Appropriateness of Existing Performance Indicators and Thresholds

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Background

As discussed in SECY-12-0081, "Risk-Informed Regulatory Framework for New Reactors," the case studies developed for the Mitigating System Performance Index (MSPI) tabletops showed that the existing MSPI is not adequate and would be largely ineffective in determining an appropriate regulatory response for active new reactor designs. Furthermore, a meaningful MSPI may not even be possible for passive systems using the current formulation of the indicator. The staff noted that the existing performance limit approach, which incorporates a backstop that indicates when the performance of a monitored component in an MSPI system is significantly lower than expected industry performance, potentially could be modified and emphasized for active new reactor designs. The staff concluded in SECY-12-0081 that alternate performance indicators (PIs) in the Mitigating Systems cornerstone could be developed or additional inspection could be used for the new reactors to supplement insights currently gained through MSPI for the current fleet.

In response to the staff requirements memorandum (SRM) on SECY-12-0081 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12296A158), the staff reviewed the basis and related thresholds for the remaining PIs to determine whether they could be appropriately applied to the operation of new reactor design plants. A more detailed discussion on the appropriateness of existing PIs and their thresholds for new reactors is provided in the sections that follow.

Performance Indicator Review

PIs, together with risk-informed baseline inspections, are intended to provide a broad sample of data to assess licensee performance in the risk-significant areas of each cornerstone. Objective performance evaluation thresholds are intended to help determine the level of regulatory engagement appropriate to licensee performance in each cornerstone area. Implementation guidance for the PI program is contained in U.S. Nuclear Regulatory Commission (NRC) Inspection Manual Chapter (IMC) 0608, "Performance Indication Program" (ADAMS Accession No. ML043560102). More detailed guidance on the data collection and PI calculations are contained in IMC 0308, Attachment 1, "Technical Basis for Performance Indicators," (ADAMS Accession No. ML071860516), and within NEI 99-02, "Regulatory Assessment Performance Indicator Guideline" (ADAMS Accession No. ML092931123), which is jointly produced and maintained by the Nuclear Energy Institute (NEI) and the NRC. In response to the SRM on SECY-12-0081, the staff reviewed the basis and related thresholds for the PIs in each cornerstone to determine whether they can be appropriately applied to plant operation for new reactor designs.

Initiating Events

The objective of the initiating events cornerstone is to limit the frequency of those events that upset plant stability and challenge critical safety functions, during shutdown as well as power operations. Three PIs are associated with this cornerstone.

The Unplanned Scrams per 7,000 Critical Hours indicator is used to monitor the number of unplanned scrams, both automatic and manual, assessed over a 4-quarter period. This PI measures the rate of scrams per year of operation at power (7,000 hours) and provides an indication of initiating event frequency. As documented in SECY-99-007, “Recommendations for Reactor Oversight Process Improvements,” dated January 8, 1999 (ADAMS Accession No. ML992740073), probabilistic risk assessment (PRA) models were used to provide a risk-perspective on the current thresholds for this PI. This was done by performing sensitivity studies to investigate how the Core Damage Frequency (CDF) of plants varies as the values of the PI changes. Three thresholds were established as described in Appendix H of SECY-99-007. The green–white threshold corresponds to licensee performance outside of a generically achievable level of performance. The white–yellow threshold corresponds to substantially declining licensee performance and was determined by identifying the PI values that would correspond to increases in CDF of 1×10^{-5}. The yellow–red threshold corresponds to unacceptable licensee performance and corresponds to an increase in CDF of 1×10^{-4}. As a result of the sensitivity studies, the thresholds were set to 6.0 scrams per 7,000 critical hours for white–yellow threshold and 25.0 scrams per 7,000 critical hours for the yellow–red threshold for the existing reactor designs. The thresholds are set below that which PRA data would recommend. The current green-white threshold was set to 3.0 scrams per 7,000 critical hours, incorporating both performance and risk data to be commensurate with a generally achievable level of performance that takes into account the statistical variability across the current plant designs. Because the risk estimates for the new reactor designs are approximately one or two orders of magnitude lower than those for operating reactor designs, the staff concludes that Unplanned Scrams per 7,000 Critical Hours PI and existing thresholds can appropriately be applied to plant operation for new reactor designs to determine a regulatory response.

