

Application of NRC Reactor Oversight Process Performance Indicators to the AP1000 Design

The following describes the Reactor Oversight Process (ROP) performance indicators and discusses how they may be applied to the AP1000 design. The purpose and definition of the indicators is taken from NEI 99-02, Revision 7, Regulatory Assessment Performance Indicator Guideline.

A key difference between the existing fleet and the AP1000 design is the use of passive rather than active safety systems and use of defense-in-depth systems:

- The safety-related passive systems are the credited method for heat removal, accident mitigation, and core protection.
- Defense-in-Depth (DID) systems are not safety related and provide support for normal plant operations. These systems also minimize unnecessary challenges to the safety-related passive systems. Defense-in-depth systems are designed for more probable component and system failures.

Note that the Mitigating System Performance Index is addressed in a separate White Paper, “White Paper on Aspects of the Reactor Oversight Process for the AP1000 Reactor Design.”

1. UNPLANNED SCRAMS PER 7,000 CRITICAL HOURS

Purpose:

This indicator monitors the number of unplanned scrams. It measures the rate of scrams per unit of time at power and provides an indication of initiating event frequency.

Definition:

The number of unplanned scrams during the previous four quarters, both manual and automatic, while critical per 7,000 hours.

Unplanned scram means that the scram was not an intentional part of a planned evolution or test as directed by a normal operating or test procedure. This includes scrams that occurred during the execution of procedures or evolutions in which there was a high chance of a scram occurring but the scram was neither planned nor intended.

Discussion:

This indicator should apply as-is to the AP1000 design.

2. UNPLANNED POWER CHANGES PER 7,000 CRITICAL HOURS

Purpose:

This indicator monitors the number of unplanned power changes (excluding scrams) that could have, under other plant conditions, challenged safety functions. It may provide leading indication of risk-significant events but is not itself risk-significant. The indicator measures the number of plant power changes for a typical year of operation at power.

Definition:

The number of unplanned changes in reactor power of greater than 20% of full-power, per 7,000 hours of critical operation excluding manual and automatic scrams.

Discussion:

The AP1000 design supports rapid down powers due to transients where the reactor will remain critical and continue to provide power to the turbine/generator to support plant operating loads. The automatic and manual rapid down powers should be included in the Unplanned Power Changes per 7,000 Critical Hours Performance Indicator. This would be in addition to other unplanned power changes, as defined in the performance indicator.

3. UNPLANNED SCRAMS WITH COMPLICATIONS

Purpose:

This indicator monitors that subset of unplanned automatic and manual scrams that either require additional operator actions beyond that of the normal scram or involve the unavailability of or inability to recover main feedwater. Such events or conditions have the potential to present additional challenges to the plant operations staff and therefore, may be more risk-significant than uncomplicated scrams.

Definition:

The performance indicator is defined as the number of unplanned scrams while critical, both manual and automatic, during the previous four quarters that require additional operator actions or involve the unavailability of, or inability to recover, main feedwater.

Discussion:

NEI 99-02 provides two sets of questions related to this performance indicator, one for PWRs and one for BWRs. A third set of questions for passive designs (such as the AP1000), or appropriate notes on application of the PWR questions, would seem appropriate:

PWR Question	AP1000 Discussion	Possible AP1000 Question
Did two or more control rods fail to fully insert?	Would likely apply as is.	Did two or more control rods fail to fully insert?

PWR Question	AP1000 Discussion	Possible AP1000 Question
Did the turbine fail to trip?	Would likely apply as is.	Did the turbine fail to trip?
Was power lost to any ESF bus?	The Class 1E DC And UPS System (IDS) provides power for mitigation and control of accident conditions, including a total loss of offsite or onsite AC power. The AP1000 ESF systems (Containment, Passive Containment Cooling System, Containment Isolation System, Passive Core Cooling System) use IDS power.	Was power lost to any IDS bus?
Was a safety injection signal received?	Would likely apply (Safeguards signal is the AP1000 equivalent).	Was a safeguards signal received?
Was main feedwater unavailable or not recoverable using approved plant procedures during the scram response?	Would likely apply as is.	Was main feedwater unavailable or not recoverable using approved plant procedures during the scram response?
Was the scram response procedure unable to be completed without entering another EOP?	Would likely apply as is.	Was the scram response procedure unable to be completed without entering another EOP?

