Gap Analysis of the Reactor Oversight Process

PURPOSE:

The purpose of this analysis is to review the capability of the Performance Indicator (PI) Program in concert with the Reactor Inspection Program to ensure adequate performance insights in each safety cornerstone's key safety attributes as defined in Reactor Oversight Process (ROP) basis documentation. The Security Cornerstone was not included in this analysis.

BACKGROUND:

On April 21, 2010, the NRC hosted a Category 2 public meeting to discuss a framework for considering new PIs. The initial approach focused on potential new PIs that would supplement the existing suite of indicators. While this approach had merit, the NRC and industry agreed to hold off on dedicating resources to consider any new PIs without a well-defined problem statement. As a result, the NRC agreed to perform a gap analysis to reveal potential areas of the ROP that warrant additional oversight through inspection or PIs. The results of this gap analysis could be considered for the biennial ROP realignment process.

PROCESS:

The staff recognizes that there are numerous approaches to analyze and evaluate the PI and inspection programs' effectiveness in maintaining coverage and oversight of the safety cornerstones' key safety attributes. For the purposes of this particular exercise, and based on available staff resources, the following process was used for the gap analysis:

1) Review and evaluate potential PIs described in SECY-99-007, "Recommendations for the Reactor Oversight Process," that were either never designed or implemented to determine if their viability has changed, or if they could add value to the ROP and if that value is needed to ensure adequate coverage of the associated ROP safety cornerstones.

2) Review and evaluate recent sources of information on ROP implementation (*e.g.*, annual ROP self-assessments, feedback forms, Action Matrix deviations, task force reports, and industry initiatives) to determine if they reveal any potential areas for improvement in either the PI program or the inspection program.

3) Make recommendations based on the results of the evaluations and categorize each recommendation as either:

    - Coverage is adequate,
    - Coverage could be enhanced, or
    - Defer.

4) Summarize the gap analysis.

EVALUATION:

Initiating Events Cornerstone

1. Shutdown Safety Margin

Description: Shutdown safety margin was recommended as a potential PI in SECY-99-007. This indicator would have tracked the number of unplanned reductions in the safety margin for (1) reactor coolant inventory, (2) reactor coolant temperature, and (3) reactivity while the plant is shutdown. This indicator would have counted the events that jeopardized the capability to remove decay heat from a shutdown reactor or could have caused an unplanned criticality. SECY-99-007 stated that experience had shown that certain plant activities while the reactor is shutdown with safety equipment out-of-service could have serious consequences. SECY-99-007 also stated that it was important that reactor coolant level and temperature be controlled to maintain heat removal capability and prevent inadvertent criticality.

Evaluation: Creating a shutdown safety margin PI was explored in NUREG-1753, "Risk-Based Performance Indicators: Results of Phase 1 Development." This NUREG identified a major challenge that continues to apply: initiating events do not accumulate statistical data quickly enough to support timely detection of declining performance. As a result, creating a risk-based initiating event PI for shutdown operations is not feasible.

The inspection program currently provides coverage of licensee performance during shutdown conditions. Inspection Procedure (IP) 71111.20, "Refueling and Other Outage Activities," requires inspectors to verify reactor coolant system instrumentation, decay heat removal system parameters, and inventory and reactivity control.

Recommendation: Coverage is adequate. Instead of developing a shutdown safety margin PI, the inspection program should continue to cover this area by sampling licensee performance during reactor shutdown conditions. The resultant research and data from NUREG-1753 could be used to support the ongoing development of significance determination process (SDP) tools for low-power and shutdown operations.

Mitigating Systems Cornerstone

2. Shutdown Operations Performance

Description: Shutdown operations performance was recommended as a potential PI in SECY-99-007. This indicator would have measured the percent of outage time that defense-in-depth was compromised. Most licensees manage shutdown risk in accordance with NUMARC 91-06, "Guidelines for Industry Actions to Assess Shutdown Management." Licensees manage defense-in-depth through configuration control of key safety functions (*e.g.*, decay heat removal, inventory control, electrical power availability, reactivity control, and containment). This PI would have measured the percent of outage time that each key safety function lacked defense-in-depth from either installed equipment or contingency actions.