The Unplanned Scrams with Complications indicator is used to monitor a subset of unplanned automatic and manual scrams that occur while occur while the reactor is critical and require additional operator actions as determined by the guidance in NEI 99-02 that are more risk-significant than uncomplicated scrams. The PI monitors these six actions or conditions that have the potential to complicate the post-trip recovery; reactivity control, pressure control (boiling water reactors)/turbine trip (pressurized water reactors), availability of power to emergency buses, actuation of emergency injection sources, availability of main feedwater, and the use of emergency operating procedures to address complicated scrams. The staff notes that the NEI 99-02 guidance will need to be supplemented with additional guidance to account for passive systems since complicating conditions may not be the same for new reactor designs. The current threshold is established to identify industry performance outliers over a 4-quarter period. The staff concludes that because the PI and corresponding thresholds are not linked to PRA data, the Unplanned Scrams with Complications indicator can appropriately be applied to the operation of plants with new reactor designs. However, additional NEI 99-02 guidance would need to be developed to reflect the constitution of a complicated scram associated with the new designs.

The Unplanned Power Changes per 7,000 Critical Hours indicator is used to monitor the number of unplanned power changes that could have, under other plants' conditions, challenged safety functions. This PI measures the number of plant power changes for a typical year of operation at power and is not a direct measure of risk. The current threshold was determined using industry mean plus one standard deviation based on data over a 2-year period. Because the PI and threshold are not directly linked to PRA data, the staff concludes that the Unplanned Power Changes per 7,000 Critical Hours indicator and corresponding thresholds can appropriately be applied to plant operation for new reactor designs to determine a regulatory response.

Mitigating Systems

The objective of the mitigating systems cornerstone is to ensure the availability, reliability, and capability of systems that mitigate plant transients and reactor accidents. Six PIs are associated with this cornerstone.

The Safety System Functional Failure (SSFF) indicator is used to monitor events or conditions that could have prevented the fulfillment of the safety function of structures or systems that are needed to:

- shut down the reactor and keep it in a safe shutdown condition
- remove residual heat
- control the release of radioactive material
- mitigate the consequences of an accident

The PI is not directly linked to PRA data, but to the reporting requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 50.73, "Licensee Event Report System." The thresholds were determined using the industry mean plus one standard deviation based on data over a 2-year period. Because the SSFF PI has a regulatory basis and the thresholds are not directly linked to PRA data, the staff concludes that the SSFF PI and corresponding thresholds can appropriately be applied to plant operation for new reactor designs to determine a regulatory response.

The other five PIs within the cornerstone are the MSPI. MSPI is addressed in SECY-12-0081, "Risk-Informed Regulatory Framework for New Reactors," dated June 6, 2012 (ADAMS Accession No. ML12117A012). The staff concluded that the existing MSPI would not be adequate and would be largely ineffective in providing meaningful input to the risk-informed regulatory decision-making process. Numerous case studies demonstrated this shortfall. The case studies demonstrated that it would be extremely rare to cross greater-than-green MSPI thresholds that would result in an increased regulatory response for active new reactor designs, and a meaningful MSPI might not even be possible for passive systems using the current formulation of the indicator. As noted in SECY-12-0081, the staff determined that alternate PIs in the mitigating systems cornerstone, specifically MSPI, could be developed and additional inspection could be used for the new reactors to supplement insights currently gained through MSPI for the current fleet.

Barrier Integrity

The objective of the barrier integrity cornerstone is to ensure that physical barriers protect the public from radionuclide releases caused by accidents. This cornerstone contains the Reactor Coolant System Specific Activity and the Reactor Coolant Leakage indicators. These indicators are used to monitor the integrity of the fuel cladding and reactor coolant system's pressure boundary. The thresholds are a percentage of the Technical Specification limits and therefore, have a regulatory basis as opposed to a PRA basis. The staff concludes that because these PIs are linked to a regulatory standard, both the PIs and the corresponding thresholds can appropriately be applied to plant operation for new reactor designs to determine a regulatory response.

Emergency Preparedness

The objective of the emergency preparedness cornerstone is to ensure that actions taken as part of the emergency plan would protect the public health and safety during a radiological emergency. Three PIs are associated with this cornerstone.

The Drill/Exercise Performance indicator is used to monitor timely and accurate licensee performance in drills and exercises when presented with opportunities for classification of emergencies, notification of offsite authorities, and development of protective-action recommendations. The Emergency Response Organization Drill Participation indicator measures the percentage of key Emergency Response Organization members who have participated recently in drills and exercises or in an actual event. The Alert and Notification System Reliability indicator is used to monitor the reliability of the offsite Alert and Notification System, a critical link for alerting and notifying the public of the need to take protective actions. It indicates the percentage of the sirens that are capable of performing their safety function as measured by the testing program.

The thresholds associated with these PIs are not specifically tied to PRA data, but to regulatory requirements or the professional judgment of the staff and industry. The staff concludes that because the PIs are linked to regulatory requirements or professional judgment, the Emergency Preparedness PIs and the corresponding thresholds can appropriately be applied to plant operation for new reactor designs to determine a regulatory response.

