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NRC Meeting: Risk Significance Methodology

Date: 01 May 2024

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Meeting Agenda

- Introductions
- Purpose & Outcome
- Guidance
- Need for New Risk Significance Criteria
- Alternate Approved Methodology
- SMR-300 Risk Significance Criteria
- Basis for Risk Significance Criteria
  - ✓ Basis for CDF Criteria (RAW, FV)
  - ✓ Basis for LRF Criteria (RAW, FV)
- Benefits
- Open Forum

Introductions

- NRC Staff
- Holtec Staff

Purpose and Outcome

- Purpose

  To provide a high-level overview of the SMR-300 risk significance methodology

- Outcome

  To inform the NRC staff for their review of the LTR

Guidance

- RG 1.200 Risk Significance Criteria
  - 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."
- NEI 00-04 (Endorsed by RG 1.201)
  - CCF – RAW ≥ 20

Guidance (Cont.)

- 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
  - ACRS stated that guidance should not distinguish between plant designs that employ "passive" safety features or "active" safety features

Need for New 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 risk for current fleet of reactors
    - (CDF of ~1 x 10^{-5}/yr)
  - SMR-300 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}

Alternate Approved Methodology

- NRC SER for NuScale Methodology (ML16181A218)
  - NRC staff emphasized limitation that the criteria may be used "provided the CDF is very low (i.e., approximately 1 x 10^{-7} per year or less)."

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

SMR-300 Risk Significance Criteria

CDF	LRF	FV	RAW – BE	RAW – CCF
$1 \times 10^{-5} \geq 5 \times 10^{-6}$	$1 \times 10^{-6} \geq 5 \times 10^{-7}$	0.005	2	20
$5 \times 10^{-6} > CDF \geq 1 \times 10^{-6}$	$5 \times 10^{-7} > LRF \geq 1 \times 10^{-7}$	0.01	4	32
$1 \times 10^{-6} > CDF \geq 5 \times 10^{-7}$	$1 \times 10^{-7} > LRF \geq 5 \times 10^{-8}$	0.05	5	35
$5 \times 10^{-7} > CDF \geq 1 \times 10^{-7}$	$5 \times 10^{-8} > LRF \geq 1 \times 10^{-8}$	0.1	10	40
$1 \times 10^{-7} > CDF$	$1 \times 10^{-8} > LRF$	0.2	30	60

- Orange = Proposed SMR-300 Risk Significance Criteria
- Red = risk significance criteria based on current NRC guidance; Green = risk significance criteria for an alternate approved methodology (ML16181A218)
- RAW is applied across all hazards and operating modes aggregately
- FV is applied to each hazard group and operating mode individually

Basis for CDF Basic Event RAW Values

CDF (Rb)	RAW	Increased Risk (R1)	Basis
1×10^{-5}	2	2×10^{-5}	Current criteria for CDF of 1×10^{-5}/yr
5×10^{-6}	4	2×10^{-5}	Same R1 as for CDF of 1×10^{-5}/yr
1×10^{-6}	5	5×10^{-6}	R1 lowered to reflect lower CDF but still identify risk significant basic events – using R1 of 2×10^{-5}/yr would result in few to no basic events being considered risk significant
5×10^{-7}	10	5×10^{-6}	Same R1 as for CDF of 1×10^{-6}/yr
1×10^{-7}	30	3×10^{-6}	Equivalent to NRC-approved methodology where R1 = 3×10^{-6}/yr @ CDF 1×10^{-7}/yr

- RAW threshold value is scaled from RAW used in traditional risk significance metric (for NPPs with CDF ~1×10^{-5}/yr) to RAW derived in alternate methodology approved for NPPs with CDF < 1×10^{-7}/yr

Basis for CDF CCF RAW Values

CDF (Rb)	BE RAW	Factor Increase for CCF	CCF RAW	Basis
1×10^{-5}	2	10	20	Current criteria for CDF of 1×10^{-5}/yr
5×10^{-6}	4	8	32	Factor increase was conservatively lowered to reflect the lower CDF
1×10^{-6}	5	7	35	Factor increase was conservatively lowered to reflect the lower CDF
5×10^{-7}	10	4	40	Factor increase was conservatively lowered to reflect the lower CDF
1×10^{-7}	30	2	60	Factor increase was conservatively lowered to reflect the lower CDF

