Response to SDAA Audit Question

Question Number: A-19.1-27

Receipt Date: 05/29/2023

Question:

In the staff approved LTR, the threshold Fussel-Vessely (FV) value used to determine candidate risk significant components was 0.2 (20%) for each hazard group and mode of plant operation. NuScale calculated an equivalent FV threshold of 0.5 for a plant with a CDF of 1E-7 per year compared with the operating fleet. NuScale reduced this value to 0.2 to assure that significant contributors are not screened out, stating “setting a threshold for FV at 0.5 does not reflect the intent behind the use of FV for identifying those components that contribute a significant portion of the risk.” Further, the staff’s SE of the approved LTR states, “NuScale has created a de facto upper bound on FV of 0.2 for very low base CDFs, which is acceptable to the staff.”

In the SDA FSAR, NuScale instead uses a sliding scale for the FV threshold value ranging from 0.2 to the CDF-based values listed in Table 19.1-19 of the FSAR. A basis and justification commensurate with that provided in the initial topical report for each FV threshold on the sliding scale is not provided in the SDA FSAR.

While the range of FV thresholds in the SDA may maintain parity with the operating fleet, per Table 19.1-19 of the SDA FSAR, a reduction from 0.5 to 0.2 to assure that significant contributors are not screened out is only applicable if the CDF is on the order of 1E-7 per year. The same assurance is unavailable for the other FV thresholds, despite uncertainty typically increasing as the CDF decreases. Consequently, the impact of PRA modeling uncertainty on candidate risk significance determination is unknown. This consideration of uncertainty is particularly important for a new design without operating data. The SDA FSAR does not include any demonstration that the candidate risk significance determination when CDF is less than 1E-7 per year is not impacted due to PRA modeling uncertainty and the lack of assurance that significant contributors are not screened out.

Limitation and Condition #2 on the approved Risk Significance topical report states, in part, “…the ultimate determination of risk significance shall be based on the specific application, with appropriate consideration of uncertainties, sensitivities, traditional engineering evaluations and regulations, and maintaining sufficient defense-in-depth and safety margin. As such, PRA risk insights shall be considered along with deterministic approaches and defense-in-depth concepts such that the user is implementing a “risk-informed” rather than a solely “risk-based” approach.” The FSAR and docketed material lack justification that the application of the topical report to the SDAA meets Limitation and Condition #2.

1.Provide FSAR markup with basis and justification for the range of FV thresholds in the SDA, shown in Table 19.1-19, compared to the DCA.
2.Demonstrate that candidate risk significance determination when CDF is less than 1E-7 per year is not impacted due to PRA modeling uncertainty and the lack of assurance that significant contributors are not screened out. An example of such a demonstration could be showing that candidate risk significance determination remains unchanged with a FV CDF and LRF criteria of:
•0.3 (instead on 0.5) for 1E-8 per year<= CDF< 1E-9 per year and 1E-9 per year<= LRF< 1E-10 per year,
•0.7 (instead of 0.9) for 1E-9 per year<=CDF<1E-10 per year and 1E-10 per year<= LRF< 1E-11 per year,
•0.8 (instead of 1.0) for CDF<1E-10 per year and LRF<1E-11 per year.
Provide FSAR markups with discussion and results of the demonstration, including changes to the candidate risk significant SSCs in Table 19.1-19.
3.Provide a docketed response that demonstrates how Limitation and Condition #2 on the use of the approved Risk Significance topical report is met for the SDA FSAR using an example to illustrate that the final risk significance determination is risk-informed and not risk-based and appropriately considered uncertainties, sensitivities, traditional engineering evaluations and regulations, and maintains sufficient defense-in-depth and safety margin. It is preferred that the example is for an SSC where the final risk significance assigned by the IDP is different than the candidate risk significance from the PRA.

Response:

1. In the staff approved topical report (LTR), the threshold Fussell-Vesely (FV) value for determining candidate risk-significant components is 0.2 (20%) for each hazard group and mode of plant operation, contingent on the core damage frequency (CDF) being no greater than 1E-7 per year. In the discussion supporting the method described in the LTR, NuScale calculated an equivalent FV threshold of 0.5 for a plant with a CDF of 1E-7 per year as being comparable to the FV values commonly used by the operating fleet. NuScale reduced this value to 0.2 to ensure that significant contributors are not screened out, stating “setting a threshold for

FV at 0.5 does not reflect the intent behind the use of FV for identifying those components that contribute a significant portion of the risk.” The staff’s safety evaluation of the LTR states, “NuScale has created a de facto upper bound on FV of 0.2 for very low base CDFs, which is acceptable to the staff.”