Occupational Radiation Safety

The objective of the occupational radiation safety cornerstone is to ensure adequate protection of worker health and safety by preventing workers' exposure to radiation from radioactive material during routine civilian nuclear-reactor operation. One PI is associated with this cornerstone. The Occupational Exposure Control Effectiveness PI is used to monitor the control of access to, and work activities within, radiologically significant areas of the plant and occurrences involving the degradation or failure of radiation-safety barriers that result in readily identifiable unintended doses. The PI is the sum of the number of instances of non-conformance with the Technical Specifications, or comparable procedures, controlling access to, and work within, a high-radiation area (with dose rates greater than one rem per hour), instances of non-conformance with controls for a very-high-radiation area, and the number of unintended-exposure occurrences. The PI thresholds are based on review and analysis of quarterly occupational radiological occurrence data provided by numerous licensee sites over a 2-year period. The PI thresholds were agreed upon by an expert panel composed of NRC and industry representatives. The staff concludes that because the Occupational Exposure Control Effectiveness PI is based on regulatory requirements (in 10 CFR 20.1101, “Radiation protection programs;” 20.1602,”Control of access to high radiation areas;” and 20.1602, “Control of access to very high radiation areas”) and plant technical specifications with no specific link to PRA data, the PI and the corresponding thresholds can appropriately be applied to plant operation for new reactor designs to determine a regulatory response.

Public Radiation Safety

The objective of the public radiation safety cornerstone is to ensure adequate protection of public health and safety by preventing exposure to radioactive material released into the public domain as a result of routine civilian nuclear-reactor operations. One PI is associated with this cornerstone. The radiological effluent technical specifications (RETS) and Offsite Dose Calculation Manual (ODCM) Effluent Occurrence PI is used to monitor the performance of the radiological effluent control program. The associated thresholds of this PI are a percentage of the values derived from the RETS/ODCM and, therefore, have a regulatory basis as opposed to a probabilistic risk basis. The current thresholds were based on a review and graphical analysis of Licensee Event Reports data associated with process radiation monitoring system activities provided by all operating nuclear power-plant sites over a 2-year period.

As documented in SRM-SECY-08-0197, “Options to Revise Radiation Protection Regulations and Guidance with Respect to the 2007 Recommendations of the International Commission on Radiological Protection,” dated April 2, 2009 (ADAMS Accession No. ML090920103), the staff is currently participating in technical committees and evaluating the recommendation in the International Commission on Radiological Protection Publication 103 to determine whether changes to current regulations are merited. One potential result of this effort might result in amending the effluent limits in 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” Appendix I, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low as is Reasonably Achievable’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents.” This would lead to a change in the PI thresholds for both existing and new reactor designs. The staff concludes that because the current RETS and ODCM Effluent Occurrence PI is based on regulatory requirements (from 10 CFR Part 50, Appendix I) and is not specifically linked to PRA data, the PI and the corresponding thresholds can appropriately be applied to plant operation for new reactor designs to determine a regulatory response.

Security

The objective of the Security cornerstone is to provide assurance that the licensees’ security systems and material control and accounting programs use a defense in-depth approach and can protect against (1) the design-basis threat of radiological sabotage from external and internal threats and (2) the theft or loss of radiological materials. One PI is associated with this cornerstone. The Protected Area Security Equipment Performance Index is used to monitor the unavailability of the protected area's intrusion-detection systems and alarm-assessment systems to perform their intended function to ensure operability of the protected area. The PI serves as a measure of the plant's ability to keep equipment available to perform its intended function as well as to repair degraded and out-of-service intrusion-detection equipment in a timely manner. Similar intrusion-detection systems will be required for new reactors. The Security PI is not specifically tied to probabilistic risk data. The current thresholds were developed and agreed to by an expert panel composed of NRC and industry representatives based on historical industry data. The staff concludes that because the Security PI is not specifically tied to PRA data, the PI and corresponding thresholds can appropriately be applied to plant operation for new reactor designs to determine a regulatory response.

Conclusions

The staff concludes that many of the PIs are based on regulations or standards that would also apply to new reactor designs and that many of the thresholds are deterministic. The staff notes that for the Unplanned Scrams with Complications indicator in the Initiating Events cornerstone, a complicated scram for new reactor designs would need to be defined. As noted in SECY-12-0081, a risk-informed alternative to the MSPI indicators in the Mitigating Systems cornerstone would need to be developed for new reactor applications. The staff concludes that the remaining PIs and related thresholds could apply to new reactors. Pending Commission approval, the staff plans to further analyze the current PIs and thresholds and attempt to develop appropriate PIs and thresholds for new reactor applications, particularly in the Mitigating Systems cornerstone. If the staff determines that appropriate PIs and thresholds are not feasible for new reactor applications, the staff plans to develop additional inspection guidance to address any shortfalls to ensure that all cornerstone objectives are adequately assessed.