A Holtec International Company

SMR, LLC		8002
Sponsoring Company		**Project No.**
HI-2230875	0	11 Jun 2024
Company Record Number	**Revision No.**	**Issue Date**

Report	Copyright
Record Type	**Proprietary Classification**
Nuclear	No
Quality Class	**Export Control Applicability**

Record Title:

Holtec PSA Risk Significance Determination Methodology Licensing Topical Report

Prepared by:	**Reviewed by:**	**Approved by:**
S.Mccloskey, 11 Jun 2024	H.Hovhannisyan, 11 Jun 2024 J.Dolecki, 11 Jun 2024	A.Brenner, 11 Jun 2024

Signature histories are provided here for reference only. Company electronic signature records are traceable via the provided Verification QR Code and are available for review within the secure records management system. A valid Verification QR Code and the presence of this covering page indicates this record has been approved and accepted.

Verification QR Code:

Proprietary Classification

This record does not contain confidential or Proprietary Information. The Company reserves all copyrights.

Export Control Status

Export Control restrictions do not apply to this record.

ACKNOWLEDGEMENTS AND DISCLAIMERS

Acknowledgement: This material is based upon work supported by the Department of Energy Office of Nuclear under Award Number DE-NE0009055.

Disclaimer: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DATA RIGHTS NOTICES

Protected Rights Notice: These protected data were produced under agreement no. DE-NE0009055 with the U.S. Department of Energy and may not be published, disseminated, or disclosed to others outside the Government for a period of 5 years from the date of Agreement execution unless express written authorization is obtained from the Recipient. Upon expiration of the period of protection set forth in this Notice, the Government shall have unlimited rights in this data. This Notice shall be marked on any reproduction of this data, in whole or in part.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

Revision Log

Revision	Description of Changes
0	Initial Issue.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

Executive Summary

This report describes the methodology that SMR, LLC (Holtec) has developed to identify candidate risk-significant systems, structures, and components (SSCs) using the SMR-300 probabilistic safety assessment (PSA). It should be noted that use of the term “PSA” by Holtec is intended to be consistent with the use of the term “probabilistic risk assessment” (PRA) by U.S. entities, including the Nuclear Regulatory Commission (NRC).

This methodology uses alternative risk significance criteria than those given in Regulatory Guide (RG) 1.200 [1]. Section 19.0 of the NUREG-0800 Standard Review Plan (SRP) [2] states that the term ‘significant’ is intended to be consistent with the definition provided in RG 1.200 when used in the context of PSA results and insights. RG 1.200 discusses ‘significant’ in terms of relative risk criteria and defines the basic events (i.e., equipment unavailabilities and human failure events) that have a Fussell-Vesely (FV) importance greater than 0.005 or a risk-achievement worth (RAW) greater than 2 as ‘significant’.

Because the relative importance measures in RG 1.200, RAW and FV, are based on the relative risk associated with the operating fleet of reactors, they do not account for the lower risk profile of the passive SMR-300 design. Applying the relative risk criteria outlined in RG 1.200 to SMR-300 would artificially elevate the significance of SSCs that do not have commensurate contribution to risk in the SMR-300 design. This artificially inflated significance of SSCs would not be risk-informed because it would result in unnecessary resource allocation for both the licensee and regulatory staff. Therefore, an alternative methodology to determine risk significance is needed that is sensitive to the lower risk profile of the SMR-300 design.

For the SMR-300 design, Holtec is directly addressing the ratio limitations of the RAW and FV traditional importance measures by implementing an alternative methodology that adjusts these ratio limits based on the estimated risk level to ensure that measurable contributors to risk are identified regardless of the risk profile. The principles and guidelines of RG 1.174 [3] are used to risk-inform this alternative methodology of identifying candidate risk-significant SSCs. The Holtec criteria ensures margins to NRC Safety Goals [4] are maintained while also taking credit for the significantly lower risk profile of the SMR-300 design.

