

2018 Status of “Requirements for Low Power and Shutdown PRA” LPSD PRA Standard ANSI/ANS-58.22

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Low Power and Shutdown (LPSD) Standard Objectives

- Establish requirements that must be fulfilled for LPSD quantitative probabilistic risk assessments (PRA) and for shutdown qualitative risk assessments (QLRA) in support of risk-informed decisions for commercial nuclear power plants.
- Not a procedures guide for “how to do it”; rather, just the requirements as to “what to do”.
- To be consistent with Joint Committee on Nuclear Risk Management (JCNRM) standards for at-power conditions for the three levels of PRA; i.e., Level 1, Level 2, and Level 3.

LPSD Standard Scope

- Trial-use version is similar in format to American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) RA-Sa-2009 (“Addendum A”) for requirements during at-power conditions; still has three capability category approaches and the same methods to apply requirements for a specific, risk-based application.
- Supports quantitative PRA for annual average risk and for qualitative (QLRA), or quantitative (PRA), assessments of a specific outage.
- Includes both internal and external hazard groups, except for internal fires.
- Excludes purposeful human-induced security threats.

LPSD Standard Scope (Continued)

- Requirements for full Level 1 analysis (core damage frequency [CDF]) and for limited Level 2 of large early release frequency (LERF) of operating plants.
- Only for accidents while in the reactor vessel (not for accidents involving the spent fuel pool).
- Additional supporting requirements may be needed for advanced designs or for assessment during design and construction phases.
- Qualitative Risk Assessment (QLRA) requirements are restricted to Modes 3–6 for pressurized water reactors and for Modes 3–5 for boiling water reactors; i.e., during shutdown only.

JCNRM Directives

- Develop standalone LPSD standard.
- QLRA and quantitative PRA to be combined in one LPSD standard.
- Outage specific requirements to be included; e.g., to support 10 CFR 50.65 (a)(4)—the “maintenance rule”.
- Metrics other than CDF/LERF should be permitted for both PRA or QLRA, but users must formulate applicable requirements.
- Supporting requirements (SR) to be updated to be consistent with the Next Edition Standard for at-power conditions, still under going the ballot and approval process.
- Include full text of all requirements.

Next Edition Changes to Be Incorporated

- Exclude Capability Category III.
- Update action verbs.
- Explicitly back-reference SRs as needed.
- Notes to be used only as cautions or for applicable references.
- Commentaries moved to non-mandatory appendices.
- Purpose of walkdowns to be discussed.

LPSD Standard Background

- A volunteer writing group was first formulated by ANS after the standard was formally authorized in 2003.
- Ballots of prior drafts were conducted in 2005, 2008, 2009, 2013, and 2014.
- The most recent ballot in 2014 (by JCNRM, a joint committee of ANS and ASME) approved the LPSD Standard for Trial Use only.
- The 3-year trial-use period has been extended until December 2018.
- Comments on the trial use version have already been received, but Writing groups is still requesting more feedback.
- Key remaining input is a largely completed version of the Next Edition.
- Goal: Ready revised standard by June ~~2018~~ 2019 for ballot.

LPSD Standard Outline

1. General Requirements for a LPSD Quantitative PRA and QLRA
 - a. Introduction
 - b. Acronyms and Definitions
 - c. LPSD PRA Risk-Informed Assessment Applications Process
 - d. LPSD Requirements for Use of Expert Judgment
 - e. LPSD PRA Configuration Control
 - f. LPSD PRA Peer Review

2. Plant Operating State (POS) Analysis

1. Overview of POS Analysis for LPSD Quantitative PRA
2. High Level and Supporting Requirements for the POS Analysis

Appendix 2.A (Non-Mandatory) Plant Operating State Analysis Methodology for LPSD Quantitative PRA

3. Technical Requirements for Internal Events LPSD Quantitative PRA
 - a. Overview of Internal Events LPSD Quantitative PRA Requirements
 - b. Internal Events LPSD Quantitative PRA Technical Elements and Requirements
 - c. Peer Review for Internal Events LPSD Quantitative PRA
4. Requirements for Internal Floods for LPSD
5. Seismic Analysis

LPSD Standard Outline (Continued)

6. Requirements for Screening and Conservative Analysis of Other External Events
 - a. Approach for Screening and Conservative Analysis for Other External Hazards during LPSP Conditions
 - b. Technical Requirements for Screening and Conservative Analysis of Other External Hazards during LPSP Conditions
 - c. Peer Review for Screening and Conservative Analysis of Other External Hazards during LPSP Conditions
7. High Wind Analysis
8. External Flood Analysis
9. Other External Hazard Analysis
10. LPSP PRA for a specific LPSP Evolution
11. Shutdown Qualitative Risk Assessment Requirements (QLRA)
 - a. Overview of Qualitative Risk Assessment Requirements
 - b. Risk Assessment Technical Requirements
 - c. Peer Review

Appendix 11.A (Non-Mandatory) Technical Basis for Shutdown QLRA Methodology

12. References

Example SRs in POS Technical Element

Table 2-2(b) Supporting Requirements for Plant Operating State Analysis – High Level Requirement B (Cont'd)

The POS analysis shall justify all screening and grouping of POSs or LPSD evolutions to facilitate an efficient but realistic estimation of CDF and LERF and to support subsequent requirements to be evaluated by a POS or group of POSs (HLR-LPOS-B).