4. SAFETY SYSTEM FUNCTIONAL FAILURES (SSFF)

Purpose:

This indicator monitors events or conditions that prevented, or could have prevented, the fulfillment of the safety function of structures or systems that are needed to:

- (a) Shut down the reactor and maintain it in a safe shutdown condition;
- (b) Remove residual heat;
- (c) Control the release of radioactive material; or
- (d) Mitigate the consequences of an accident.

Definition:

The number of events or conditions that prevented, or could have prevented, the fulfillment of the safety function of structures or systems in the previous four quarters.

The indicator includes a wide variety of events or conditions, ranging from actual failures on demand to potential failures attributable to various causes, including environmental qualification, seismic qualification, human error, design or installation errors, etc.

Because the contribution to risk of the structures and systems included in the SSFF varies considerably, and because potential as well as actual failures are included, it is not possible to assign a risk-significance to this indicator. It is intended to be used as a possible precursor to more important equipment problems, until an indicator of safety system performance more directly related to risk can be developed.

Discussion:

The definition of a safety system functional failure is identical to 10 CFR 50.73(a)(2)(v):

(v) Any event or condition that could have prevented the fulfillment of the safety function of structures or systems that are needed to:

(A) Shut down the reactor and maintain it in a safe shutdown condition;

(B) Remove residual heat;

(C) Control the release of radioactive material; or

(D) Mitigate the consequences of an accident.

Section 10 CFR 50.73(a)(2)(v) requires reporting of such failures (via a Licensee Event Report). Also, as stated in NEI 99-02, requirements for reporting under other paragraphs of 10 CFR 50.73 should be evaluated to determine if they also prevented the fulfillment of a safety function.

Therefore, any safety system function failures reported under 10 CFR 50.73 for the AP1000 design would be counted in this indicator. NUREG-1022, Event Report Guidelines – 10 CFR 50.72 and 50.73, provides guidance on making this reportability determination.

5. MITIGATING SYSTEM PERFORMANCE INDEX

Purpose:

The Mitigating System Performance Index (MSPI) monitors the performance of selected systems based on their ability to perform risk-significant functions. It is comprised of three elements - system unavailability, system unreliability, and system component performance limits. The index is used to determine the cumulative significance of failures and unavailability over the monitored time period.

Definition:

MSPI is the sum of changes in a simplified core damage frequency evaluation resulting from differences in unavailability and unreliability relative to industry standard baseline values. The MSPI is supplemented with system component performance limits.

Unavailability is the ratio of the hours the train/system was unavailable to perform its monitored functions (as defined by the train/system boundaries, PRA success criteria and mission times) due to planned and unplanned maintenance or test during the previous quarters while critical to the number of critical hours during the previous 12 quarters.

The five systems monitored are:

- Emergency AC Power Systems
- High Pressure Injection Systems
- Heat Removal Systems
- Residual Heat Removal Systems
- Cooling Water Systems

Discussion:

Application of MSPI to the AP1000 is of sufficient complexity that it has been addressed in a separate White Paper entitled, "White Paper on Aspects of the Reactor Oversight Process for the AP1000 Reactor Design."

6. REACTOR COOLANT SYSTEM (RCS) SPECIFIC ACTIVITY

Purpose:

This indicator monitors the integrity of the fuel cladding, the first of the three barriers to prevent the release of fission products. It measures the radioactivity in the RCS as an indication of functionality of the cladding.