The risk significance criteria proposed for the SMR-300 are summarized in Table 7.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

Table of Contents

1.0 Purpose 5
2.0 Background 5
2.1 Regulatory Guidance for Treatment of Risk 6
2.2 Impetus for SMR-300 Alternative Risk Significance Criteria 8
3.0 Methodology 9
3.1 SMR-300 PSA Risk Significance Determination Criteria 9
3.2 Applicability and Limitations of Methodology 14
4.0 Summary and Conclusions 14
5.0 References 15

List of Figures

Figure 1: RG 1.174 Acceptance Guidelines 8

List of Tables

Table 1 SMR-300 Basis for CDF BE RAW Values 10
Table 2 SMR-300 Basis for CDF CCF RAW Values 11
Table 3 SMR-300 Basis for LRF BE RAW Values 11
Table 4 SMR-300 Basis for LRF CCF RAW Values 12
Table 5 SMR-300 Basis for CDF BE FV Values 13
Table 6 SMR-300 Basis for LRF BE FV Values 13
Table 7 SMR-300 Criteria for Risk Significance Determination 14

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

1.0 PURPOSE

This report provides SMR, LLC's (Holtec's) SMR-300 Probabilistic Safety Analysis (PSA) methodology for identifying candidate risk-significant SSCs and the basis for the risk significance criteria used. Holtec requests NRC approval that the methodology provided herein is technically acceptable and consistent with current regulations. This report includes the following:

- Discussion of the need for alternative risk significance criteria specific to the SMR-300 design that deviate from Regulatory Guide (RG) 1.200 [1].
- Description of the alternative SMR-300 risk significance criteria based on a sliding scale evaluation of the risk achievement worth (RAW) and Fussell-Vessely (FV) importance measures dependent on core damage frequency (CDF) and large release frequency (LRF) (or large early release frequency (LERF), as applicable) values.
- The basis for the SMR-300 risk significance criteria with a comparison to the NRC Safety Goals.

This report outlines the approach used to identify structures, systems, and components (SSCs) within the PSA that qualify as potential risk-significant candidates. The methodology is applicable for both internal and external hazards, covering all operational modes, including low-power and shutdown scenarios. The methodology is also applicable for a range of CDF and LRF for each individual SMR-300 unit.

The SSCs not included in the PSA are outside of the scope of this methodology. The SSCs typically not modeled in the PSA include those that do not result in a reactor trip, do not perform a safety-related function as defined in 10 CFR 50.2 [5] (or support or complement a safety function), do not support operator actions credited in the PSA (including recovery actions), and are not part of a system that acts as a barrier to fission product release during a severe accident.

2.0 BACKGROUND

Reactor risk metrics quantify the potential risk posed to the public by reactor operations including severe core damage accidents. The two primary risk metrics commonly employed in evaluating operating reactors are CDF and LERF/LRF. These metrics serve as proxies for the Quantitative Health Objectives (QHOs). Specifically, CDF is considered a surrogate for the individual cancer fatality risk QHO, while LERF/LRF adequately represents the individual early fatality risk QHO [6]. It is important to note that, while CDF and LERF/LRF serve as surrogates for risk, their application in the context of the SMR-300 design is more conservative compared to the operating fleet.

It should be noted that this report establishes risk significance criteria against LRF since LRF and conditional containment failure probability (CCFP) are used during modern application reviews. As discussed in SECY-12-0081 [7], the staff recommends transitioning at or before initial fuel load from LRF and CCFP to LERF. Also, as discussed in SECY-13-0029 [6], "the staff's view is that the objective of using LRF as a basis for determining whether a level of safety ascribed to a plant is consistent with the safety goal policy statement is fulfilled today by the use of LERF and CDF guidelines for operating reactors." As such, the SMR-300 criteria for identifying candidate risk-significant SSCs based on LERF would be the same as those proposed for LRF. This is conservative based on the LRF goal of < 10^{-6} per year being more restrictive than the LERF goal of < 10^{-5} per year.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

In SECY-12-0081, the NRC reaffirmed that existing Safety Goals, subsidiary risk goals and associated risk guidance, and quantitative metrics for implementing risk-informed decision making are sufficient for new plants. Currently, the NRC employs a risk-informed and performance-based approach to shape its initiatives, aligning with the overarching goal of establishing a comprehensive regulatory framework. The NRC has issued several guidance documents that specifically address situations where licensees opt to utilize risk-based arguments to address licensing issues [8] [9] [10] [3].

