) analysis of the data provided by the NRC associated with six plants concludes that failures unrelated to maintenance are a major contributor to all failures and are accrued together with failures that are related to maintenance. Assuming that one could eliminate all maintenance related failures, the proposed indicator would still indicate a "maintenance ineffectiveness" trend. The logic is technically flawed.

The proposed indicator methodology relies on the premise that the Nuclear Plant Reliability Data System (NPRDS) narrative reports alone contain sufficient detailed information to enable an independent person to establish the root cause or causes of equipment failure. The AHAC analysis of the data that underpins the proposed indicator concludes that significant information beyond that normally available in NPRDS is required to establish the primary or contributing root cause or causes. Further, our assessment of the causes

Thomas M. Novak
August 10, 1990
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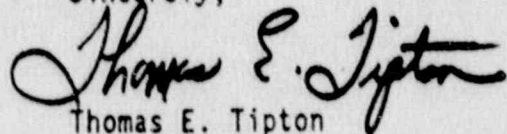
that contribute to equipment failure is substantially different from the NRC perceived cause distribution. The NPRDS, as a reliability data base, was not established to require detailed root cause determination of all reported failures.

The proposed indicator methodology does not exclude a degraded or potentially degraded condition that has been evaluated for its system effect and properly determined to be repaired or replaced when necessary. These decisions reflect neither ineffective maintenance nor a non-aggressive management approach to maintenance but instead reflect appropriate licensee judgement.

Regarding the NRC's meeting minutes dated July 13, 1990, of our June 26, 1990 meeting, based on our detailed review of the data and methodology, we are unable to support the NRC's position that, "the data does provide useful insights into maintenance trends at an individual plant and that a trend of aggregated data across all plants gives insights into industry trends related to maintenance." We are unable to substantiate these premises by comparison of the indication frequency with the average SALP performance for three years from 1986 to 1988, the results of 52 plant maintenance team inspections and with the participating utility evaluations of the proposed indicator data.

As we discussed at our meeting with you on June 26, we conclude that the proposed indicator as currently defined or as proposed to be modified does not measure maintenance effectiveness. If you have any questions relative to this letter or its enclosure, please contact Walt Smith, Warren Hall, or me.

Sincerely,



Thomas E. Tipton
Director
Operations, Management and
Support Services Division

TET\WJS:amw
Enclosure

cc: E. Jordan
M. Williams

Evaluation of the NRC
Proposed Maintenance Effectiveness Indicator

August 10, 1990

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EXECUTIVE SUMMARY

BACKGROUND

The Commission in its Staff Requirements Memorandum of June 26, 1989, from Samuel J. Chilk to Victor Stello, stated "...To assist the Commission in monitoring industry improvement initiatives, the staff should proceed with validation and implementation of its maintenance effectiveness indicator on an expedited basis. As a first step, the staff should invite the voluntary participation of licensees in a small, NRC-utilities, demonstration project to identify quantitative indicators for the evaluation of the performance of maintenance programs. This project should begin immediately and would have the objective of developing a product suitable for use on a trial-basis within one year. Following the identification of a mutually agreed upon set of indicators, a testing period (of adequate duration) of their use should begin."

Industry participated with the NRC Office for Analysis and Evaluation of Operational Data (NRC-AEOD) in the evaluation of a proposed indicator that would indicate maintenance effectiveness. It was reviewed by a Nuclear Management and Resources Council (NUMARC) Ad Hoc Advisory Committee (AHAC) consisting of six utilities with participation by the Institute of Nuclear Power Operations (INPO) and NUMARC. This proposed indicator was developed by the NRC as a result of an NRC study, AEOD/S804B.

The proposed indicator trends the failure rate increase of a selected set of Nuclear Plant Reliability Data System (NPRDS) components within selected systems that fail for any reason including failures that are not related to maintenance. As described in AEOD/S804B, "The resultant computerized indicator formula counts the number of component failures discovered during each month in a five-month span of time for each of the selected systems. Dividing the number of component failures for each of the systems in a selected time period by the number of months in the period, it then calculates the average component failure rate for each system for (a) the first three months of the five-month time span and (b) the failure rate for the last two months of the span. It then compares the two average rates and, if the rate in the last two months exceeds that of the first three months by more than a threshold value, an indicating mark is placed in the last month of the five-month span. The program then adds the next more recent month and drops the oldest month, i.e. the five-month span is shifted forward one month and the failure rate calculations and comparisons are repeated." The phrase "an indicating mark" is referred to in this report as an "indication."

PURPOSE AND APPROACH

The project purpose was to evaluate the NRC proposed indicator as a method to measure maintenance effectiveness. The six utilities, INPO, and NUMARC supported this evaluation with over two man-years of effort in detailed reviews and analysis. Meetings were held with the NRC, including both group meetings and individual utility meetings at each facility. This report addresses only the maintenance performance indicator described in AEOD/S804B.

The evaluation, as detailed in the body of this report, addresses the following questions:

- o Does the proposed indicator measure maintenance effectiveness?
- o Can the proposed indicator be validated by comparison with other data or criteria?
- o What additional concerns exist relative to the use of the proposed indicator?

In addition to these three key questions, current methods were identified that the licensees use to measure or provide insight to maintenance effectiveness.

SUMMARY

DOES THE PROPOSED INDICATOR MEASURE MAINTENANCE EFFECTIVENESS?

No. The proposed indicator does not measure maintenance effectiveness.

The proposed indicator trends the failure rate increase of a selected set of systems and components from the NPRDS data base. Since component failures due to all causes, even those unrelated to maintenance, are included in this trend, the user is unable to determine if the indication is maintenance related.

For the proposed indicator to measure maintenance effectiveness, improper maintenance would have to be the dominant cause of the failures that resulted in indications. A detailed analysis for six units involving a total of 84 indications and their associated 279 NPRDS failure reports determined that 13 percent of the failures were related to improper maintenance. It is recognized that some failures that are coded as unknown and wearout that could not be anticipated, if analyzed in depth, might be attributed to maintenance; however, it is likely that the increase in the number of cases attributable to maintenance would be proportionate to the distribution of all causes. Wearout that could not be anticipated (e.g., first-time failures) and design/manufacturing problems constituted 60% of the failures.

The proposed indicator measures failure rate change at a system level but does not address the consequence of the component failure; therefore, the safety significance or loss of function as a result of the failure is not demonstrated. For example, the indication may be the result of non-critical component failures (e.g. non-essential chart recorders). During a review of the 279 NPRDS failure reports, of 65 failures attributed to operation only 7 affected actual plant operation such as a plant power reduction.

Using the proposed indicator, many causes of failures that are not related to maintenance are aggregated and treated as if all the failures are related to maintenance. Examples include failures due to original design, manufacture or installation. This is technically incorrect and not consistent with the NRC's definition of a failure that indicates ineffective maintenance.

The proposed indicator is influenced by specific activities that, in fact, are targeted to improve component reliability and availability. For example, the proposed indicator will appear negative and reflect a higher indication rate as a result of an aggressive preventive maintenance (PM) program. As a result of an aggressive PM program and conservative NPRDS reporting, a utility may conservatively enter degraded component reports in the NPRDS data base. Although a component may be degraded, it may still be able to perform its intended function. As in the case of one of the participating utilities, the proposed indicator could penalize the utility for a good PM program and conservative reporting.