In the standard design approval application (SDAA), instead of using a fixed FV threshold regardless of CDF (as was done in the design certification application [DCA]), NuScale uses a sliding scale for the FV threshold starting at 0.2 for CDFs between 1E-7 per year to 1E-8 per year, and increasing the threshold as CDF decreases.

The range of FV thresholds in the SDAA are listed in SDAA Table 19.1-19, and in Table 1 below. Consistent with the DCA, the SDAA incorporates a reduction from 0.5 to 0.2 to ensure that significant contributors are not screened out if the CDF is less than 1E-7 per year (but greater than 1E-8 per year). This same relative assurance of margin is also available for the other FV thresholds. As the CDF decreases (with uncertainty likely increasing as the CDF decreases), the FV threshold is gradually increased, but disproportionally so. Consequently, the impact of PRA modeling uncertainty on candidate risk significance determination is effectively accounted for. {{

}}2(a),(c)

NuScale has revised SDAA Section 19.1.4.1.1.9 to include a basis and justification for the range of FV thresholds used in the SDAA.

2. Fussell-Vesely is not the only importance measure used for identifying candidate risk-significant components. Conditional core damage frequency and conditional large release frequency thresholds are absolute importance measures that provide a reasonable redundant and diverse mechanism for determining candidate risk-significance, as they did in the DCA.

Tables 1 and 2 below show {{

}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

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}}2(a),(c)

3. The subject matter expert identifies safety-related, regulatory treatment of nonsafety systems, nonsafety-related with augmented requirements, and risk significance of the system functions per {{ }}2(a),(c). The proposed categorization is presented to the expert panel for review and approval. The expert panel deliberates and chooses to accept or reject the recommendation via considerations of a combination of probabilistic, deterministic, and other methods of analysis, as well as industry operating experience and defense-in-depth.

An example of a structure, system, or component that was determined by the expert panel to have a risk significance different than the candidate risk significance from the PRA is the Control

Building. The PRA did not identify the Control Building as a candidate for risk significance. However, the expert panel classified the Control Building as risk-significant. Factors beyond the PRA recommendation that informed this decision include the location of manual switches in the main control room that are part of the safety-related module protection system, and the protection of operators, as part of a defense-in-depth strategy.

Markups of the affected changes, as described in the response, are provided below:

19.1.4.1.1.9 Risk-Significance Determination

The PRA provides insights into the risk-significance of SSC and operator actions with regard to core damage and large release frequencies. Importance measures provide a method to observe how significant a component is with respect to these risk metrics.

The process of calculating PRA system importance parameters has two aspects: 1) calculating the potential maximum risk increase and 2) calculating the overall percent contribution to the total risk. The first aspect is based on an absolute evaluation of the risk achievement worth (RAW), which considers the effect of complete unavailability of SSC. The second aspect is based on the Fussell-Vesely (FV) importance measure, which represents the fractional reduction in risk given perfect performance. As described in TR-0515-13952-NP-A (Reference 19.1-7), "significance" for the NuScale Power Plant US460 standard design is evaluated using an approach that reflects its very low calculated frequency of core damage. The very low calculated CDF implies that even exceedingly small changes in the calculated core damage or large release frequencies would be risk-significant if traditional approaches based on relative changes were used. The approach provided in Reference 19.1-7 allows insights into the potential risk-significance of SSC and operator actions with respect to safety goals without identifying small changes in a very low calculated risk metric as risk-significant.

As illustrated in Table 19.1-19, the criteria for determining SSC as candidates for risk-significance are based on absolute rather than relative importance measures. The absolute importance measures are defined as the conditional core damage frequency (CCDF) and conditional large release frequency (CLRF). These absolute measures are used to evaluate risk-significance instead of the traditional RAW evaluation based on a relative change in risk.

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In addition to individual components, the FV importance measure is used to evaluate the risk-significance of other basic events. This risk measure is used to identify basic events that have the largest fractional risk contribution by evaluating the reduction in risk if the basic event is assumed to be always successful. The FV importance measures are developed for contribution to core damage frequency (FVCDF) and contribution to large release frequency (FVLRF). As shown in the Table 19.1-19, threshold values are derived based on the calculated CDF and LRF. When the CDF is 1E-07 per mcyr or less, or the LRF is 1E-08 per mcyr or less, the FV thresholds are scaled to maintain an equivalent level of absolute risk, with additional margin added as risk decreases to compensate for potential increases in PRA uncertainty and ensure significant contributors do not screen. For a calculated CDF contribution below 1E-10 per mcyr and LRF contribution below 1E-11 per mcyr a component is not considered risk significant.