www.holtec.com
www.smrllc.com

NRC Meeting: Risk Significance Methodology

Date: 25 October 2023

Presented By: Sean McCloskey

SMR, LLC, A Holtec International Company
Krishna P. Singh Technology Campus
One Holtec Boulevard
Camden, NJ 08104, USA

[Not Export Controlled]

Meeting Agenda

- Introductions
- Purpose & Outcome
- Regulations
- Guidance
- Need for Absolute Risk Significance Criteria
- SMR-160+ Risk Significance Criteria
- Basis for Risk Significance Criteria
  - ✓ Basis for CDF Criteria
  - ✓ Basis for LRF Criteria
- Benefits
- Open Forum

Introductions

- NRC Staff
- Holtec Staff

Purpose and Outcome

- Purpose

  To provide a high-level overview of the SMR-160+ risk significance methodology

- Outcome

  To inform the NRC staff for their review of the LTR

Regulations

- RG 1.200
  - RAW ≥ 2.0
  - FV ≥ 0.005
  - "It is recognized that for those new reactor designs with substantially lower risk profiles (e.g., internal events CDF below 10^{-6}/year) that the quantitative screening value should be adjusted according to the corresponding baseline risk value."

Regulations (Cont.)

- RG 1.174
  - Allows risk-informed decision making with adequate justification to reduce unnecessary burden on licensees
  - Provides a benchmark for an acceptable change in absolute risk
  - Metrics are based on the current fleet with CDF ~1 x 10^{-5}/yr and LRF ~1 x 10^{-6}/yr

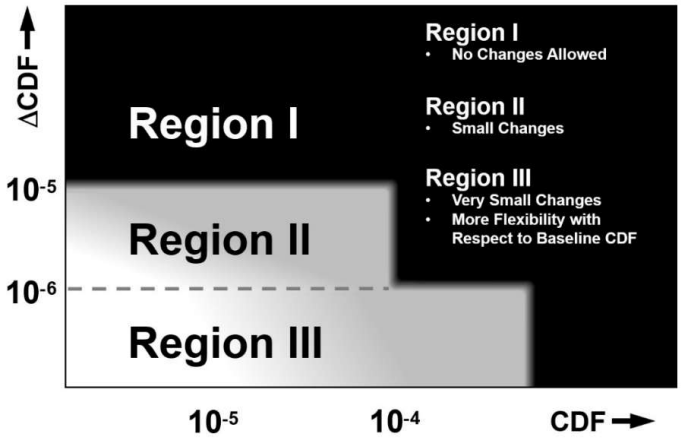

Figure 4. Acceptance guidelines* for core damage frequency

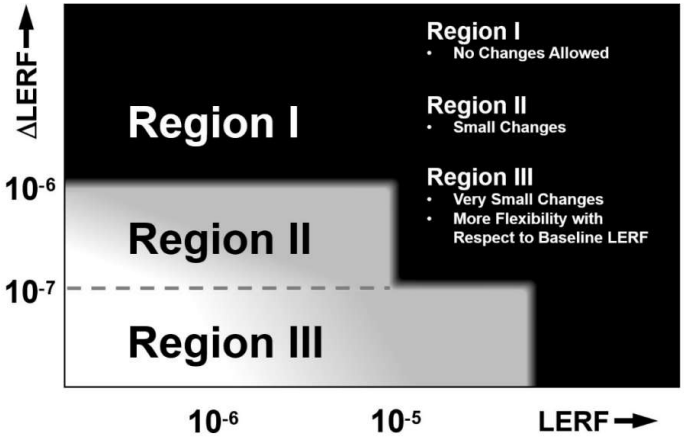

Figure 5. Acceptance guidelines* for large early release frequency

Guidance

- ACRS Guidance on SRP Chapter 19 and Section 17.4 (ML14196A119)
  - ACRS noted that the RG 1.200 criteria may produce an inappropriately large population of SSCs that are subject to enhanced availability and reliability controls, with commensurate undue burden for both the licensee and regulatory staff
  - ACRS recommended that risk significance criteria be consistent for a broad spectrum of designs and absolute levels of overall plant risk

Guidance (Cont.)

