PERFORMANCE INDICATORS IN THE REACTOR OVERSIGHT PROCESS
A STATUS REPORT

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Introduction

The overall performance of commercial nuclear power plants in the United States improved significantly from 1988 to 1997, as demonstrated by trends in many of the NRC's performance indicators (PIs). This improving performance was attributed, in part, to the NRC's regulatory oversight. Nevertheless, the NRC noted that the inspection, assessment, and enforcement processes then in place were at times not clearly focused on the most important safety issues, overly subjective, and redundant. In March 1998 the NRC staff forwarded to the Commission a proposal for a new, integrated assessment process incorporating the following fundamental concepts: (1) inspection findings to provide the basis for assessment, (2) inspection findings to be scored by safety significance, (3) assessment to be accomplished by totaling the scores and comparing them to threshold values, (4) performance categories to be color coded, and (5) NRC actions to be based upon decision models.

In parallel with the staff's work, the nuclear power industry, coordinated and led by its Nuclear Energy Institute (NEI), developed an independent proposal for improving the assessment process. This approach established tiers of licensee performance based on maintaining the barriers to the release of radionuclides, minimizing events that could challenge the barriers, and ensuring that systems can perform their safety functions. Performance would be measured by objective indicators with thresholds to define a utility response band, a regulator response band, and a band of unacceptable performance.

In response to the NEI proposal and Commission comments on the NRC's proposal, the staff set out to develop a single set of recommendations to improve its regulatory oversight process. The staff sponsored a 4-day public workshop from September 28 to October 1, 1998, to obtain and evaluate industry and public input. That workshop achieved consensus on an overall philosophy and defining principles of a new oversight process.

Following the workshop, the staff formed three task groups of NRC experts in various aspects of regulatory oversight to develop the recommendations from the workshop into what would become known as the Reactor Oversight Process (ROP). The Technical Framework Group completed the oversight structure by defining three strategic performance areas - Reactor Safety, Radiation Safety, and Safeguards - supported by seven cornerstones of safety: Initiating Events, Mitigating Systems, Barrier Integrity, Emergency Preparedness, Occupational Radiation Safety, Public Radiation Safety, and Physical Protection (Figure 1). Within the seven cornerstones, the Technical Framework Task Group identified performance indicators wherever possible to provide objective measurement of licensee performance, along with appropriate thresholds for NRC engagement. The green band is the Licensee Response Band; the NRC will not engage the licensee if the PI is green. The green-white threshold was determined using historical data to identify plants whose performance differed significantly from industry average. The white band is the Increased Regulatory Response Band; if a PI is in this band, the NRC will perform an inspection to evaluate the licensee's root cause analysis to ensure that the cause(s) of any performance issues have been identified and appropriate corrective actions have been taken to prevent recurrence. The yellow band is the Required Regulatory Response Band; for a PI in the yellow band, the NRC will perform a more intensive inspection. The red band is the Unacceptable Performance Band; with a red PI, the licensee's performance warrants extensive NRC oversight. The white-yellow and yellow-red thresholds were determined using generic Probabilistic Safety Assessment (PSA) models to identify performance in each PI that alone would result in an increase in core damage frequency of 10^{-5} and 10^{-4}, respectively. PIs were selected from those readily available (such as Safety System Unavailability, which was identical to the World Association of Nuclear Operators' Safety System Performance Indicator) or easily developed (such as Unplanned Power Changes, which was developed from Monthly Operating Report data submitted by every licensee).

The Inspection Task Group was responsible for developing the scope, depth, and frequency of a risk-informed baseline inspection program that would identify performance deficiencies to supplement and verify the PIs. The program was developed using a risk-informed approach to determine a comprehensive list of areas to inspect within each cornerstone of safety. The program currently includes about 30 inspectable areas.

The Assessment Process Task Group developed methods for integrating PI and inspection data, determining NRC actions based on assessment results, and communicating results to licensees and the public. A Significance Determination Process (SDP) was developed to color-code inspection findings so that the risk-significance of those findings would be directly comparable to the PIs. An Action Matrix (Figure 2) was established that provides guidance for consistency in NRC actions among plants. Results of the assessment process are communicated to the Commission through quarterly updates of assessment data, semiannual inspection planning letters, and annual assessment tools that are forwarded to the Commission prior to the annual Commission meeting. These assessments of licensee performance are discussed in public meetings that are held annually in the vicinity of each nuclear power plant site.

The NRC's Office of Enforcement coordinated with the three task groups to develop changes to the enforcement policy that reflect the changes in the inspection and assessment processes. The fundamental purposes of the enforcement policy have not changed, but violations have been tied to licensee performance determined through the assessment process.

The NRC conducted a six-month pilot program at nine sites (13 reactors) that began in May 1999. The last data were submitted in November 1999. A Lessons Learned Workshop was convened in February 2000 and one PI (Containment Leakage, in the Barrier Integrity Cornerstone) was removed from the program. Industry-wide implementation of the ROP began with 18 PIs (Figure 3) reported in April 2000 for the first quarter of calendar year 2000.