Evaluation: Creating a shutdown operations PI was explored in NUREG-1753, and the following challenges were identified and continue to apply:

- Because risk changes from configuration management are detectable in short time intervals, monitoring shutdown risk has an episodic SDP character rather than a longer-term trending indicator character.

- Development of a baseline would require characterizing a nominal outage.

- Operational exigencies drive variations in shutdown risk that are substantially greater than the risk changes associated with PI thresholds in the ROP. PIs that measure changes in shutdown risk would therefore capture influences whose relationship to licensee performance in configuration management is indirect. This could potentially lead to unintended consequences.

For these reasons, a shutdown operations PI is not currently a viable risk-based indicator. However, the inspection program provides coverage of licensee performance during shutdown operations. IP 71111.20 provides for the review of a licensee's outage risk control plan, monitoring of equipment configuration control during shutdowns, and verification of a licensee's maintenance of defense-in-depth commensurate with the outage risk control plan. In addition to the parameters that are inspected as described in the afore-mentioned shutdown safety margin PI discussion, this IP also provides for the verification of electrical power configuration, spent fuel pool cooling operation, and containment closure.

Recommendation: Coverage is adequate. The inspection program should continue to cover this area by sampling licensee performance during shutdown conditions. However, deterministic and qualitative considerations could be applied to establish thresholds for performance bands if there was a desire to have the inspection and PI programs share coverage in this area for efficiency purposes. Additionally, a technical basis for those thresholds would need to be developed. The resultant research and data from NUREG-1753 could be used to support the ongoing development of SDP tools for low-power and shutdown operations.

3. Maintenance Rule Implementation

Description: Maintenance Rule (*i.e.*, Title 10 of the *Code of Federal Regulations*, Part 50, Section 65 (10 CFR 50.65)) implementation was recommended for potential PIs in SECY-99-007. One potential PI would have indicated changes in cumulative core damage frequency based on the changes resulting from at-power and shutdown safety assessments. The PI threshold values would have been plant-specific. Another potential PI would have indicated structures, systems, and components (SSCs) that had either remained in an (a)(1) status for long periods or entered into an (a)(1) status on multiple occasions over relatively short duration.

Evaluation: The performance-based nature of the Maintenance Rule allows a diverse set of maintenance programs to exist throughout the industry. Although most licensees use internal performance metrics to manage their maintenance effectiveness programs, establishing a standardized PI would not be feasible because each site or licensee can create a program that is slightly different but still meets the intent of the Maintenance Rule. In addition, the number of SSCs in (a)(1) is not necessarily an indication of declining performance in the area of maintenance effectiveness. An evaluation of the SSCs in (a)(1) would need to be performed on a case-by-case basis to detect a declining performance trend.

The inspection program, via routine baseline procedures IP 71111.12, "Maintenance Effectiveness," and IP 71111.13, "Maintenance Risk Assessments and Emergent Work Control,"

covers the key safety attributes associated with the Mitigating Systems Cornerstone and is flexible enough to adapt to minor differences among licensees in their implementation of the Maintenance Rule. These inspection procedures provide for the review of licensees' management of risk during maintenance and emergent work conditions and the appropriateness of (a)(1) and (a)(2) classifications by reviewing SSC performance and condition history.

Recommendation: Coverage is adequate. The industry uses its own maintenance metrics to verify safety-related and some non-safety-related SSCs are able to perform their intended functions. Standardizing these metrics would not be feasible, and there is no clear indication that a Maintenance Rule PI would complement current inspection efforts. Because the inspection program covers the key safety attributes and is flexible enough to adapt to minor differences among licensees in their implementation of the Maintenance Rule, a PI in this area is not needed.

4. Passive Systems (New Reactor Design)

Description: Passive systems in new reactor designs are likely to have PIs that are different from the current PIs used to assess the operating power reactor fleet. As a result, new possibilities for passive system PIs should be explored.