Trending component failure rate changes as an indication of maintenance effectiveness also implies that the goal of maintenance is to prevent all component failures. In fact, many component failures are allowed to occur because the severity of the problem does not warrant replacement prior to failure. Additionally, some design or preventive maintenance solutions may not be appropriate from an ALARA or cost/benefit standpoint and become management decisions.

The results of this study also show that most indications occur during planned outages suggesting that the indications reflect the level of maintenance effort rather than maintenance effectiveness.

CAN THE PROPOSED INDICATOR BE VALIDATED BY COMPARISON WITH OTHER DATA OR CRITERIA?

No. A review of the proposed indicator data did not demonstrate a significant correlation between the number of failures and the number of indications between plants perceived as good plants and plants that are perceived as needing improvement in elements of their maintenance program. Some plants receiving a good rating based on SALP and NRC maintenance team inspection data had as many or more indications as plants that were not as highly rated.

Additionally, a review of other indicators that provide insight into maintenance effectiveness did not result in a meaningful correlation to the proposed indicator data.

The proposed indicator as currently constructed does not monitor the affect of a component failure on systems or on the plant from a safety, reliability or availability standpoint. Reviews did not establish a correlation between the indications and power reductions or component forced outages that occurred at the participating plants.

WHAT ADDITIONAL CONCERNS EXIST RELATIVE TO THE USE OF THE PROPOSED INDICATOR?

The following additional items of concern relative to the use of the proposed indicator were noted:

- o If the NPRDS data base is used as a basis for measuring the effectiveness of a selected function or organization, such as maintenance, reporting could be unnecessarily delayed, technical resources diverted and additional cost incurred to establish the root cause or causes. NPRDS is established as a component reliability data base with emphasis to ensure that failures of important components in selected systems are reported. The reporting of failures to the NPRDS data base, regardless of cause, assists users in comparing their component failure rates with industry experience. Additionally, the concept of sharing industry experience on important plant components by identifying other users that have experienced similar problems does not rely on the determination of a specific root cause. Through experience it has been determined that in-depth root cause analysis, while beneficial in many cases, is neither cost effective nor warranted for all failures reported in the NPRDS data base.

Use of the NPRDS data base in support of the proposed indicator will impact NPRDS reporting. As explained in paragraph E.1.5, reporting of borderline failures has a major impact on the number of indications at a plant. Because the proposed indicator is dependent upon the number of failure reports submitted to NPRDS, an incentive is created to exclude component problems that are "borderline" failures, per NPRDS reporting guidance. This incentive is counterproductive to current industry efforts to improve the completeness of reporting to the data base.

- o Both NRC and industry resources could be misdirected in an attempt to utilize the data. For an indicator to be useful, it should provide a meaningful perspective without requiring additional complex analysis. During the pilot project, no meaningful results could be established without significant engineering analysis and detailed knowledge of the failure and plant practices. Following an extensive engineering analysis, it was concluded that none of the indications would result in a change to individual maintenance programs. Because of the extensive analysis required and the need for data not normally available in NPRDS, it is doubtful that the user can effectively use the proposed indicator to identify what

maintenance program deficiencies are contributing to these indications.

- o The use of the data external to AEOD will be subject to misinterpretation and significant error due to a lack of reference data and expertise in the use of the data. The curves and trends produced by the NRC from the NPRDS proprietary data base can not be easily understood by others external to the AEOD organization without extensive analysis and explanation. The indications provided under the proposed methodology do not result in consistent trends that discriminate performance within a plant or between plants. Some programs that are viewed as good, satisfactory or in need of improvement can display approximately the same number of indications.
- o The methodology, as presently used, provides indications with no corresponding failure data ("ghost" indications). A review of the 84 indications identified 16 (19%) that occurred with no associated NPRDS failure reported.

OTHER METHODS EXIST TO MEASURE OR PROVIDE INSIGHT TO MAINTENANCE EFFECTIVENESS

Many in-depth and diverse methods already exist that systematically monitor component and system performance and provide meaningful insight and perspective into maintenance effectiveness. Examples include:

- o Overall performance indicators -- A well maintained plant clearly contributes to good performance in the industry overall performance indicators;
- o Individual utility maintenance process indicators -- Utilities use indicators such as the quantity and age of corrective and preventive maintenance backlogs, rework and other indicators to monitor individual plant maintenance effectiveness;
- o Industry and NRC performance monitoring of selected important components and systems and analysis of Licensee Event Reports (LER's);
- o Operator and NRC resident inspector rounds and other physical inspections of the plant including supervisory and quality assurance monitoring of plant operation and maintenance activities;
- o Utility self assessments and periodic independent evaluations and assistance visits by INPO that not only provide continuing monitoring of programmatic aspects of plant operations and maintenance but also include the inspections of the material and equipment condition of the plant;

- o Assessment of the results of surveillance tests required by the station Technical Specifications, ASME Section XI, and other code requirements; and
- o Quarterly assessments of the Component Failure Analysis Report (CFAR) module of NPRDS that compare the failure rate of components at a plant with industry failure rates.

SUMMARY CONCLUSION

The NUMARC Ad Hoc Advisory Committee concluded that the proposed indicator does not measure maintenance effectiveness, does not provide consistent results that discriminate performance within a plant or between plants, and could potentially dilute the usefulness of the NPRDS data base to the industry. Other diverse methods exist that, when combined, provide insight into the effectiveness of maintenance from a broader perspective than can be achieved by a single indicator.

EVALUATION OF THE NRC
PROPOSED MAINTENANCE EFFECTIVENESS INDICATOR

A. INTRODUCTION

On November 28, 1988, the Nuclear Regulatory Commission (NRC) issued a proposed rule on "Ensuring the Effectiveness of Maintenance Programs for Nuclear Power plants," 10 CFR 50.65. The proposed rule would require licensees to formalize their maintenance programs in accordance with the definition in the rule and to monitor the effectiveness of their programs. Specifically the rule would require the licensees to: "...regularly assess the effectiveness of this maintenance program, and based upon this assessment, make improvements as appropriate."

Based upon NRC studies conducted by the Office for Analysis and Evaluation of Operational Data (AEOD), as documented in NRC report AEOD/S804, the NRC concluded that "...indicators which are based upon actual component reliability and failure history provide the best measure of maintenance effectiveness monitoring."

The Commission in its Staff Requirements Memorandum of June 26, 1989, from Samuel J. Chilk to Victor Stello, stated "...To assist the Commission in monitoring industry improvement initiatives, the staff should proceed with validation and implementation of its maintenance effectiveness indicator on an expedited basis. As a first step, the staff should invite the voluntary participation of licensees in a small, NRC-utilities, demonstration project to identify quantitative indicators for the evaluation of the performance of maintenance programs. This project should begin immediately and would have the objective of developing a product suitable for use on a trial-basis within one year. Following the identification of a mutually agreed upon set of indicators, a testing period (of adequate duration) of their use should begin."