- CCF RAW threshold value begins with CCF RAW used in traditional risk significance criteria and is scaled conservatively with respect to baseline CDF

Basis for CDF FV Values

CDF (Rb)	FV	Decreased Risk (R0)	Basis
1×10^{-5}	0.005	5×10^{-8}	Current criteria for CDF of 1×10^{-5}/yr
5×10^{-6}	0.01	5×10^{-8}	Increased FV to yield same R0 as for CDF of 1×10^{-5}/yr
1×10^{-6}	0.05	5×10^{-8}	Increased FV to yield same R0 as for CDF of 1×10^{-5}/yr
5×10^{-7}	0.1	5×10^{-8}	Increased FV to yield same R0 as for CDF of 1×10^{-5}/yr
1×10^{-7}	0.2	2×10^{-8}	Increased FV, but reduced R0 to ensure contributors are identified for extremely low risk profile, consistent with another NRC-approved methodology

- FV threshold value is scaled from FV used in traditional risk significance criteria (for NPPs with CDF ~1×10^{-5}/yr) to FV threshold used in alternate methodology approved for NPPs with CDF < 1×10^{-7}/yr

Basis for LRF Basic Event RAW Values

LRF (Rb)	RAW	Increased Risk (R1)	Basis
1×10^{-6}	2	2×10^{-6}	Current criteria for LRF of 1×10^{-6}/yr
5×10^{-7}	4	2×10^{-6}	Same R1 as for LRF of 5×10^{-6}/yr
1×10^{-7}	5	5×10^{-7}	R1 lowered to reflect lower LRF but still identify risk significant basic events – using R1 of 2×10^{-6}/yr would result in few to no basic events being considered risk significant
5×10^{-8}	10	5×10^{-7}	Same R1 as for LRF of 1×10^{-7}/yr
1×10^{-8}	30	3×10^{-7}	Equivalent to NRC-approved methodology where R1 = 3×10^{-7}/yr @ LRF 1×10^{-8}/yr

- RAW threshold value is scaled from RAW used in traditional risk significance metric (for NPPs with LRF ~1×10^{-6}/yr) to RAW derived in alternate methodology approved for NPPs with LRF < 1×10^{-8}/yr

Basis for LRF CCF RAW Values

LRF (Rb)	BE RAW	Factor Increase for CCF	CCF RAW	Basis
1×10^{-6}	2	10	20	Current criteria for LRF of 1×10^{-6}/yr
5×10^{-7}	4	8	32	Factor increase was conservatively lowered to reflect the lower LRF
1×10^{-7}	5	7	35	Factor increase was conservatively lowered to reflect the lower LRF
5×10^{-8}	10	4	40	Factor increase was conservatively lowered to reflect the lower LRF
1×10^{-8}	30	2	60	Factor increase was conservatively lowered to reflect the lower LRF

- CCF RAW threshold value begins with CCF RAW used in traditional risk significance criteria and is scaled conservatively with respect to baseline LRF

Basis for LRF FV Values

LRF (Rb)	FV	Decreased Risk (R0)	Basis
1×10^{-6}	0.005	5×10^{-9}	Current criteria for LRF of 1×10^{-6}/yr
5×10^{-7}	0.01	5×10^{-9}	Increased FV to yield same R0 as for LRF of 1×10^{-6}/yr
1×10^{-7}	0.05	5×10^{-9}	Increased FV to yield same R0 as for LRF of 1×10^{-6}/yr
5×10^{-8}	0.1	5×10^{-9}	Increased FV to yield same R0 as for LRF of 1×10^{-6}/yr
1×10^{-8}	0.2	2×10^{-9}	Increased FV, but reduced R0 to ensure contributors are identified for extremely low risk profile, consistent with another NRC-approved methodology

- FV threshold value is scaled from FV used in traditional risk significance criteria (for NPPs with LRF ~1 x 10^{-6}/yr) to FV threshold used in alternate methodology approved for NPPs with LRF < 1 x 10^{-8}/yr

Benefits

- Sliding scale thresholds are benchmarked by current regulatory guidance and another approved risk significance methodology
- Directly addresses the 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
- Allows the licensee to focus resources on the SSCs important to absolute risk

Open Forum

Reference – 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
  - $CLRF = LRF * RAW$