Evaluation: The evaluation of potential passive system PIs is currently on hold until further work can be completed on new reactor oversight activities and until construction and licensing of new reactors draws nearer to completion.

Recommendation: Defer. Any recommendations are deferred until further work can be completed on new reactor oversight.

Barrier Integrity Cornerstone

5. Reactor Coolant System (RCS) Pressure Boundary Leak(s) Frequency

Description: The frequency of RCS pressure boundary leak(s) was recommended as a potential PI in SECY-99-007. This indicator would have monitored the frequency of pressure boundary leaks (excluding leaks from steam generator tubes) as defined by a plant's technical specifications (TS).

Evaluation: The RCS leakage rate described as a percentage of a plant's TS limits is currently used as a PI. The RCS leakage frequency PI would attempt to capture a slightly different data set (*i.e.*, the number of RCS leakage events) involving the same key safety attribute. Because the overall RCS leakage rate PI is a percentage of TS limits, a PI that would monitor the frequency of RCS leaks would not add significant additional coverage.

The inspection program provides coverage of this key safety attribute (*i.e.*, RCS leakage). Inspection Manual Chapter 2515, Appendix D, "Plant Status," requires inspectors to routinely ensure that a licensee properly monitors for RCS leakage and adheres to technical specifications governing RCS pressure boundary leakage. In addition, inspectors are required to perform IP 71111.08, "Inservice Inspection Activities," during every refueling outage to assess the effectiveness of a licensee's program for monitoring degradation of the RCS pressure boundary.

Recommendation: Coverage is adequate. Another PI that monitors the frequency of RCS leaks would not add substantial coverage to the Barrier Integrity Cornerstone because the PI and the inspection programs already address the same key safety attribute.

6. Reactor Coolant System (RCS) Individual In-Service Inspections (ISIs)

Description: RCS individual ISIs was recommended as a potential PI in SECY-99-007. This indicator would have monitored the percentage of individual ISIs that required disposition against ASME standards. Such an indicator could have been objectively derived and have a threshold related to historically good industry performance. A percentage indicator, rather than an absolute numerical indicator, would have been less likely to influence the assessment of non-destructive examinations (NDEs) as the numerical count of flaw indications increased. Verification and validation of this indicator would have likely included ensuring that industry operating experience was being applied to the selection of areas for NDE.

Evaluation: Monitoring the percentage of ISIs that would require disposition against ASME standards would augment performance insights in a key safety attribute that currently does not have an indicator. However, counting the number of times that an ISI requires an ASME standard disposition does not necessarily reflect declining performance. IP 71111.08 currently provides for sampling ISI activities every refueling outage and evaluating the ISI results on a case-by-case basis.

Recommendation: Coverage is adequate. Although a PI that monitors RCS ISIs that require an ASME standard disposition would add coverage to a key safety attribute that does not currently have a PI, the inspection program provides a sufficient level of effort to ensure the safety cornerstone objectives are met.

7. Containment Leakage

Description: A containment leakage PI was defined in SECY-99-007 and used during the pilot phase of the ROP. The indicator was designed to estimate the "as-found" integrated leak rate for the containment, provide a reasonable indication of effluents during operation, and provide an indication of the leak-tight integrity of the containment barrier. Measurement data would have been based on the last integrated leak rate test result and informed by the results of subsequent local leak rate tests. The data would have been reported as a fraction of the design basis leak rate. Licensees currently collect these data as required by 10 CFR 50, Appendix J.

Evaluation: Two major limitations with this indicator were identified and continue to be applicable:

- "As-found" leak rate data are not collected in a consistent manner at all plants. Specifically, some plants perform the Type C tests at the end rather than at the beginning of the refueling outage. The leak rate data for those plants may not reflect the actual leak rate that existed during power operation, particularly if the isolation valves were cycled during the outage. Some changes to licensee practices would be needed to achieve consistency.