2.1 Regulatory Guidance for Treatment of Risk

The NRC issued a series of policy statements regarding Safety Goals for operating reactors and expectations for new reactors [4] over the past four decades. In the NRC's policy statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants [11] the Commission stated that it "expects that vendors engaged in designing new standard (or custom) plants will achieve a higher standard of severe-accident safety performance than their prior designs." Also, in the NRC's policy statement on Regulation of Advanced Nuclear Power Plants [12] the Commission further stated that it "expects that advanced reactors will provide enhanced margins of safety and/or utilize simplified, inherent, passive, or other innovative means to accomplish their safety and security functions." The following provides a summary of the NRC Safety Goals and subsidiary objectives applicable to new reactors [11] [13]:

- CDF < 10^{-4} per reactor year
- LRF < 10^{-6} per reactor year
- CCFP less than approximately 0.1

These quantitative Safety Goals are identified as acceptance criteria for risk in the NUREG-0800 Standard Review Plan (SRP) Section 19.0 [2]. Section 19.0 of the SRP pertains to the NRC review of the PSA and severe accident analysis for licensing applications. Acceptance Criterion No. 17 in Section 19.0 of the SRP provides a definition for "significant" in the context of the PSA, which states:

> In the context of the [PSA] results and insights, the term "significant" is intended to be consistent with its definition provided in RG 1.200. The definitions of "significant accident sequence" and "significant contributor" are suitable for both CDF and LERF/LRF. Using any other definition of "significant" inconsistent with the definitions provided by RG 1.200 shall be subject to additional staff review and approval.

In RG 1.200, the following numerical criteria are used for defining significance:

- Basic events (BEs)/contributors that have a RAW > 2
- BEs/contributors that have a FV importance > 0.005
- Set of sequences (defined at the functional or systemic level) that compose 95 percent of the CDF or LERF/LRF, or that individually contribute more than one percent to CDF or LERF/LRF

Within these documents, significance is measured with respect to the contribution to the total CDF or LERF/LRF, or with respect to the contribution to the CDF or LERF/LRF for a specific hazard group or plant operating state. RAW measures the risk impact of specific failures or component unavailabilities, while FV measures the overall fractional contribution to risk. The following equations provide details on how RAW and FV importance measures are calculated:

$$RAW = R1/Rb \text{ (range} \geq 1)$$

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

Where:

R1 = increased risk with BE set to true (i.e., 1.0, failed), “conditional CDF” or “conditional LRF”

Rb = baseline PSA risk metric (i.e., CDF or LRF)

$$FV = 1 - R0/Rb \text{ (range 0 to 1)}$$

Where:

R0 = decreased risk with BE or initiating event set to false (i.e., 0.0, perfectly reliable)

Rb = baseline PSA risk metric (i.e., CDF or LRF)

RG 1.174 provides an integrated decision-making framework that incorporates risk insights to facilitate permanent modifications to a licensee’s approved licensing basis. The acceptance guidelines outlined in RG 1.174 are rooted in subsidiary objectives derived from the NRC Safety Goals and their QHOs. A fundamental tenet of risk-informed regulations is that any proposed changes in CDF and risk should be small and aligned with the Safety Goals.

RG 1.174 guidelines are founded on the principles and expectations for risk-informed regulation, supporting licensing basis changes for an operating plant. Figure 1 illustrates the guidelines from RG 1.174. It depicts the permissible changes in CDF and LERF/LRF that the NRC deems acceptable when implementing permanent modifications to a plant’s licensing basis. Notably, for scenarios where the baseline CDF and LERF/LRF are small, the NRC may accept larger risk increases.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