B. INDUSTRY PARTICIPATION

In response to the request of the Commission, AEOD, six utilities, INPO, and NUMARC agreed to participate in the evaluation of the proposed indicator initially developed as a result of the AEOD/S804B report. Utilities were requested to participate to achieve a relatively representative group of generating units from the NRC regions and include:

Commonwealth Edison Company
Duke Power Company
Northeast Utilities

Rochester Gas and Electric*
Southern California Edison*
Systems Energy Resources Inc.

(*) Utilities involved with EPRI in a pilot test of Reliability Centered Maintenance

Over two man years of utility effort were expended in data reviews, analyses and in interface meetings with the NRC both in Washington and at utility facilities. Each of the meetings at the utility facilities were in-depth two day meetings that addressed plant specific data and trends (see table 1).

TABLE 1
PERFORMANCE INDICATOR PILOT GROUP
MEETINGS

- o September 1989 NRC/Industry - initial scoping
- o October 1989 NRC/Industry - preliminary evaluation results
- o November 1989 NRC/Commonwealth Edison - utility specific data
- o December 1989 NUMARC AHAC - analysis of indications
- o December 1989 NRC/Southern California Edison - utility specific data
- o January 1990 NRC/Duke Power - utility specific data
- o February 1990 NRC/System Energy Resources - utility specific data
- o February 1990 NRC/Rochester Gas & Electric - utility specific data
- o March 1990 NRC/Northeast Utilities - utility specific data
- o March 1990 NRC/Industry - summary of results to date
- o April 1990 NRC/Industry - pilot study results & future directions

C. PURPOSE OF THE MAINTENANCE PERFORMANCE INDICATOR PROJECT

The project purpose was to evaluate the NRC proposed indicator as a method to measure maintenance effectiveness. NUMARC formed an AD Hoc Advisory Committee (herein after referred to as AHAC) consisting of six utilities, INPO and NUMARC. This report addresses only the maintenance performance indicator described in the NRC report AEOD/S804B.

D. KEY ELEMENTS OF THE NRC PROPOSED INDICATOR

Before addressing the key findings from the evaluation, the following key definitions and the approach used in the methodology are briefly described.

D.1 DEFINITIONS

MAINTENANCE

As defined in INPO 90-008, "Maintenance Programs in the Nuclear Power Industry," the industry has defined maintenance to be the aggregate of those actions that prevent the degradation or failure of and that promptly restore the intended functions of structures, systems and components. As such, maintenance includes not only the activities traditionally associated with identifying and correcting actual or potential degraded conditions (that is repair, surveillance, and other measures)¹, but also extends to supporting functions for the conduct of these activities. Examples of these functions include engineering support of maintenance; operator identification of material deficiencies; and some aspects of chemistry control, radiological protection and training. This description and the elements of an effective maintenance program are further described in INPO 90-008 revised March 1990, and are consistent with the revised NRC Policy Statement issued in December 1989.

INEFFECTIVE MAINTENANCE

The NRC has defined ineffective maintenance² as failures (emphasis added) experienced while conducting, or as a consequence of maintenance, upkeep, repair, surveillance, testing and calibration of plant equipment. Examples include personnel errors of omission and

¹ During the demonstration project the traditional activities described above became known as little "m" to enable comparison of this scope with the scope that is added to reflect activities that support the performance of maintenance. The total scope including support activities is referred to as big "M." A concern expressed was that the proposed indicator included support activities that were not within the span of control of the maintenance manager.

² NRC Report AEOD/S804B, Page 13.

commission by maintenance staff, procedure problems resulting in inadequate/improper maintenance, problems traceable to maintenance program administrative control and equipment failures due to improper previous repair.

Although AEOD/S804B uses this definition of ineffective maintenance, the proposed indicator methodology collects all failures, even if the cause of failures is not related to maintenance.

THE NUCLEAR PLANT RELIABILITY DATA SYSTEM (NPRDS)

NPRDS is a computer based collection of engineering, operational and failure data on systems and components installed in United States' nuclear plants. Systems and components within the scope of NPRDS are selected based on their importance to safe and reliable plant operation. Maintenance personnel are trained in the ways NPRDS can be used to support maintenance activities. Examples of typical uses of NPRDS include the following: locating critical spare parts, identifying high failure rate components and adverse trends in component performance, finding other plants that have experienced similar component problems or have a good performance record; determining appropriate frequencies and types of preventive maintenance based on component aging and wearout patterns; and providing a summary of corrective maintenance history data.³

FAILURE

The NRC proposed indicator methodology results in the extraction of failures of selected components from the NPRDS data base that are classified as having a failure severity of immediate or degraded. Components that are classified as incipient failures were not included in the calculation methodology. Failures are defined⁴ as follows:

IMMEDIATE - a failure that is sudden and complete.

DEGRADED - a failure that is gradual, partial or both--The component degrades to a level that, in effect, is a termination of the ability to perform its required function. This code should be chosen when a system or component does not satisfy the minimum acceptable performance for a specific function or when a component must be removed from service or isolated to perform corrective maintenance.

³ INPO 90-008 "Maintenance Programs in the Nuclear Power Industry," page 4, paragraph 3.5.

⁴ NPRDS Reporting Guidance Manual, page 6-22.

INCIPIENT⁵ - an imperfection in the state or condition of a component that could result in a degraded or immediate failure if corrective action is not taken--This indicates an optional record, since failure has not occurred. This code also is used by INPO to classify records judged not to be failures during the INPO evaluation process.

D.2 SYSTEM AND COMPONENT SELECTION

For the purposes of the NRC report AEOD/SB04B "...the study considered only major components in systems which have historically been significant contributors to forced outages." The systems and components were selected for application of the proposed indicator from the NPRDS data base and do not include all systems or all components of the selected system.

The AHAC agrees that component selection should be based on the significance of the component (the potential of the component, upon failure, to contribute to a significant system or plant effect from the standpoint of safety, and reliability). Although the component selection basis was initially developed to consider systems and components that contribute to forced outages, the AHAC analysis of indications did not find any correlation between actual forced outages and the rate or timing of indications analyzed. Further, no correlation of the indications to power reduction was determined. It was found that the indication is very sensitive to the components selected in that the selection of a different set of components in the same system could change the indications significantly.

D.3 INDICATOR CALCULATION ALGORITHM

A computerized indicator formula, as described in AEOD/SB04B, counts the number of component failures discovered during each month in a five month span of time for each of the selected systems (WHETHER OR NOT THE FAILURE IS RELATED TO MAINTENANCE). Dividing the number of component failures for each month in the period by the number of months in the period, it then calculates the average component failure rate for each system for:

- a) the first three months of the five-month time span, and
- b) the last two months of the span.

It then compares the two average rates and, if the rate in the last two months exceeds that of the first three-months by more than 1.01, an indicating mark is placed in the last month of the five month span. The program then adds the next more recent month and drops the oldest month, i.e. the five-month span is shifted forward one month, and the

⁵ An analysis of indications shows that INCIPIENT CONDITIONS are frequently (and conservatively) reported as DEGRADED FAILURES

failure rate calculations and comparisons are repeated. The AHAC analysis of indications determined that the averaging method reference para. E.1.5 produces indications although no failures have occurred.