- The data obtained from integrated and local leak rate tests are gathered relatively infrequently. In accordance with Appendix J, licensees are required to perform integrated leak tests (Type A tests) on a frequency of three tests every ten years, and to leak-test Type B and Type C components during each reactor shutdown for refueling,

but in no case at intervals greater than two years. Licensees adopting Option B of Appendix J can extend the integrated leak test frequency to one test every ten years, and extend the test interval up to 60 months for Type B penetrations, except personnel airlocks, and Type C components, except main steam and feedwater isolation valves in BWRs and containment purge and vent valves in PWRs and BWRs. The extended test interval for those excepted components would be limited to 30 months. Thus, depending on the licensee's test program, updates to the PI would occur on an infrequent basis.

For these two reasons, a containment leakage PI is not a viable indicator. The inspection program provides coverage of licensee performance regarding containment leakage. Specifically, IP 71111.08 requires inspectors to assess the effectiveness of a licensee's program for monitoring degradation of containment system boundaries.

Recommendation: Coverage is adequate. Because each licensee has a variety of options for meeting the requirements of 10 CFR 50, Appendix J, creating a standardized metric is not practicable. The containment portion of the Barrier Integrity Cornerstone should continue to be monitored under the inspection program to account for the various design and operational differences among the fleet.

Emergency Preparedness Cornerstone

Description: SECY-99-007 did not recommend any potential PIs for future consideration in this cornerstone. Recent sources of information on ROP implementation did not reveal any potential areas for improvement in this cornerstone.

Public Radiation Safety Cornerstone

8. Groundwater Contamination

Description: The purpose of the Public Radiation Safety (PRS) Cornerstone is to assess a licensee's radiological effluent control program performance. The only PI in this cornerstone counts the number of radiological effluent release occurrences - liquid and gaseous - per site that exceed pre-determined values. The white and yellow PI thresholds constitute one and three occurrences, respectively. There is no red threshold for this PI.

There is a growing concern about groundwater contamination from leakage. Unless the leakage reaches a measuring point (*i.e.*, a monitoring well) and indicates a sufficient dosage, it will not count against this PI. Even though the identified leaks/spills (ADAMS Accession Number ML101270439) have not posed a hazard to human health, they have impacted public confidence for some stakeholders and led them to question NRC's interest in environmental protection.

There have been two Action Matrix deviations to increase NRC oversight at Vermont Yankee (ADAMS Accession Number ML100960321) and Indian Point (ADAMS Accession Number ML083590057) because of groundwater contamination. The events at both plants did not adversely affect public health and safety. The deviation for increased oversight at Vermont Yankee was proposed, in part, because of the extraordinary level of interest and concern by public stakeholders. The deviation to increase oversight at Indian Point was proposed because some processes and procedures important to the overall effectiveness and quality of the licensee's long-term program for monitoring groundwater contamination were not sufficiently developed and implemented in time for the NRC to perform a proper assessment in CY 2008.

In addition, NRC regional inspectors have questioned the adequacy of the PI in identifying declining performance and have expressed a desire to have a more structured approach to oversight of groundwater contamination issues.

The Groundwater Task Force issued a final report in June 2010 (ADAMS Accession Number ML101680435) that recommended enhancing the NRC's response to groundwater contamination events. This recommended action included potential development of a PI. The report states that an effective PI for groundwater protection would change as a function of the number, quantity, and type(s) of radionuclide, and/or locations of leaks/spills for groundwater protection.

Evaluation: The industry undertook a groundwater protection initiative to address potential environmental concerns. NEI 07-07, "Industry Groundwater Protection Initiative," was developed to provide guidance on improving licensees' management of and response to instances where the inadvertent release of radioactive substances may result in low but detectible levels of radioactive materials in subsurface soils and water. The limits set by the NEI 07-07 guidance are well below the NRC limits.