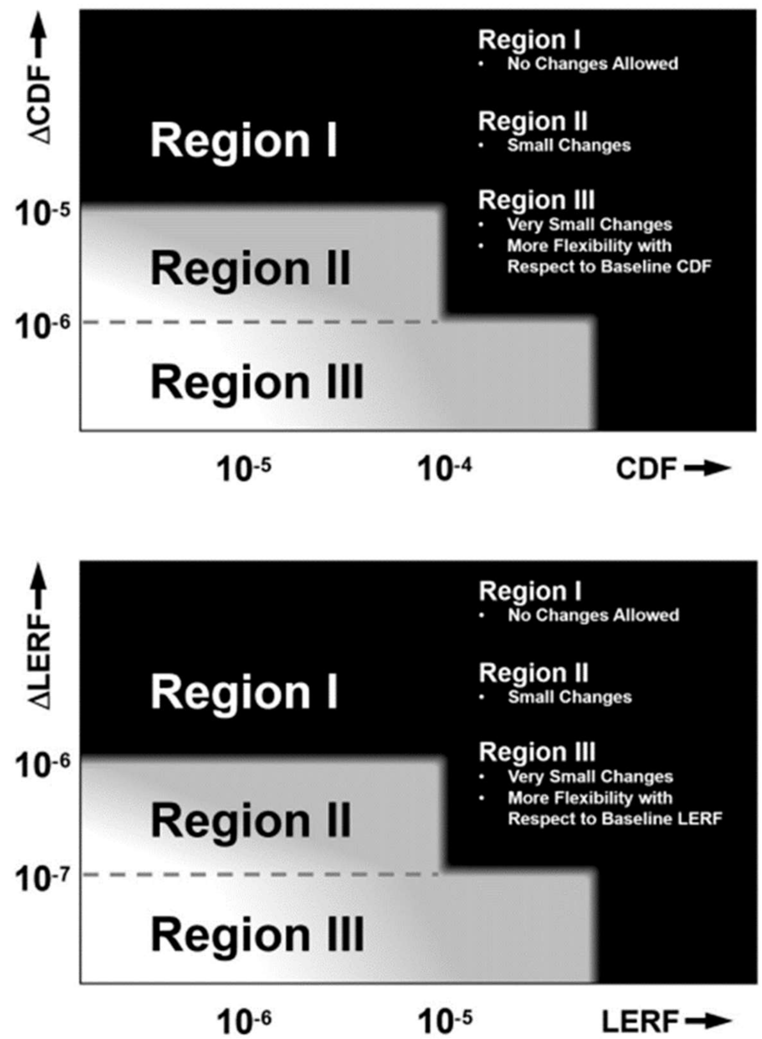

Figure 1: RG 1.174 Acceptance Guidelines

While RG 1.174 provides guidance on permanent plant changes, one key principle is that proposed increases in CDF and LERF/LRF are small and are consistent with the intent of the NRC's Safety Goals. While importance measures for component failures and unavailabilities do not directly correlate with risk changes due to permanent plant modifications, component failures and unavailabilities similarly impact the overall CDF and LERF/LRF of the plant. As such, the SMR-300 methodology described herein for identifying candidate risk-significant SSCs aligns with the principles of RG 1.174 that changes in CDF and LERF/LRF are small and sufficient safety margins are maintained.

2.2 Impetus for SMR-300 Alternative Risk Significance Criteria

The SMR-300 design, characterized by its simplicity and passive safety features, yields baseline CDF or LERF/LRF risk estimates at least an order of magnitude lower than those associated with operating plants. The RG 1.200 risk significance criteria, which are determined as a ratio to the total CDF or LERF/LRF, are suitable for the current fleet of large operating LWRs. However, applying these criteria to the SMR-300 would artificially result in components being perceived as

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

risk-significant although they would have a low contribution to CDF or LERF/LRF relative to the current operating fleet of LWRs. Considering the RG 1.200 criterion of RAW > 2 for BEs, a currently operating reactor with a CDF of 1 x 10^{-5} per reactor year would only identify a BE as risk-significant if its R1 exceeds 2 x 10^{-5} per year. Applying the same criterion if the baseline CDF is approximately 1 x 10^{-7} per year, then a BE would be identified as risk-significant if its R1 is only 2 x 10^{-7} per year. This is a substantial difference of two orders of magnitude. This approach to defining risk significance is also contradictory to the RG 1.174 guidance that considers a change in CDF of less than 1 x 10^{-6} to be very small or not risk significant.

The adoption of alternative criteria to RG 1.200 is not unprecedented. The Advisory Committee on Reactor Safeguards (ACRS) highlighted implications of using the RG 1.200 criteria for new plant designs because a large number of SSCs may be identified as risk-significant [14]. The ACRS stated, in part, that this is especially true for new plant designs that have very low estimated frequencies of core damage and large releases and universal application of 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. For these reasons, new light water reactors (LWRs) have adopted alternative criteria for identifying potentially risk-significant BEs.