Definition:

The maximum monthly RCS activity in micro-Curies per gram ($\mu\text{Ci}/\text{gm}$) dose equivalent Iodine-131 per the technical specifications, and expressed as a percentage of the technical specification limit. Those plants whose technical specifications are based on micro-curies per gram ($\mu\text{Ci}/\text{gm}$) total Iodine should use that measurement.

Discussion:

This indicator should apply as-is to the AP1000 design.

7. REACTOR COOLANT SYSTEM LEAKAGE

Purpose:

This indicator monitors the integrity of the RCS pressure boundary, the second of the three barriers to prevent the release of fission products. It measures RCS Identified Leakage as a percentage of the technical specification allowable Identified Leakage to provide an indication of RCS integrity.

Definition:

The maximum RCS Identified Leakage in gallons per minute each month per the technical specifications and expressed as a percentage of the technical specification limit.

Discussion:

This indicator should apply as-is to the AP1000 design.

8. DRILL/EXERCISE PERFORMANCE

Purpose:

This indicator monitors 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 (PARs). It is the ratio, in percent, of timely and accurate performance of those actions to total opportunities.

Definition:

The percentage of all drill, exercise, and actual opportunities that were performed timely and accurately by Key Positions, as defined in the ERO Drill Participation performance indicator, during the previous eight quarters.

Discussion:

This indicator should apply as-is to the AP1000 design.

9. EMERGENCY RESPONSE ORGANIZATION DRILL PARTICIPATION

Purpose:

This indicator tracks the participation of ERO members assigned to fill Key Positions in performance enhancing experiences, and through linkage to the DEP indicator ensures that the risk significant aspects of classification, notification, and PAR development are evaluated and included in the PI process. This indicator measures the percentage of ERO members assigned to fill Key Positions who have participated recently in performance-enhancing experiences such as drills, exercises, or in an actual event.

Definition:

The percentage of ERO members assigned to fill Key Positions that have participated in a drill, exercise, or actual event during the previous eight quarters, as measured on the last calendar day of the quarter.

Discussion:

This indicator should apply as-is to the AP1000 design.

10. ALERT AND NOTIFICATION SYSTEM RELIABILITY

Purpose:

This indicator monitors the reliability of the offsite Alert and Notification System (ANS), a critical link for alerting and notifying the public of the need to take protective actions. It provides the percentage of the sirens that are capable of performing their safety function based on regularly scheduled tests.

Definition:

The percentage of ANS sirens that are capable of performing their function, as measured by periodic siren testing in the previous 12 months.

Discussion:

This indicator should apply as-is to the AP1000 design.

11. OCCUPATIONAL EXPOSURE CONTROL EFFECTIVENESS

Purpose:

This indicator monitors the control of access to and work activities within radiologically-significant areas of the plant and occurrences involving degradation or failure of radiation safety barriers that result in readily-identifiable unintended dose.

Definition:

The performance indicator for this cornerstone is the sum of the following:

- Technical specification high radiation area (>1 rem per hour) occurrences
- Very high radiation area occurrences
- Unintended exposure occurrences

Discussion:

This indicator should apply as-is to the AP1000 design.

12. RETS/ODCM RADIOLOGICAL EFFLUENT OCCURRENCE

Purpose:

This indicator assesses the performance of the radiological effluent control program.

Definition:

Radiological effluent release occurrences per site that exceed NEI 99-02 specified values.

Discussion:

This indicator should apply as-is to the AP1000 design.

13. PROTECTED AREA (PA) SECURITY EQUIPMENT PERFORMANCE INDEX

Purpose:

This indicator is used to monitor the unavailability of PA intrusion detection systems and alarm assessment systems to perform their intended function.

Definition:

PA Security equipment performance is measured by an index that compares the amount of the time CCTVs and IDS are unavailable, as measured by compensatory hours, to the total hours in the period. A normalization factor is used to take into account site variability in the size and complexity of the systems.

Discussion:

This indicator should apply as-is to the AP1000 design.