E. DOES THE PROPOSED INDICATOR MEASURE MAINTENANCE EFFECTIVENESS?

No. The proposed indicator does not measure maintenance effectiveness. It trends the failure rate increase of a selected set of systems and components from the NPRDS data base. Component failures due to all causes, even those unrelated to maintenance, are included in this trend. These findings are supported by a detailed analysis for six plants involving a total of 84 indications and their associated 279 failure reports.

E.1 ANALYSIS OF INDICATIONS

E.1.1 BACKGROUND

An analysis was performed of the indications and the corresponding component problems associated with the indications. The purpose of this analysis was to determine if the causes of the indications suggested problems with maintenance effectiveness. The analysis approach and results are provided in this section.

E.1.2 APPROACH

Six units, one from each utility participating in the AHAC, were selected for a detailed review of each plant specific indication. A total of 84 indications, and their associated 279 NPRDS failure reports were analyzed. This number of indications was sufficient to perform validation studies of the proposed indicator. For each indication, the utility performed a detailed review of the NPRDS failure reports that caused the indication to occur. When insufficient information was available in the NPRDS failure reports, additional information was obtained from plant records and interviews with plant technical personnel.

The method of failure detection, the cause categories of the failures, other factors that caused the indications, the timeliness of the indications, and other input provided by the utility AHAC members on these indications are presented below.

E.1.3 METHODS OF FAILURE DETECTION

The methods by which failures are detected helps characterize the effectiveness of surveillance and maintenance programs at nuclear plants. These programs are barriers preventing important component failures from occurring during system operation. For example, if important component problems in normally operating systems went undetected during surveillance and preventive maintenance activities, then failures during operation could

occur, resulting in an increased chance of the unit experiencing an equipment forced outage. The failures associated with the indications at the six units were categorized by failure detection method. The failure detection categories were:

- o Detected during surveillance: This category includes problems detected during routine surveillances to determine operability, such as pump and valve tests, instrument channel calibrations, and local leak rate tests.
- o Detected during inspections and preventive maintenance: This category includes problems detected during operator rounds, other routine or special inspections, and preventive maintenance.
- o Detected during operation: This category includes problems detected during component operation, not including surveillances. These problems typically are detected while operations is attempting to use the component or while the component is normally operating.

The distribution of failures associated with the indications, categorized by detection method, is provided in Figure 1 below.

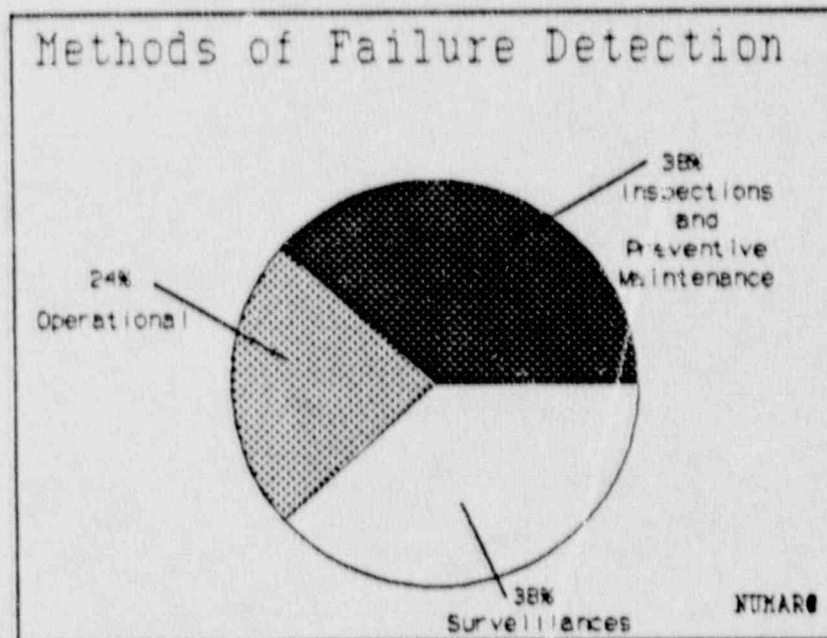


Figure 1

Preventive maintenance (PM) and inspections and surveillances detect the highest percentage of failures (38% each), suggesting that effective programs in these areas may be contributing to the indications, instead of ineffective programs in these areas

contributing to the indications. The percentage of operational failures is the lowest (24%) as a result of these other failure detection mechanisms.

A review of the failures that were detected during operation showed that 7 of the 65 failures had some affect on plant operations, such as a power reduction. Two of these seven failures could not have been detected by surveillance and maintenance programs because it is not possible to check the components (source range detectors) during power operation. The remaining 58 failures that occurred during operation did not effect the plant operation because:

- o The component that failed was not critical to plant power operation (e.g., redundant components provided the function or the component was not important to power operation);
- o The failure mode of the component did not effect the plant (e.g., valve automatic control inoperable requiring manual control, valve leak-by, instrument drift); or,
- o The failure occurred when the plant was shutdown.

E.1.4 CAUSES OF FAILURES

A review was conducted of NPRDS failure narratives and other plant records associated with the failures to help identify the root cause of the problems. The failures associated with the indications at the six units were then grouped into the following cause categories:

- o Improper Maintenance: This category includes activities improperly performed, or not performed, in order to assess, maintain, or restore component operational capabilities. This includes maintenance errors, inadequate technical support of component problems, incomplete preventive maintenance programs, and other activities within utility control.
- o Design/Manufacturing: This category includes component failures related to design of components or systems, or the component manufacturing process. Recurring problems remain in this category if a design change is justifiable in long-term corrective actions or if a decision was conscientiously made to accept the consequences of the design problem. Design problems not being addressed are included in the improper maintenance category.
- o Wearout That Could Not Be Anticipated: This category includes component failures that occurred for the first time, and other random failures that resulted from wearout of component parts. To be in this category, the preventive maintenance program

could not have avoided the failure (without foreseeing the future).

- o Other: This category includes component failures due to some of the minor cause contributors, including improper operations, and decisions to run components to failure, but not improper maintenance.
- o Unknown: This category includes component failures that could not be categorized into any of the above classifications, even if an analysis was performed. Instrument drift and out of calibration problems due to unknown causes are included in this category.

The distribution of failures associated with the indications, by cause category, is provided in Figure 2 below.