The Economic Simplified Boiling-Water Reactor (ESBWR) was approved [15] to employ the following alternative criteria:

- RAW > 5 for individual events
- FV > 0.01 for individual events
- RAW > 50 for common-cause failure (CCF) events

Additionally, the NRC approved the following alternative criteria for the NuScale design [16]:

- Conditional CDF $\geq$ 3 x 10^{-6} per year for component level BE
- Conditional CDF $\geq$ 1 x 10^{-5} per year for system level BE
- Conditional LRF $\geq$ 3 x 10^{-7} per year for component level BE
- Conditional LRF $\geq$ 1 x 10^{-6} per year for system level BE
- Total FV $\geq$ 0.20 of base CDF for BE/contributor

3.0 METHODOLOGY

3.1 SMR-300 PSA Risk Significance Determination Criteria

The SMR-300 criteria for identifying candidate risk-significant SSCs within the PSA are rooted in the acceptance guidelines for small changes in CDF and LRF, while ensuring that the total CDF and LRF remain well below the NRC Safety Goals. Based on the RG 1.174 approach that applies a “sliding scale” for acceptable increases in risk based on the baseline risk, the SMR-300 risk significance methodology similarly applies a sliding scale for its risk significance criteria.

3.1.1 Risk Achievement Worth Criteria

3.1.1.1 Core Damage Frequency

The RG 1.200 criterion uses a RAW of greater than 2 for components to determine risk significance. As such, for a baseline CDF of 1 x 10^{-5} per year, an increase in CDF by a factor of 2 represents a significant loss in safety margin with respect to the NRC Safety Goal for CDF of 1 x 10^{-4} per year. However, if the baseline CDF is on the order of 1 x 10^{-6} to 1 x 10^{-7} per year, an

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

increase in CDF by a factor of 2 does not represent a significant loss in safety margin with respect to the 1 x 10^{-4} per year Safety Goal for CDF. Therefore, for a baseline CDF of 1 x 10^{-5} per year or greater, a RAW of greater than 2 (which is equivalent to R1 $\geq$ 2 x 10^{-5} per year) is considered risk significant. However, using this same R1 for baseline CDFs in the ranges discussed above would result in very few BEs being considered as risk significant as the total CDF lowers. To account for the lower baseline CDF of the SMR-300 design, but still identify the BEs that drive the risk, the R1 is adjusted as shown in Table 1 to derive BE RAW criteria dependent on baseline CDF.

Table 1 SMR-300 Basis for CDF BE RAW Values

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

The sliding scale increases the RAW BE risk significance criterion from the RG 1.200 RAW criterion applicable to the operating fleet with baseline CDF of approximately 1 x 10^{-5} per year to the RAW value that correlates to the R1 approved for a baseline CDF of 1 x 10^{-7} per year by the NRC for the NuScale design. The CDF BE RAW criteria presented in Table 1 are considered to meet the intent of RG 1.200 and RG 1.174.

For a system-level criterion (CCF event), guidance from NEI 00-04 [17], as endorsed in Regulatory Guide 1.201 [18], were considered; specifically, the importance measure criterion for CCF events is considered to be a RAW value of 20. This value reflects that a CCF is measuring the failure of two or more trains, including the higher failure likelihood for the second train due to common causes. As such, this system-level criterion applies to CCF BEs. Most systems expected to provide or assist safety missions in the SMR-300 design typically include some inter- and intra-system redundancy, which is the rationale for using an order of magnitude increase for system-level criteria compared to component-level criteria, e.g., 20 vs. 2 for RAW.

A factor of 10 could be applied to the individual BE RAWs shown in Table 1. However, to ensure conservatism, the factor is lowered as the CDF lowers: from a factor of 7 for a CDF of 1 x 10^{-6} per year down to a factor of 2 for a CDF of 1 x 10^{-7} per year as shown in Table 2.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

Table 2 SMR-300 Basis for CDF CCF RAW Values

CDF (Rb)	BE RAW	Factor Increase for CCF	CCF RAW	Basis
1×10^{-5}/yr	2	10	20	Current criteria for CDF of 1×10^{-5}/yr
1×10^{-6}/yr	5	7	35	Due to potentially significant impact of a loss of a system due to CCF, the factor was conservatively lowered to reflect the lower CDF
5×10^{-7}/yr	10	4	40	Due to potentially significant impact of a loss of a system due to CCF, the factor was conservatively lowered to reflect the lower CDF
1×10^{-7}/yr	30	2	60	Due to potentially significant impact of a loss of a system due to CCF, the factor was conservatively lowered to reflect the lower CDF

These criteria are applied at a single unit level and are applicable to all initiating events collectively and aggregated across all hazards and operating modes (i.e., internal events, low-power and shutdown conditions, internal flooding, internal fires, and external hazards).