While reporting the ROP PIs to the NRC is voluntary, all operating nuclear power plants in the U.S. are committed to doing so. The guidance document for the ROP PIs is NEI 99-02, "Regulatory Assessment Performance Indicator Guideline." It contains, for each of the 18 indicators, the purpose, data reporting requirements, calculations, definitions, and clarifying notes. Licensees report PI data quarterly. All PI data and inspection findings are displayed on the NRC's external web site. When interpretation issues arise, licensees may send in Frequently Asked Questions (FAQs) to an NRC/Industry working group for resolution. FAQs and their answers are posted on the NRC external web site. NRC Inspectors may submit their questions or concerns to NRC headquarters using feedback forms.

It is important to note that there are fundamental differences between PIs and inspection findings. A green PI indicates that licensee performance is acceptable and NRC engagement is not necessary. A green inspection finding, however, indicates a licensee performance deficiency, albeit of very low risk. Another important difference is that inspections address individual events or conditions, with the SDP process used to color-code the risk-significance of each of them. PIs, on the other hand, monitor events or conditions over a period of time to assess the risk-significance of the aggregation of those events or conditions over that period. PIs and inspection findings, then complement each other rather than duplicate each other.

Lessons Learned

The NRC began its first agency-wide PI program in 1987. These original PIs were used to monitor individual plant performance as well as industry trends. They were one of several inputs into the NRC's assessment process, and they were typically used only if they confirmed other assessment tools. The ROP program, however, uses PIs as one of the two inputs into the process for assessing plant-specific nuclear power plant safety performance (the other being the baseline inspection program). During the four years of full implementation, the NRC staff has gained insights and learned important lessons regarding PIs and the way licensees respond to them. Some of the more important of those lessons are discussed below.

Many performance indicators lose their effectiveness over time: Many of the NRC's 1987 indicators improved significantly between 1988 and 1997. This was due to two factors: (1) the U.S. nuclear power industry implemented an effective scram reduction program, which caused the Unplanned Scrams, Safety System Actuations, and Significant Events indicators to decline markedly; and (2) the NRC was monitoring and publishing the above indicators and others, including Collective Radiation Exposure and Equipment Forced Outages per 1,000 Critical Hours, both of which also declined sharply. Performance that is monitored gets attention. In some cases, however, even additional attention was unable to result in improvement, as was the case with Safety System Failures and Forced Outage Rate, both of which showed no evidence of improved industry performance until 1999. (It should be noted that, while the U.S. industry significantly improved its capacity and availability factors during the mid- to late-1990s, that feat was accomplished not by reducing forced outage hours, but by significantly reducing planned outage hours through longer operating cycles and shorter refueling outages). By 1997, because there were significantly fewer PI events occurring in the industry, there was less spread in the PI values between plants, and therefore identifying poor performing plants became more difficult. The lesson learned is that PIs must be periodically updated or replaced in order to identify plants whose performance differs significantly from the industry average. Those early PIs, nevertheless, continue to be useful for monitoring industry trends.

Licensees challenge counts in the ROP PIs: Licensees did not often dispute PIs that were not used to identify a plant whose performance required increased NRC attention. But the ROP PIs are used to identify declining performance and they are readily available on the NRC web site where they may be viewed by financial organizations, as well as public interest groups and private citizens. For these reasons, many FAQs have been submitted by licensees to explain why a particular event or condition at their plant should not be counted, even when they have a low number of counts, or no counts at all, in that PI. Such action has made the FAQ process inefficient.

PIs should be designed so that licensee actions to improve them will also improve plant safety: The best PIs are those that can be maintained at a low level only by taking actions that will also improve plant safety. The NRC's Emergency Preparedness Cornerstone Drill Participation and Drill/Exercise Performance indicators are good examples. To stay above the green-white threshold requires licensees to have at least 80 percent of their key emergency response personnel participate in at least one drill or exercise every two years. However, to receive credit for participation, the drill must also be evaluated in the Drill/Exercise Performance PI, which requires at least a 90 percent success rate over two years.

Performance Indicators must consider accident conditions: Some licensees argue that an event or condition was not risk-significant and therefore should not be counted. It is true that events are of low risk-significance if safety systems are assumed to not fail. But the regulator must consider the capability of the plant to respond to the worst case failure in conjunction with the event or condition. The Scrams with Loss of Normal Heat Removal PI has been a particular problem in this regard. Licensees do not view the power conversion system (PCS) as risk-significant because safety systems are normally available to perform their safety functions. However, regulators must consider a situation in which high-pressure heat removal systems are unable to perform their safety function. PSAs reveal that accident sequences in which all high-pressure heat removal trains are lost is often a dominant contributor to core damage frequency. In such a situation, availability of the PCS is very important. This PI monitors the availability of the PCS and is therefore important to regulatory bodies.