	Capability Category I	Capability Category II	Capability Category III
LPOS-B5	GROUP or DELINEATE POSs that involve initiating events that are “demand-based” with initiators that are time-based (see SR LIE-C5 and LHR-K4).	EVALUATE the need to create separate POSs that are used for those brief time periods involving activities (test-, maintenance-, and evolution-related) that lead to initiating events that are “demand-based” from those that are time-based. If necessary, DELINEATE such POSs to avoid averaging the short duration of the demand over an entire POS duration or, if needed, to ensure that the representative plant conditions defined for the POS apply at the time of the “demand-based” initiating events (see SR LIE-C5 and LHR-K4).	
LPOS-B6	If POSs from an LPSD evolution are combined into groups, ENSURE that the most severe or constraining of the representative plant conditions is selected for the group (with respect to core damage or large early release) and that the type and frequency of applicable initiating events of any POS within the group are chosen for the combined group.		
LPOS-B7	No re-evaluation required.	RE-EVALUATE the POS grouping scheme, including possible subdivision of the grouped POSs, if a review of the initial quantitative results indicates that the POS groupings mask significant contributors or risk insights.	

Issues to Be Addressed by Trial Use

- Whether the required number of POSs needed to satisfy the requirements of the standard are so excessive as to make the analysis impractical.
- Whether the requirements for at-initiator human actions analysis are reasonable and effective.
- Whether the methods for human error probability quantification are suitable for shutdown conditions.
- Whether QLRA end state assignments require quantitative benchmarking against single or multiple QLRA end states.
- Whether the approach to external hazards captures adequately the needed requirements for LPSD PRA, for which fewer applications exist in the literature.

Sampling of Significant Comments

- Next Edition is a substantial revision to Addendum A for at-power conditions; need to make use of the revised wording of SRs.
- How to limit the number of POSs required for analysis (e.g., by screening, by risk significance) especially for time-dependent models.
- Whether at-initiator requirements and methods available are reasonable and effective.
- Whether external hazard approaches are suitable for shutdown conditions.
- While originally intended to address all conditions not already covered by at-power standards, its recognized that low power transients are best modeled with at-power models, and there are other interface issues to be addressed; e.g., manual shutdowns.

Sampling of Significant Comments (Continued)

- Need for research of initiator frequencies during shutdown.
- How to combine contributions across POSs and shutdown evolution types for basic event risk significance.
- For QLRA, how to draw an overall conclusion about plant risk when multiple risk metrics address different safety functions.
- QLRA is not PRA, not sufficiently quantitative and should not be included.
- Need for quantitative benchmarking of QLRA model rankings.

Other Issues

- Added Scope – Internal Fires, Heavy Load Drops, Spent Fuel Pool Risks
- Eliminate Overlapping Risk with At-Power Models (e.g., stable end states)
- Need for Time-Dependent SRs; but Not needed for At-Power Standard
- Use of Alternate Risk Metrics
- Multi-Unit Risk Supporting Requirements

Conclusions

- Consensus on the LPSD requirements has been difficult to achieve.
- Trial-use period was deemed necessary for passage and is nearing completion.
- Next ballot is to be preceded by a “readiness review”.
- Post-trial-use version to be readied for ballot, about 6 months after a December 2018 ballot of the Next Edition by June 2019.
- Formal incorporation of the LPSD Standard into the JCNRM Next Edition Standard would occur only after a follow-on, separate ballot; i.e. after the June 2019 ballot.

Definitions

LPSD Definitions

- *LPSD Evolution*: A series of connected or related activities, such as a reduction in power to a low level, or plant shutdown, followed by the return to full-power plant conditions. LPSD evolutions are modeled as a series of POSs.
- *Plant Operating State*: A standard arrangement of the plant during which the plant conditions are relatively constant, are modeled as constant, and are distinct from other configurations in ways that impact risk. POS is a basic modeling device used for a phased-mission risk assessment that discretizes the plant conditions for specific phases of a LPSD evolution.
- *Plant Configuration*: The status of a specific set of plant conditions which includes all those used to define a plant operating state plus specific equipment alignments and equipment outages.

LPSD Definitions (Continued)

- *Initiating Event:* A perturbation during a plant operating state that challenges plant control and safety systems, whose failure could potentially lead to core damage or core damage with radioactivity release. An initiating event could require a response or degrade the reliability of a normally operating system, cause a standby mitigating system to be challenged, or require that the plant operators respond in order to mitigate the event or to limit the extent of plant damage caused by the initiating event.
- *At-Initiator Human Failure Event:* A type of initiating event; human failure events that cause an initiating event. The human failure events that directly involve plant personnel actions at the time of the initiating event, including actions correctly performed but which are based on erroneous indications.

LPSD Definitions (Continued)

- *Demand-Based Initiating Event*: An initiating event that is linked to a specific activity as opposed to occurring randomly in time over the POS duration. For example, “over-draining while reducing RCS level to midloop”.
- *Time-Averaged CDF*: A risk metric for the expected number of core damage events per calendar year summed over all LPSD evolution types modeled.
- *Significant Basic Event*: A basic event that contributes significantly to the computed risks for a specific hazard group summed over all the POSs in that hazard group.

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