- NEI 00-04 and RG 1.201
  - Recommended to perform system-level SSC categorization to ensure that all functions (which are primarily a system-level attribute) are appropriately considered for risk significance

Need for Absolute Risk Significance Criteria

- Relative risk criteria artificially raises importance of SSCs for a design with significantly lower CDF than the current fleet
  - RG 1.200 criteria are based on relative risk for current fleet of reactors (CDF of ~1 x 10^{-5}/yr)
  - SMR-160+ CDF expected to be significantly lower than the current fleet
- Example
  - For a design with CDF of 1 x 10^{-5}, a RAW of 2 implies a change in CDF of 1 x 10^{-5}
  - For a design with CDF of 1 x 10^{-7}, a RAW of 2 implies a change in CDF of 1 x 10^{-7}

SMR-160+ Risk Significance Criteria

Parameter	Core Damage Criteria for Risk Significance	Large Release Criteria for Risk Significance
Component level	Conditional CDF ≥ 3×10^{-6}/yr	Conditional LRF ≥ 3×10^{-7}/yr
System level	Conditional CDF ≥ 1×10^{-5}/yr	Conditional LRF ≥ 1×10^{-6}/yr
Basic event/contributor	Total FV ≥ 0.20	

- Based on all plant conditions including, operating, low power, and shutdown conditions for internal and external events resulting in core damage and a large radiological release to the environment

Basis for CDF Criteria

CDF Criteria for Risk Significance	Basis
Component level CCDF $\geq 3 \times 10^{-6}$/yr	• Consistent with RG 1.174 risk-acceptance guidelines, which state that increases in CDF between 10^{-6} and 10^{-5} are considered if CDF can reasonably be shown to be $< 1 \times 10^{-4}$/yr • The component-level threshold of 3×10^{-6} represents approximately the midpoint (on a log scale) of the Region II range identified in RG 1.174 • Order of magnitude below NRC safety goal of CDF $\leq 1 \times 10^{-4}$/yr, with an extra half-order of magnitude (on a log scale) of margin to account for uncertainties in the PRA model
System level CCDF $\geq 1 \times 10^{-5}$/yr	• The system-level value of 1×10^{-5} represents the upper end of the Region II range for CDF identified in RG 1.174 for making permanent changes to a plant's licensing basis • Order of magnitude below NRC safety goal of CDF $\leq 1 \times 10^{-4}$/yr
Basic event FV ≥ 0.20	• Threshold more conservative than criteria for operating plants (i.e., CDF of 1×10^{-5}/yr * FV of 0.005 = 5×10^{-8}/yr is greater than the SMR-160+ CDF of 1×10^{-7}/yr * FV of 0.2 = 2×10^{-8}/yr) • Using FV of 0.2 instead of 0.5 conservatively identifies more risk significant basic events

Basis for LRF Criteria

LRF Criteria for Risk Significance	Basis
Component level CLRF $\geq 3 \times 10^{-7}$/yr	• Consistent with RG 1.174 risk-acceptance guidelines, which state that increases in LRF between 10^{-7} and 10^{-6} are considered if LRF can reasonably be shown to be $< 1 \times 10^{-5}$/yr • The component-level threshold of 3×10^{-7} represents approximately the midpoint (on a log scale) of the Region II range identified in RG 1.174 • Order of magnitude below NRC safety goal of LRF $\leq 1 \times 10^{-5}$/yr, with an extra half-order of magnitude (on a log scale) of margin to account for uncertainties in the PRA model
System level CLRF $\geq 1 \times 10^{-6}$/yr	• The system-level value of 1×10^{-6} represents the upper end of the Region II range for LRF identified in RG 1.174 for making permanent changes to a plant's licensing basis • Order of magnitude below NRC safety goal of LRF $\leq 1 \times 10^{-5}$/yr
Basic event FV ≥ 0.20	• Threshold more conservative than criteria for operating plants (i.e., LRF of 1×10^{-6}/yr * FV of 0.005 = 5×10^{-9}/yr is greater than the SMR-160+ LRF of 1×10^{-8}/yr * FV of 0.2 = 2×10^{-9}/yr) • Using FV of 0.2 instead of 0.5 conservatively identifies more risk significant basic events

Benefits

- Directly addresses the ratio limitations of traditional importance measures
- Consistent with the ACRS recommendation that risk significance criteria be consistent for a broad spectrum of designs and absolute levels of overall plant risk
- Consistent with NEI recommendation to consider risk significance at a functional (system) level
- Allows the licensee to focus resources on the SSCs important to absolute risk

Open Forum

Risk Importance Measures

- Fussell-Vesely (FV), commonly known as fraction of total risk
  - $FV = \frac{P(top) - P(top \mid A\ success)}{P(top)}$
- Risk Achievement Worth (RAW), or risk increase ratio given a SSC fails
  - $RAW = \frac{P(top \mid A\ failed)}{P(top)}$
- Conditional CDF (CCDF), or increased CDF when a SSC fails
  - $CCDF = CDF * RAW$
- Conditional LRF (CLRF), or increased LRF when a SSC fails
  - $CLRF = LRF * RAW$