The CDF CCF RAW criteria provided in Table 2 are similar to the NRC-approved criteria for the ESBWR (RAW > 50 for CCF events) and NuScale (CCDF > 1×10^{-5} per year for system level BE, which corresponds to a RAW of 100 for a CDF of 1×10^{-7} per year) and are considered to meet the intent of RG 1.200 and RG 1.174.

3.1.1.2 Large Release Frequency

In addition to core damage, BEs are evaluated for risk significance against LRF, the PSA Level 2 risk metric. The SMR-300 risk significance approach for LRF is similar to that for CDF, but the LRF criteria are reduced by an order of magnitude, which is consistent with the Commission's CCFP goal of less than 0.1 for new reactors and the approach taken for the guidelines in RG 1.174. The LRF criteria and basis for RAW for the SMR-300 are shown in Table 3.

Table 3 SMR-300 Basis for LRF BE RAW Values

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

The sliding scale increases the RAW risk significance criterion from the RG 1.200 RAW criterion applicable to the operating fleet with baseline LERF of approximately 1×10^{-6} per year to the RAW value that correlates to the R1 approved for a baseline LRF of 1×10^{-8} per year by the

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

NRC for the NuScale design. The LRF BE RAW criteria provided in Table 3 are considered to meet the intent of RG 1.200 and RG 1.174.

For the evaluation of CCF events, the same approach as used for the CDF CCF RAW determinations is used. Similarly, a factor of 10 could be applied to the individual BEs shown in Table 3. However, to ensure conservatism, the factor is lowered as the LRF lowers, from a factor of 7 for a LRF of 1 x 10^{-7} per year to a factor of 2 for a LRF of 1 x 10^{-8} per year as shown in Table 4.

Table 4 SMR-300 Basis for LRF CCF RAW Values

LRF (Rb)	BE RAW	Factor Increase for CCF	CCF RAW	Basis
1 x 10^{-6}/yr	2	10	20	Current criteria for LRF of 1 x 10^{-6}/yr
1 x 10^{-7}/yr	5	7	35	Due to potentially significant impact of a loss of a system due to CCF, the factor was conservatively lowered to reflect the lower LRF
5 x 10^{-8}/yr	10	4	40	Due to potentially significant impact of a loss of a system due to CCF, the factor was conservatively lowered to reflect the lower LRF
1 x 10^{-8}/yr	30	2	60	Due to potentially significant impact of a loss of a system due to CCF, the factor was conservatively lowered to reflect the lower LRF

These criteria are applied at a single unit level and are applicable to all initiating events collectively and aggregated across all hazards and operating modes (i.e., internal events, low-power and shutdown conditions, internal flooding, internal fires, and external hazards).

The LRF CCF RAW criteria provided in Table 4 are similar to the NRC-approved criteria for the ESBWR (RAW > 50 for CCF events) and NuScale (CLRF > 1 x 10^{-6} per year for system level BE, which corresponds to a RAW of 100 for a LRF of 1 x 10^{-8} per year) and are considered to meet the intent of RG 1.200 and RG 1.174.

As discussed in Section 2.0, the presented risk significance criteria for SMR-300 are based on LRF; LRF and CCFP are being used for modern application reviews. Because the objective of using LRF is fulfilled today by the use of LERF for operating plants, the criteria for LERF would be the same as those proposed for LRF and applicable to licensing of new operating SMR-300 plants.

3.1.2 Fussell-Vesely Criterion

To supplement the RAW criteria, the FV importance measure is used to identify those SSCs that have the largest fractional contribution to risk. The focus of this criterion is on identifying SSCs for which reliability and availability have the greatest influence on the risk profile. This criterion is used to identify BEs that are a significant fraction of a hazard with very low risk. In addition to equipment unavailabilities and human failures, internal initiating event contributors are also evaluated using FV because they play an important role in a PSA. External initiating events are excluded because they are not initiated by plant components.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

For a baseline CDF of 1 x 10^{-5} per year, when setting a BE or initiating event to false, the RG 1.200 FV criterion (i.e., 0.005 or 0.5 percent) translates to a decrease in CDF of 5 x 10^{-8} per year. Applying the same decrease in CDF of 5 x 10^{-8} per year to a plant with a baseline CDF of 1 x 10^{-7} per year corresponds to an FV of 0.5 or 50 percent. However, using a FV criterion of 0.5 does not reflect the intent to use FV for identifying those components that contribute a significant portion of the risk.