The PRS Cornerstone is of significant interest to the public. When the ROP was being developed, the NRC and external stakeholders recognized that a licensee's control of its radioactive material is a significant issue for members of the public even when very low levels of radioactive material are involved. As such, public confidence in the PI and SDP is an important consideration in assessing ROP effectiveness. Although public confidence is important under the PRS Cornerstone, unmonitored and uncontrolled nature of onsite leaks is of concern because they have the potential, albeit small, to impact public health and safety and the environment.

Recommendation: Coverage could be enhanced. Multiple sources of information (*i.e.*, two Action Matrix deviations, internal feedback, industry initiatives in groundwater monitoring, and the Groundwater Task Force) collectively indicate a potential opportunity to work with stakeholders on enhancing the PRS Cornerstone to monitor and control releases to groundwater. Potential enhancements could include development of or changes to inspection program tools or a PI.

9. Unauthorized Radioactive Material Release Occurrence

Description: Monitoring unauthorized radioactive material release occurrences was recommended as a potential PI in SECY-99-007. Specifically, the PI would have monitored the release of radioactive material(s) from licensee control that could have reasonably resulted in public exposure in excess of 1 millirem per year (mrem/yr) total effective dose equivalent. This PI would have assessed licensee performance in effectively monitoring and preventing measurable dose to members of the public from the uncontrolled release of solid materials from the plant protected area.

Evaluation: An indicator that monitors the occurrences of uncontrolled solid releases of radioactive material could supplement the current PI, which only monitors liquid and gaseous releases. Currently the inspection program addresses these radioactive releases to the public on a case-by-case basis; however, there could be value in monitoring the occurrences assuming that there are enough data to support a statistically valid indicator. The low number of unauthorized radioactive material releases may be insufficient to establish a statistically valid indicator. This would pose a significant challenge for a potential PI.

Another potential challenge would be in defining the phrase "could reasonably result in public exposure." Determining what is reasonable and what is unreasonable involves subjectivity, which can defeat the purpose of a PI as an objective indicator of performance.

Recommendation: Coverage is adequate. IP 71124, "Radiation Safety – Public and Occupational," and its attachments ensure unauthorized radioactive release occurrences are inspected so that licensee performance deficiencies are identified and addressed. A PI that monitors uncontrolled solid radioactive releases to the public could provide additional insights for the Public Radiation Cornerstone. However, there would be some challenges in establishing a robust data set and objective thresholds for the indicator.

Occupational Radiation Safety Cornerstone

Description: SECY-99-007 did not recommend any potential PIs for future consideration in this cornerstone. Recent sources of information on ROP implementation did not reveal any potential areas for improvement in this cornerstone.

Multiple Safety Cornerstones

10. Operator Licensing Examination (Initial and Requalification)

Description: Operator licensing examination performance is a potential area for future PI development. No PIs currently cover operator licensing examination and training. IP 71111.11, "Licensed Operator Requalification Program," directs inspectors to review licensed operator requalification programs.

Evaluation: The staff considered developing a PI that would monitor the pass/fail rate of initial and requalification examinations administered by licensees. Accumulating and processing data for this potential indicator would not require much effort. However, analyzing and evaluating the data to identify a performance trend may be difficult. For example, at two different sites, a pass-to-fail ratio is 5-to-1 whereas the fleet average is 15-to-1. Although it might seem apparent that these two sites with a higher failure rate have a negative performance trend, the numbers alone can be misleading. For instance, one licensee might have a poor, low-quality training program that results in a high failure rate, whereas the other might have an extremely rigorous training program that sets a very high standard of performance. In both cases, the data indicate a low pass-to-fail ratio, but the reasons are completely different.

The inspection program provides coverage in overseeing licensed operator examination programs. Inspectors biennially perform IP 71111.11, which includes a review of the number of applicants and the pass/fail results of written examinations, individual operating tests, and simulator operating tests. This IP is undergoing a comprehensive revision to become more performance-based. Responsiveness of operator training programs to industry events and station performance through a review of available data and trends and increased emphasis on observation of operator performance during actual plant operations are inspectable areas being considered. Enhanced focus in these areas is directed at detecting weaknesses in operator performance because of recent significant industry events involving licensed operators.