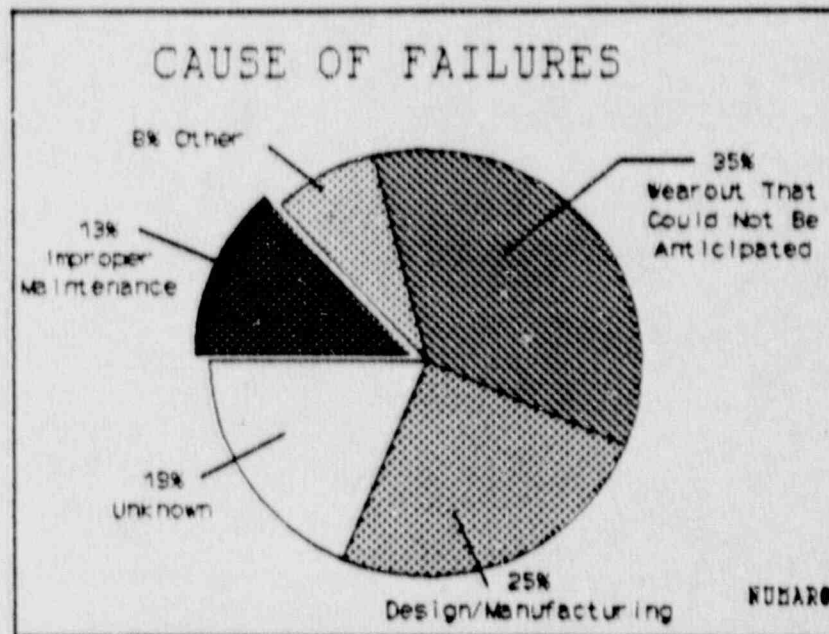


Figure 2

Improper maintenance contributes 13 percent of the total, demonstrating that the causes of the indications are not primarily maintenance-related. It is recognized that some failures that are coded as unknown, if analyzed in depth, might be attributed to maintenance; however, it is likely that the increase in the number of cases attributable to maintenance would be proportionate to the distribution of all causes (resulting in an increase of approximately 3%). Additionally, many of the cases of wearout are clearly initial failures that could not have been reasonably anticipated or precluded by the maintenance program. As in any subjective assessment, a comprehensive root cause analysis of

other wearout conditions could result in differing assignment of causes and some wearout might appropriately be attributed to maintenance.

Wearout That Could Not Be Anticipated

Wearout that could not be anticipated is the dominant cause of failures, contributing about 35 percent of the total. In most of these cases, the component failures occurred with no prior history of similar problems. Examples of these types of problems include:

- o During a one month period, two pressure switches and one voltage regulator in the main feedwater system would not calibrate during surveillance, resulting in an indication. Parts of the components were worn out and were replaced. These were the first problems of this type experienced by these components and they were found during surveillances that were designed to check for these types of problems. No system impact occurred.
- o During a one month period, while conducting preventive maintenance inspections, two circuit breakers and one transformer in the plant AC power system were found to have worn out parts resulting in an indication. The deficiency did not have a system affect. The worn out parts were replaced. These parts had not previously had any problems, and they were found during preventive maintenance inspections that were designed to check for these types of problems.
- o During a one month period, four hydraulic control units (HCU's) experienced leakage on two valve seats, a cylinder, and a valve stem, resulting in an indication. The plant routinely overhauls one-half of the HCU's during each refueling, and these four HCU's were not overhauled during the previous refueling. Wear of the parts of the HCU's could not be anticipated because of premature part failure (in less than 3 years) despite being included in an aggressive preventive maintenance program. Because problems with these HCU's are quickly detected during existing surveillances and inspections, and the failure mode is not significant, no changes to the HCU preventive maintenance program were implemented and the problems were not classified as improper maintenance.

Design/Manufacturing Problems

Design/manufacturing problems were the second largest cause category, contributing 25 percent of the total number of failures. While many of these problems would appear to be maintenance-related, based on a more detailed review of cause information than

is typically available in NPRDS (e.g., root cause analysis reports, engineering studies, discussions with cognizant engineers) shows that system and component design is the cause of these failures. Examples of these types of problems include:

- o Twenty-three component failures occurred within a reactor protection system cabinet during a two year time period, contributing to three indications. Most of these failures were caused by high temperatures within the cabinet, due to inadequate cabinet cooling design. The utility performed a design change to reduce the internal ambient temperature within the cabinet. The design change required substantial time to implement, primarily because of seismic qualification concerns and the need to perform the modification when the plant was down.
- o Six valve operator limit switches in the service water system were inspected during a refueling outage and found to have broken finger bases, causing an indication to occur. The inspection was initiated as a result of an NRC Inspection and Enforcement Notice, which stated that the cause of the problem was design-related. The broken finger bases did not affect the ability of the valve operators to perform their intended functions. The valve operators were still able to correctly position the valve. Per the NPRDS reporting guidance manual, pages 6-77 to 6-80, these are not reportable degraded failures.
- o Five reactor trip breaker problems occurred in two successive months, resulting in two indications. Problems included broken relay coil contact blocks, failed current transducers, and undervoltage trip devices out of adjustment. None of the problems resulted in a system affect. A root cause analysis identified component design as the causes of the problems and the breakers were sent back to the manufacturer for redesign, and were then successfully returned to service.

In summary, "wearout that could not be anticipated" and "design/ manufacturing" are the dominant causes of the failures that created indications. Maintenance effectiveness was not the dominant cause of the component problems evaluated in the six utility plants.

E.1.5 ANOTHER FACTOR THAT CAUSES INDICATIONS

A review of the data provided by AEOD identified an important factor that cause indications to occur that is not related to component failures. A review of the 84 indications identified that 16 indications, (19%) occurred with no associated NPRDS failure reports. Each of the six units experienced from 2 to 4 "ghost" indications, suggesting that this is a significant

problem. This problem has a much more pronounced effect on units with a small number of indications; at three of these units, "ghost" indications contributed 7 of 22 total indications (31%).

The cause of these "ghost" indications appears to be due to the algorithm method having no check for a failure to occur in the month that an indication appears. Because of the method used to average and compare indications, a high rate of indications in a previous period can cause an indication to be reflected in a month in which no failures have occurred.

The algorithm method also has no check for a sustained high number of failures in a system. It is possible that no indication would occur when several failures were discovered in one month because the previous months exhibited a high number of failures.

E.1.6 COMPLETENESS AND TIMELINESS OF THE INDICATIONS

An NRC stated purpose of the proposed indicator is to provide a timely indicator "...in trending the effectiveness of each plant's maintenance program in ensuring component performance...". A review of NPRDS component failure history during the two-year time period of the AEOD study identified several instances in which recurring component problems occurred, but were not indicated. Examples of this include:

- o There were four inverter failures in the Instrument AC power system at one plant during the two year time period, resulting in a high inverter failure rate. One inverter failed three times during this time period. No indications appeared in this system because the inverter failures were distributed over different months.
- o There were seven failures of an auxiliary feedwater pump during the two year time period, resulting in a high pump failure rate. No indication occurred because the failures were distributed over six different months, and this particular type of pump was not included in the component selection criteria.

A review of NPRDS component failure history identified several instances where recurring component problems were not identified in a timely manner or where recurring problems did not continue to be indicated. Examples are provided below:

- o A design-related problem with a valve operator in the condensate system was indicated in October 1987. However, previous failures of this valve operator in March and June 1987 did not generate an indication.

- o Problems with diaphragm valves in the CVCS system were indicated in March 1987 and February 1988. Repetitive diaphragm valve problems in May 1987, July 1987, and December 1987, however, did not generate an indication.
- o Twenty-three problems with components in a reactor protection system cabinet were reported during the two year study period, generating an indication in March 1987. However, problems in April, May, July, August, September, October, and December 1987 did not generate an indication.