Similar to the sliding scale applied to the RAW risk significance criteria, the FV risk significance criterion is also adjusted as shown in Table 5 and Table 6 to ensure that the reduced CDF/LRF is maintained if the BE is perfectly reliable.

Table 5 SMR-300 Basis for CDF BE FV Values

CDF (Rb)	FV	Decreased Risk (R0)	Basis
1 x 10^{-5}/yr	0.005	5 x 10^{-8}/yr	Current criteria for CDF of 1 x 10^{-5}/yr
1 x 10^{-6}/yr	0.05	5 x 10^{-8}/yr	Increased FV to yield same R0 as for CDF of 1 x 10^{-5}/yr
5 x 10^{-7}/yr	0.1	5 x 10^{-8}/yr	Increased FV to yield same R0 as for CDF of 1 x 10^{-5}/yr
1 x 10^{-7}/yr	0.2	2 x 10^{-8}/yr	Equivalent to NRC-approved methodology where R0 = 2 x 10^{-8}/yr for CDF of 1 x 10^{-7}/yr

Table 6 SMR-300 Basis for LRF BE FV Values

LRF (Rb)	FV	Decreased Risk (R0)	Basis
1 x 10^{-6}/yr	0.005	5 x 10^{-9}/yr	Current criteria for LRF of 1 x 10^{-6}/yr
1 x 10^{-7}/yr	0.05	5 x 10^{-9}/yr	Increased FV to yield same R0 as for LRF of 1 x 10^{-6}/yr
5 x 10^{-8}/yr	0.1	5 x 10^{-9}/yr	Increased FV to yield same R0 as for LRF of 1 x 10^{-6}/yr
1 x 10^{-8}/yr	0.2	2 x 10^{-9}/yr	Equivalent to NRC-approved methodology where R0 = 2 x 10^{-9}/yr for LRF of 1 x 10^{-8}/yr

The sliding scale increases the FV risk significance criterion from the RG 1.200 FV criterion applicable to the operating fleet with a baseline CDF of 1 x 10^{-5} per year (LRF of 1 x 10^{-6} per year) to the FV value approved for a baseline CDF of 1 x 10^{-7} per year (LRF of 1 x 10^{-8} per year) by the NRC for the NuScale design. The FV criteria provided in Table 5 and Table 6 are considered to meet the intent of RG 1.200 and RG 1.174.

The FV criterion is applied at a single unit level and is applied individually to each hazard group and mode of plant operation. For example, SSCs are identified as risk-significant candidates if any one of the SSC's failures modes (BEs) exceeds the criterion for internal events risk, or seismic risk, or external flood risk, etc. It is also applied individually to CDF and LRF because the focus is on identifying SSCs for which the reliability and availability have the greatest influence on risk.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

3.1.3 Consolidated SMR-300 PSA Risk Significance Determination Criteria

Table 7 provides the consolidated criteria used to determine SMR-300 candidate risk-significant SSCs.

Table 7 SMR-300 Criteria for Risk Significance Determination

CDF (/yr)	LRF (/yr)	FV	RAW	
			BE	CCF
$1 \times 10^{-6} > CDF \geq 5 \times 10^{-7}$	$1 \times 10^{-7} > LRF \geq 5 \times 10^{-8}$	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

3.2 Applicability and Limitations of Methodology

The following applicability conditions and limitations apply to this methodology:

1. This methodology is specific to the SMR-300 design.
2. This methodology can only be used in concert with a PSA and analysis of CDF and LRF/LERF that the NRC has determined to be technically adequate. The SMR-300 CDF must be less than 1×10^{-6} per year and the LRF must be less than 1×10^{-7} per year.
3. This methodology identifies candidate risk-significant SSCs from the SMR-300 PSA but is not the sole determinant of risk significance. To ensure a holistic risk-informed approach is taken, additional consideration of uncertainties, sensitivities, traditional engineering evaluations and regulations, and maintaining sufficient defense-in-depth and safety margin will be used to determine a complete list of risk-significance and will be identified in a future application that references this report.