Recommendation: Coverage is adequate and being enhanced through the inspection program. Although data for an operator licensing examination PI might be easy to collect, consistently interpreting the data to determine performance trends would be difficult. Also, because each site's program is slightly different, oversight of the operator licensing program is more conducive

to inspection than a PI. The staff is already enhancing oversight of operator training and requalification programs by revising IP 71111.11. Therefore, inspection is the most effective method to monitor and evaluate licensed operator training and requalification programs.

11. Pre-Initiator Human Performance

Description: Pre-initiator human performance was recommended as a potential PI in SECY-99-007. Although the safety cornerstone approach to licensee assessment relies on objective indicators of plant performance to make inferences about human reliability, a more direct measure of pre-initiator human performance could provide a leading indication of changing plant performance. For example, errors during maintenance, testing, and operations affecting plant configurations would eventually, if not corrected, be revealed through degraded equipment availability and reliability and increased frequency of transients and scrams.

Evaluation: The ROP inspection and assessment programs evaluate a licensee's human performance through oversight of the human performance cross-cutting area. Cross-cutting aspects related to human performance can be assigned to inspection findings. If these aspects accumulate over an assessment period, a licensee may reach the threshold of a cross-cutting theme. If the NRC does not have confidence that a licensee is addressing a cross-cutting theme, a substantive cross-cutting issue (SCCI) in the area of human performance would be identified.

Although identification of an SCCI does not cause Action Matrix movement, a human performance PI could cause Action Matrix movement. The subjectivity associated with trying to quantify causal relationships would be a significant challenge with creating such a PI. However, no matter how quantitative an indicator is, it is not feasible to engineer all (or almost all) subjectivity from the PI framework.

Recommendation: Coverage is adequate. The inspection program provides adequate coverage in the area of pre-initiator human performance through assignment of cross-cutting aspects to inspection findings. However, new approaches might be considered if the agency discontinues the current SCCI process in favor of a more effective or efficient indication of human performance. Although it may be difficult to generate an objective and truly leading PI based on human performance, this effort could become more viable in the future. Other industries are using risk models such as Bayesian Belief Networks (BBNs) to quantify causal relationships. BBNs or other models and frameworks might be useful in creating a human performance PI in the future.

Summary:

The table on the next page lists the eleven areas that were reviewed and evaluated for possible enhancements. A recommendation is provided for each area, and a brief comment describes the proposed path forward.

Summary Table

Area	Recommendation	Comments
1. Shutdown Safety Margin	Coverage is adequate	Inspection is the preferred method of covering this area of performance.
2. Shutdown Monitoring Performance	Coverage is adequate	Inspection is the preferred method of covering this area of performance.
3. Maintenance Rule Implementation	Coverage is adequate	Inspection is the preferred method of covering this area of performance.
4. Passive Systems in New Reactors	Defer	Any changes are pending the design, construction, and licensing of new reactors.
5. RCS leakage - frequency	Coverage is adequate	Current PIs and inspection for the Barrier Integrity Cornerstone provide enough coverage.
6. RCS leakage - ISI vs. ASME Code	Coverage is adequate	Current PIs and inspection for Barrier Integrity Cornerstone provide enough coverage.
7. Containment Leakage	Coverage is adequate	Inspection is the preferred method of covering this area of performance.
8. Groundwater Contamination	Coverage could be enhanced	The Public Radiation Safety Cornerstone PI and inspection tools could be enhanced to provide more structured oversight of industry initiatives.
9. Unauthorized Radioactive Material Release Occurrence	Coverage is adequate	Inspection is the preferred method of covering this area of performance. Monitoring solid radioactive release occurrences is a potential option for future consideration.
10. Operator Licensing Exam	Coverage is adequate	Inspection is the preferred method of covering this area of performance.
11. Pre-Initiator Human Performance	Coverage is adequate	Inspection is the preferred method of covering this area of performance. NRC staff is exploring ways to possibly measure human performance.