The causes of the unidentified repetitive component problems were primarily due to two factors; the indicator algorithm method employed and the selection criteria used for the components.

All of the examples of problems that were not identified by the proposed indicator were identified by other methods available to the utility. In addition, for each set of component problems that resulted in an indication, the utilities had other mechanisms for detecting these trends. Examples of methods used by individual utilities to identify these trends include:

- o Component Failure Analysis Report (CFAR)--The three examples of high failure rate components that were missed by the proposed indicator were detected by CFAR.
- o Plant-specific component trending programs
- o Station-initiated requests for engineering assistance and root cause analysis to resolve identified problems
- o Reliability centered maintenance programs that evaluate each failure for trends and considers modifying either the method or frequency of the preventive maintenance tasks

None of the above methods are considered indicators, but are useful in identifying potentially adverse component performance trends and monitoring the effectiveness of corrective actions.

E.2 DETERMINATION OF CAUSE AND FUNCTIONAL RESPONSIBILITY FROM NPRDS

The NPRDS Reporting Guidance Manual states that the narrative portion of a failure report should reflect "...the root cause or the apparent root cause of equipment failure." Further the guidance suggests, "The causes of component failures will be investigated to varying levels of detail, depending on the nature of each failure. Such factors as the potential severity of failure, similar previous failures and the information needs of the plant staff will affect how deeply to investigate the cause of each failure." Interviews of plant

personnel, analysis of NPRDS narratives, and retrieval of plant records resulted in the conclusion that maintenance is not the dominant cause of component failure (13-24%).

Evaluation of the NRC identified failures suggest that the organization or function that is the sole or primary contributor to the cause of a component failure can not be determined from an evaluation of the NPRDS narrative report alone. NRC analysis of NPRDS narratives (alone) resulted in the NRC conclusion that maintenance is the dominant cause of component failure (>75%). During NRC/Utility discussions relative to the cause of failures, it became obvious that different interpretations of the cause of failure could be suggested by the narratives depending on the extent of plant specific knowledge and an individual's point of view.

NPRDS is established as a component reliability data base with emphasis to ensure that failures of important components in selected plant systems are reported on a timely basis. The NPRDS data base does not ensure that the function or program (e.g. Design, Manufacturing, Maintenance etc.) that contributes the most or solely to component degradation is precisely designated. To determine this information, data would be required from sources beyond that which is normally available in the NPRDS data base.

E.3 COMPARISONS OF THE PROPOSED INDICATOR AND THE SCOPE OF MAINTENANCE PROGRAMS

The proposed indicator methodology collects all failures including those that are not related to maintenance or those that have been appropriately decisioned to be allowable as a result of a technical assessment. Failures for these reasons should not be used to characterize ineffective maintenance.

Preventive maintenance programs are established to detect and minimize the effects of wear to the extent necessary and practical on the basis of technical judgement, vendor recommendations and experience. Additionally, design codes and the plant Technical Specifications establish required surveillance test frequency criteria that is used to establish and monitor portions of the maintenance program.

Maintenance programs consider the significance of the system and component relative to the potential for a component failure to affect safe, reliable and economic plant operations. Based on these considerations, an option of preventive or corrective maintenance is selected. Maintenance programs are not structured to preclude all component degradation or failure. The decision to apply a preventive or corrective maintenance activity is often based on safety significance, ALARA or economic decisions. As a result, component failure does not necessarily reflect ineffective maintenance.

Preventive maintenance programs do not usually preclude wear or failure due to errors in original component design, manufacture or application of the component to a specific use. Some examples of these problems include failure of a design to provide for adequate cooling or humidity control of electronic enclosures. When failures occur for these reasons, preventive maintenance programs can be introduced, in some cases, that will mitigate the effects of these problems in the future. Original failures that are caused by conditions beyond the scope of the maintenance program should not be included in an indicator to measure the effectiveness of maintenance.

Other failures occur that are not attributable to conditions within the control of a utility's overall maintenance program. Examples include original manufacturing defects and materials that have an intrinsically short design life such as rubber gasket and bellows materials or electronic piece parts, such as some capacitors. Some component degradation occurs after having been in-service for extended periods of time even with an effective maintenance program in place. In some cases, original component selection was limited by state-of-the-art available components, especially, in the area of electronics and instrumentation. Although a more extensive maintenance program may be required, a repair or replacement may be less of an impact than incurring the costs for redesign and plant modification.

First of a kind failures that are not related to maintenance adequacy should be excluded from the proposed indicator.

Preventive or corrective maintenance to correct initial degradation or failure after a component is in-service for a reasonable time is frequently directed to correct the apparent cause of the degradation; and, the root cause or causes may not be practically discernable until the initial degradation recurs. Determining the root cause or most dominant cause of an initial failure or possibly more than one failure of the same kind is frequently not cost effective. To conduct a root cause analysis in all cases would divert technical resources inappropriately.

All of the above failures (e.g. first of a kind) regardless of cause are collected and used as part of the proposed indicator methodology. Collecting all failures of components that have occurred, even when the failure is not maintenance related, masks the relationship of the component failure to the adequacy of the maintenance program.

The results of applying the proposed indicator methodology suggests that indications occur most frequently during outages. This condition appears valid because preventive and corrective maintenance are most effectively performed when operational conditions are most suitable and when maintenance can be best planned, coordinated and controlled. Although not evaluated in detail, it is likely that the number of indications during outages may be more related to the scope

and duration of the outage and to conservative reporting of component degradation than to the effectiveness of the maintenance program.

F. CAN THE PROPOSED INDICATOR BE VALIDATED BY COMPARISON WITH OTHER DATA OR CRITERIA?

A comparison of the number of indications produced by the proposed indicator methodology at plants commercial prior to 1985 was made with the following data:

- o a 3 year SALP average (1986 to 1988);
- o the ratings assigned by the NRC Maintenance Inspection Teams of 52 plants;
- o plants added or removed from the semi-annual problem plant list since June of 1987;
- o age, size, and NSSS vendor
- o forced outages and power reductions;
- o INPO overall performance indicators;
- o AEOD 1987 report on manual and automatic trips, significant events and safety system failures; and,
- o Licensee Event Reports (LER).

A review of the proposed indicator data does not demonstrate a significant difference between the number of indications received by plants perceived as good plants and plants that are perceived as needing improvement in elements of their maintenance program. Some plants receiving a good rating based on SALP and NRC maintenance team inspection data had as many, or more indications as plants that were not as highly rated. For example the plant with the best SALP performance over a three year period had more indications than the plant with the median number of indications and the same number of indications as plants that were evaluated as 23rd, 49th, 66th, 75th, and 82nd out of 84 plants in commercial operation prior to 1986. In another observation it was noted that problem plants experienced fewer indications than those plants in the highest indication frequency range (23-33).

Additionally, a review of other indicators that provide insight into maintenance effectiveness did not result in a meaningful correlation to the proposed indicator data. One utility indicated that the LER data appeared to correlate with its trend of indications while many other plants show no correlation.