4.0 SUMMARY AND CONCLUSIONS

A methodology for identifying candidate risk-significant SSCs for the SMR-300 design is presented and justified in this report. Applying existing guidance from RG 1.200 to the SMR-300 design would be overly conservative and inappropriately identify an excessive list of candidate risk-significant SSCs. The RG 1.200 guidance was developed for the CDF and LRF risk profiles of the operating fleet, and therefore does not adequately consider the lower risk profiles of new reactors such as the SMR-300 design. Given the SMR-300 PSA is under development, risk significance criteria are presented for a range of baseline CDF and LRF to ensure appropriate criteria can be applied independent of the final CDF and LRF values for the SMR-300 design. The SMR-300 alternative risk-significance criteria meet the intent of RG 1.200 and RG 1.174. The specific risk-significant criteria are presented in Table 7.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

5.0 REFERENCES

[1] U.S. Nuclear Regulatory Commision, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," RG 1.200, Rev. 3, December 2020.

[2] U.S. Nuclear Regulatory Commision, "Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors," NUREG-0800, Chapter 19, Section 19.0, Rev. 3, December 2015.

[3] U.S. Nuclear Regulatory Commission, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Regulatory Guide 1.174, Rev. 3, January 2018.

[4] U.S. Nuclear Regulatory Commission, "Safety Goals for the Operation of Nuclear Power Plants; Policy Statement," Correction and Republication, Federal Register Vol 51 FR 30028, August 21, 1986.

[5] U.S. Code of Federal Regulations, "Definitions," Section 50.2, Part 50, Chapter I, Title 10, “Energy,” (10 CFR 50.2).

[6] U.S. Nuclear Regulatory Commission, "History of the Use and Consideration of the Large Release Frequency Metric by the U.S. Nuclear Regulatory Commission," SECY-13-0029, March 22, 2013.

[7] U.S. Nuclear Regulatory Commission, "Risk-Informed Regulatory Framework for New Reactors," SECY-12-0081, June 2012.

[8] U.S. Nuclear Regulatory Commission, "An Approach for Plant-Specific Risk-Informed Decision making for Inservice Inspection of Piping," Regulatory Guide 1.178, Rev. 2, April 2021.

[9] U.S. Nuclear Regulatory Commission, "An Approach for Plant-Specific, Risk-Informed Decision making: Inservice Testing," Regulatory Guide 1.175, Rev. 1, June 2021.

[10] U.S. Nuclear Regulatory Commission, "An Approach for Plant-Specific, Risk-Informed Decision-Making: Technical Specifications," Regulatory Guide 1.177, Rev. 2, January 2021.

[11] U.S. Nuclear Regulatory Commission, "Modifying the Risk-Informed Regulatory Guidance for New Reactors," SECY-10-0121, September 14, 2010.

[12] U.S. Nuclear Regulatory Commission, "Policy Statement on the Regulation of Advanced Reactors," Final Policy Statement, Federal Register Vol 73 FR 60612, October 14, 2008.

[13] U.S. Nuclear Regulatory Commission, "Evolutionary Light Water Reactor (LWR) Certification Issues and their Relationships to Current Regulatory Requirements," SRM to SECY-90-016, June 26, 1990.

[14] Stetkar, John W., Chairman, Advisory Committee on Reactor Safeguards, memorandum to Mr. Mark A Satorious, Executive Director for Operations, U.S. Nuclear Regulatory Commission, "Standard Review Plan Chapter 19 and Section 17.4," July 16, 2014.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]

[15] U.S. Nuclear Regulatory Commission, "Final Safety Evaluation Report Related to the Certification of the Economic Simplified Boiling-Water Reactor Standard Design," NUREG-1966, Volume 4, April 2014.

[16] U.S. Nuclear Regulatory Commission, "Staff Safety Evaluation Report for NuScale Power, LLC Licensing Topical Report TR-0515-13952-NP, “Risk Significance Determination"," ML16181A218, Rev. 0.

[17] Nuclear Energy Institute, "10 CFR 50.69 SSC Categorization Guideline," NEI 00-04, Rev. 0, July 2005.

[18] U.S. Nuclear Regulatory Commission, "Guidelines for Categorizing Structures, Systems, and Components in Nuclear Power Plants According to their Safety Significance," Regulatory Guide 1.201 (for trial use), Rev. 1, May 2006.

Copyright Holtec International © 2024, all rights reserved
[Not Export Controlled]