Performance Indicator definitions should not contain numbers: It is difficult to identify a number in a PI definition that distinguishes between acceptable and unacceptable performance. The NRC's Unplanned Power Changes per 7,000 Critical Hours has been a problem because it includes two numbers: a 20 percent minimum on the magnitude of the power change and a 72 hour interval for planning the evolution. Both of these numbers have affected license actions in order to avoid a count in this indicator. One licensee changed an off-normal procedure to reduce power by 19 percent rather than 40 percent, and other licensees have developed procedures to be able to say that they have planned for more than 72 hours. In reality, experienced plant operators can reduce power quickly when necessary, so the 72 hour limit only applies to preparing for whatever activity is to be accomplished after power has been reduced. Many times, 72 hours is either longer than necessary or not long enough, depending upon the circumstances. The lesson learned is that numbers should be avoided in PI definitions.

Performance Indicators cannot measure human performance: Licensees want to credit operator recovery actions in the Safety System Unavailability and Scrams with Loss of Normal Heat Removal indicators. However, a PI can only measure equipment performance, not human performance. This is not to say that operators cannot recover the system. A Human Reliability Analysis must be performed to determine the probability of successful recovery. That probability varies from plant to plant depending upon plant procedures, equipment, training, and other conditions. The only credit that the ROP PIs allow for operator recovery actions are those that are virtually certain to be successful (i.e., probability near one) during accident conditions, meaning that any operator on any shift at any plant would be successful. This allows for nothing much more complicated than pushing the manual start button when the automatic start function fails.

Performance Indicator Issues

Safety System Functional Failures (SSFFs): This indicator measures the number of events or conditions reported by licensees in which a safety system may be incapable of performing its safety function. It includes potential as well as actual failures. While there are very few actual failures of all trains in a system (except for single train systems), there are many conditions that have the potential to disable a safety system. Examples of the latter include discovery of a part not seismically or environmentally qualified that, under the right set of circumstances, might fail and cause the system to fail. NRC contractors at the Idaho National Engineering and Environmental Laboratory read event reports to identify SSFFs. Licensees report the number of events (but not the event report numbers) quarterly to the NRC. Since the beginning of full implementation, licensees have reported about 20 percent fewer events than the lab has counted. Investigation into this problem has begun and there are some preliminary results. In some cases, licensees report the failure of a single train without determining the status of the other train(s) in the system. If the other train(s) was (were) unavailable at any time during the unavailability of the reported train, that condition would constitute an SSFF.

RCS Leakage: As a result of the event at the Davis-Besse nuclear power plant, the staff has developed a three-phase program to accomplish the following tasks:

(1) Improve the existing indicator
(2) Develop an indicator to track the number, duration, and rate of RCS leaks
(3) Determine the feasibility of developing a risk-informed RCS indicator

Phase 1 is currently underway. The staff proposes to have licensees report the highest value in each month of every leakage parameter currently required by technical specifications, which typically include unidentified leakage and either identified or total leakage. Some PWRs may also have a separate technical specification on primary-to-secondary leakage. The highest quarterly value of each parameter will be displayed on the NRC web site and the highest of these quarterly values will determine the color of the PI.

Fuel Cladding Integrity: The current indicator of fuel clad integrity monitors the dose-equivalent I-131 in the primary coolant. The staff believes that the Fuel Reliability indicator used by the World Association of Nuclear Operators (WANO) may provide a better indication of the integrity of that barrier. The staff plans to work with WANO to investigate the possibility of using their Fuel Reliability PI.

Containment Integrity: This PI was used in the pilot program to monitor Type B and C containment leak rate test results. It provides an indication of the worst-case containment leakage during the prior fuel cycle. It was eliminated from the PI program prior to full implementation because licensees are allowed to choose one of two options for performing the leak rate tests, one of which does not require licensees to record as- found leakage. For licensees who choose that option, there would be no recorded data that would be useful to the

PI. Currently, all licensees are being monitored in this area through inspection. However, some licensees have indicated a willingness to change leak rate test options so as to collect the data to support the PI. One proposal going forward would be, for those who do not elect to change, to continue to monitor containment integrity through inspection.

Physical Protection: The current PIs in the Safeguards Cornerstone are being reported by licensees and displayed on the NRC's web site. The NRC is presently re-evaluating the PIs in this cornerstone.

Conclusion

The ROP PIs have served for four years to monitor licensee performance in the specific areas for which they are suited. While they have identified plants whose performance required additional NRC oversight, they have become less discriminatory with time as licensees responded to the parameters being measured. Therefore the NRC will continue to assess the ROP PI program as a normal part of the ROP. The goal is to identify improvements to PI definitions, calculations, and thresholds that will maintain the effectiveness of the ROP PI program and improve safety in weak performance areas. All stakeholders will be invited to participate in this effort.