6. WHAT ADDITIONAL CONCERNS EXIST RELATIVE TO THE USE OF THE PROPOSED INDICATOR?

There is concern regarding the potential inappropriate use of the NPRDS proprietary data base and the derived curves, trends and analysis. The AEOD has identified the following potential uses of the proposed indicator:

- o Understand patterns of reporting NPRDS failures by individual utilities;
- o Screen failure rate differences among peer units for the purpose of identifying performance that diverges from the peer average to identify areas for further investigation, analysis and follow-up;
- o Draw conclusions about the effectiveness of maintenance programs (S804B states that more indications can be interpreted as a less effective maintenance program);
- o Support the identification of problem plants by NRC-AEOD when used in conjunction with other available data.

From an industry perspective, the proposed indicator displays data that is of limited use, and the necessity, benefit, or safety significance does not appear sufficient to warrant its application. The following is an assessment of the NRC anticipated uses of the proposed indicator:

G.1 NRC USE IN MONITORING NPRDS PATTERNS OF REPORTING

The proposed indicator, as constructed, is not needed and would actually complicate the monitoring of NPRDS reporting patterns because it would mask failures due to the algorithm methodology. For example, some recurring component failures are not detectable by the algorithm because the calculation methodology was not intended to identify specific component failure trends. Instead, the algorithm was established to identify an increase in the failure rate of a group of components.

The industry, through the management of the NPRDS data base by INPO, has voluntarily accepted the responsibility for improving the quality and use of the data base. The NRC staff currently monitors the management of this data base and periodically reports to the commission on the status of the program implementation. NRC participation with the NPRDS users group and periodic audit of the NPRDS data base provides a continuing opportunity to monitor the program use and implementation. This approach is cost effective and in the long term view appears to be working.

G.2 NRC USE TO IDENTIFY DIFFERENCES IN FAILURES AMONG PEER PERFORMERS FOR FURTHER FOLLOW-UP

Each of the indications produced by the proposed indicator methodology for a sample of six units (one from each utility) was evaluated. Based on this evaluation (see para E. above) it is concluded:

- o The dominant causes of components failure is wearout that could not be anticipated (35%) and Design/Manufacturing (25%). Maintenance is not the dominant cause of failure in that approximately 13% of the failures were specifically attributed to maintenance causes.
- o The proposed indicator methodology, including the trends and analysis derived, is significantly complex in scope and data use, does not identify whether the reported failure would preclude the system from performing its intended function and relies on extensive expertise and judgement to produce a conclusion that can be understood. This complexity and need for reliance on judgement will cause derived conclusions to be subjective and difficult to verify.

The rate of indications does not differentiate maintenance program performance either directly or by comparison with any other method of assessing maintenance program performance because no standard of acceptability exists and performers evaluated as good, satisfactory or in need of improvement in many cases reflect the same or very similar quantities of indications. Because the indications result from failures of different components and the failures occur as a result of different causes there is no common basis to analyze peer performance.

Peer analysis is further complicated as a result of the affect of different component operating frequency and components that perform the same function but are different in physical configuration or are installed in different orientations.

NRC research indicates that the cause of failures attributable to maintenance vary from plant to plant from 0% attributable to maintenance to 100% attributable to maintenance. The proposed indicator methodology trends plants on the basis of failures for any reason to construct a peer average. Since failures other than maintenance are combined with maintenance failures, the proposed indicator does not discriminate the affects of maintenance program weakness among peer performers.

G.3 NRC USE OF THE INDICATOR TO DRAW CONCLUSIONS RELATIVE TO MAINTENANCE EFFECTIVENESS

The proposed indicator does not measure maintenance effectiveness. It is important to monitor component failure to ensure repetitive occurrence is precluded or minimized to the extent possible. It does not follow that the proposed indicator methodology that trends groups of diverse component failures that occur for many reasons unrelated to

maintenance is a measure of maintenance effectiveness. The following factors detract from the proposed indicator's usefulness in drawing conclusions relative to the effectiveness of maintenance from component failures. (Examples of many of the areas are described in paragraph E. above).

- o Maintenance is not the dominant cause of component failure.
- o The essential elements of a maintenance program and the interrelationship of each element is complex and not measurable by a single indicator. For example, the ability to designate the relative contribution of organization, staffing and planning to the cause of failures will be highly subjective at best.
- o Many causes of failures that are not related to maintenance are aggregated and treated as if all the failures are related to maintenance. Examples include failures due to original design, manufacture, installation, improper operation and wearout. This is technically incorrect and not consistent with the NRC's definition of a failure that indicates ineffective maintenance.
- o Some plants that are judged to have good maintenance programs reflect higher levels of indications than other plants that are judged to need maintenance program implementation improvement. Maintenance performance differences are not obvious on the basis of the indication trend frequency.
- o Original design and manufacturing errors that result in component degradation or cause maintenance to be more complex are not maintenance related deficiencies. Although maintenance methodologies can be employed to mitigate original design problems, maintenance programs are not designed to anticipate either design errors or the effects of a design solution that might have been the best available option at the time of initial design, especially for failures that occur for the first time.
- o First of a kind failures are included in the NRC proposed indicator methodology. The basis stated by the NRC is that if a maintenance technique could have been applied to solve a component failure that occurs for the first time that a maintenance solution should have been applied to preclude the component failure before it occurred. Many failures that occur for the first time can not be practically predicted and would unnecessarily impact O&M costs and divert technical resources to a significant extent.
- o Technical areas of concerns identified during the interaction of the NRC and the AHAC that affect the usefulness of the proposed indicator include:
 - "Ghost" indications that incorrectly overstate failure trends.

- Component failures that do not impact the safety or reliability of systems or the plant. The AHAC analysis of indications and failure reports concludes that the proposed indicator methodology provides no insight into safety or other significant problems because a correlation to significant events, safety system failures, and power reductions is not demonstrated.
 - Conservative reporting that results in false trends of failure.
- o A component that requires frequent maintenance is not necessarily indicative of an ineffective maintenance program even if an adequate design solution is achievable. Some design solutions that could reduce the maintenance effort may not be appropriate from a cost or ALARA standpoint and become management decisions. Other design solutions may be effective but are required to be scheduled for implementation in conjunction with all other priorities.

G.4 POTENTIAL EFFECTS ON NPRDS DATA BASE USAGE

The NPRDS data base usage and data quality has steadily improved under the voluntary management of INPO. This improvement continues to be achieved by monitoring implementation during evaluation of the program and feedback from the users of the data base. Additionally, the NPRDS process has been enhanced by software changes, improvements to the guidance manual, and training those who input and use the data base products. The emphasis of the program has been to promptly identify and share lessons learned from the failure of important plant components regardless of the cause. Knowing the apparent causes or root causes of component failure is of assistance to users but is often not available from the NPRDS data base alone (reference paragraph E.2 above).

To use the data base to identify the function or organization, such as maintenance, that is the predominant or contributing cause for the failure of a specific component can be complex, costly and divert technical resources unnecessarily. The AHAC analysis of NRC supplied indicator data concludes that the predominant cause is not maintenance and that most failures do not result in a significant system or plant effect. Under current guidance it is acceptable to classify a cause as unknown and to identify the apparent cause of failure. Since failures of components can be viewed as a measure of maintenance effectiveness, it is likely that borderline cases of degradation that have not proceeded to failure will not be reflected in the data base to the extent previously captured.

The use of the NPRDS data base for the support of the proposed indicator is perceived as a disincentive in the promotion of timely and complete reporting.

H. OTHER METHODS EXIST TO MEASURE OR PROVIDE MAINTENANCE EFFECTIVENESS INSIGHT

Other methods are available that provide insight to component performance, component degraded failures and maintenance effectiveness. Examples include:

- o Methods to directly monitor component performance that minimize the loss of component functions such as:
 - Preventive (Predictive) Maintenance. The NRC maintenance team inspections indicate that virtually all plants have developed, and satisfactorily implemented, an effective program. Individual program upgrades continue.
 - Post Maintenance testing that ensures the adequacy of the maintenance.
 - Systems testing that ensure operability prior to restoration of the system to service.
 - Plant technical specification required surveillance tests.
 - ASME Section XI code required surveillance tests.
 - Performance monitoring determined to be necessary based on individual plant experience. For example, components exhibiting degraded performance are often instrumented and monitored frequently to diagnose the cause or extent of degradation.
 - Operator and NRC resident inspector rounds and other physical inspections of the plant including monitoring of plant operations and maintenance activities by management and quality assurance personnel.

- o In-depth and diverse methods to systematically monitor component and system failure. These methods provide a forcing function for the determination of root causes and the implementation of corrective action on important components and systems. Examples include:
 - The Component Failure Analysis Report (CFAR) module of NPRDS quarterly assessments.
 - Industry and NRC performance monitoring of selected important systems.

- Utility specific day-to-day meetings and safety review group oversight of operational events and LER's.
 - NRC LER cause coding and trending.
 - Periodic independent plant evaluations by INPO and peer evaluators provide not only continuing monitoring of the programmatic aspects of plant operations and maintenance but also the material and component condition of the plant.
 - Utility specific techniques that monitor repetitive failures of the same and similar components.
 - NRC quarterly performance monitoring reports.
- o Broad based indicators and other planned industry actions.

In a broad sense, utilities know on a semi-annual basis what their level of performance is in comparison with the industry at large in the area of overall indicators. All utilities periodically review their performance against not only the overall performance indicators but also the plant specific process indicators that management has determined as important to judge the effectiveness of the controls of its individual facilities.

As part of the industry action plan to continue improvement in the maintenance of nuclear power plants, other methods of evaluating maintenance effectiveness are being evaluated.

I. CONCLUSIONS:

The conclusions that follow are based on the development of the proposed indicator to date and the analysis of plant specific data from the utilities participating in the evaluation of the NRC proposed indicator. It is recognized that there are NRC on-going efforts to analyze component failures based on significance and other methods of analysis. Additionally, the interaction of the NRC and the AHAC has resulted in NRC proposed changes to the initial proposed indicator that include calculational changes and component selection adjustments that have not been evaluated by the AHAC.

- o The proposed indicator trends the failure rate increase of a selected set of NPRDS systems and components that include failures that are not maintenance related. Examples of failures unrelated to maintenance are design and original manufacturing deficiencies. Additionally, failures are included even though they may not affect safety, reliability, or availability. This approach to establish a viable indicator does not provide clear insight into a maintenance program or suggest succinctly a problem that a utility could address.

- o Component selection should be based on the significance of component (the potential of the component, upon failure, to contribute to a significant system or plant effect from the standpoint of safety and reliability). Failures that occur that affect only the economics of operation and maintenance without affecting system or plant safety and reliability should be excluded from a regulatory based indicator.
- o NRC analysis of NPRDS narratives (alone) resulted in the NRC conclusion that maintenance is the dominant cause of component failure (>75%). The AHAC determined that approximately 13% of component problems at six sample plants were related to improper maintenance, suggesting that the causes of the indications are not predominately maintenance related. The NRC Staff and the AHAC have different views relative to component failures that should be attributed to maintenance. Different interpretations of the cause of failure can be suggested by the narratives depending on the extent of plant specific knowledge and an individual's interpretation of the NPRDS report narrative. The analysis of indications required a review of the NPRDS narratives with amplification from other plant documents and interviews of knowledgeable plant technical personnel. Failures that are beyond the control of the utility or are allowable on the basis of a technical evaluation are examples of areas in which agreement has not been achieved.
- o The AHAC analysis of the causes of indications, as previously described in paragraph E.1.4 and figure 2, concludes:
 - Wearout that could not be anticipated is the dominant cause of failures, contributing about 35 percent of the total. In most of these cases, the component failures could not be anticipated and occurred with no prior history of similar problems.
- o The distribution of failures associated with indications, by cause category, is provided in Figure 2.
 - Design/manufacturing problems are the second largest cause category, contributing 25 percent of the total number of failures. Many of these problems would appear to be maintenance related, based on a review of NPRDS, because they result in recurring maintenance on components. However, a more detailed review of cause information than is typically available in NPRDS (e.g., root cause analysis reports, engineering studies, discussions with cognizant engineers) shows that system and component design is the cause of these failures.
 - None of the indications would result in a change to the maintenance program. This is considered important because the

proposed indicator is suggested as a method of assessing the effectiveness of the overall maintenance program by counting the frequency of component failures.

- The trends that are produced by the indicator are overly influenced by INCIPIENT CONDITIONS frequently (and conservatively) reported as DEGRADED FAILURES and by the algorithm averaging methodology. A review of the data provided by AEOD identified the following important factors that cause indications to occur that are not related to component failures:

NPRDS failure reports that do not meet the criterion for reportable failures. A review of 279 failure reports associated with the 84 indications identified 60 reports (22%) that do not constitute failures.

"Ghost" indications caused by the algorithm methodology. A review of 84 indications identified 16 (19%) that occurred with no associated NPRDS failure reports. Each of six plants experienced from 2 to 4 "ghost" indications (indications with no corresponding failure data), suggesting that this is a significant problem. This problem has a much more pronounced effect on plants with a small number of indications; at three units, "ghost" indications contributed 7 of 22 total indications (31%).

- o Most indications occur during planned outages suggesting that the indications reflect the level of maintenance effort rather than maintenance effectiveness.
- o A review of existing indicators and methods that provide insight into maintenance effectiveness did not result in a meaningful correlation to the proposed indicator data. The indications provided under the proposed indicator methodology do not result in consistent trends that discriminate performance. For example programs that are viewed as good, satisfactory or in need of improvement can display the same frequency of indications.
- o To assign the cause of component failures to a specific organization will be counterproductive to the use of the NPRDS data base as a reliability tool and as a method to share information relative to the degradation of important components.
- o Individual utility maintenance managers prefer to be measured according to the elements under their span of control. Although the NRC definition of the scope of maintenance and the industry definition of maintenance is very similar, the scope of the proposed indicator goes beyond the bounds of hands-on maintenance.
- o The attempt to extrapolate failures that occur for many diverse reasons to a meaningful conclusion relative to the essential elements of a maintenance program introduces significant subjectivity into the use of

the proposed indicator. It is unlikely that a single indicator could capture the affects of such a complex set of essential elements.

- o The proposed indicator, as constructed, does not measure maintenance effectiveness.