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SUBMITTAL OF THE WESTINGHOUSE EVINCI™ MICRO-REACTOR GROUP 1 WHITE PAPERS FOR PRE-APPLICATION ENGAGEMENT: EVR-SAR-GL-002, REVISION 0, "LICENSING BASIS EVENT IDENTIFICATION, SSC CLASSIFICATION AND DEFENSE-IN-DEPTH ADEQUACY"

SPONSOR INFORMATION

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Brief Description of the White Paper: The purpose of this white paper, EVR-SAR-GL-002, Revision 0, "Licensing Basis Event Identification, SSC Classification and Defense-in-Depth Adequacy," is to present the intended processes that will be used to identify licensing basis events (LBEs); classify structures, systems, and components (SSCs); and evaluate defense-in-depth (DID) adequacy in the eVinci micro-reactor.

REGULATORY ASSESSMENT

Regulatory Basis

The NRC staff is making no regulatory findings regarding this white paper and nothing herein should be interpreted as official agency positions.

The NRC staff's observations are focused on information associated with identifying LBEs, classifying SSCs, and evaluating DID. Accordingly, the NRC staff's observations are associated with the following guidance documents that address these topics:

- Nuclear Engineer Institute (NEI) 18-04, Revision 1, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development," presents a technology-inclusive, risk-informed, and performance-based process for the selection of LBEs; safety classification of SSCs and

associated risk-informed special treatments; and the determination of the DID adequacy for non-light Water Reactors (non-LWRs).

- Regulatory Guide (RG) 1.233, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors," endorses the principles and methodologies in NEI 18-04, Revision 1, as one acceptable method for informing the licensing basis for non-LWRs.

TECHNICAL ASSESSMENT

Westinghouse's Requested Feedback

Based on the review of the contents of EVR-SAR-GL-002, and subsequent pre-application discussions, Westinghouse requested the NRC staff's feedback and observations regarding the approach and information discussed in the white paper. In addition, Westinghouse is looking for feedback from the NRC staff regarding the following specific questions:

- Does the NRC staff find the process described herein to be an acceptable way to identify LBEs for the eVinci™ micro-reactor?
- Does the NRC staff find the process described herein to be an acceptable way to classify eVinci™ micro-reactor SSCs?
- Does the NRC staff find the process described herein to be an acceptable way to evaluate the adequacy of the DID equipment for the eVinci™ micro-reactor?
- Are there any aspects of the eVinci™ micro-reactor design that appear to prevent adherence to the NEI 18-04 and RG 1.233 guidance?

The NRC staff observes that the process described in this white paper can be used as a reasonable approach to identify LBEs, classify SSCs, and evaluate DID adequacy as it generally follows the guidance in NEI 18-04 and RG 1.233 with some deviations. The NRC staff did not identify any aspects of the eVinci™ micro-reactor design that would prevent adherence to RG 1.233. The NRC staff, however, are providing observations and feedback below, regarding specific items identified during the review of the white paper. The staff expects that additional discussions on some of the issues below should help to improve the clarity of the risk-informed and performance-based process outlined in this white paper.

The NRC Staff's Observations for EVR-SAR-GL-002

1. (General) Glossary of Terms has the following: "Safety-related (SR) structures, systems, and components (SSCs) - SSCs that are credited in the fulfillment of [Required Safety Functions] RSFs and are capable to perform their RSFs in response to any Design Basis External Hazard Level." Elsewhere, this white paper states that **[[**

]] The Glossary appears to be inconsistent with that statement and should be corrected.

2. (General) The terms associated with SSC classification categories should be used consistently according to NEI 18-04, which has the following: Safety-Related (SR), Non-Safety-Related with Special Treatment (NSRST), and Non-Safety-Related with No Special Treatment (NST). Unless explained separately, the use of other terms such as 'safety related,' 'non-safety related,' 'safety-related,' 'NS,' etc., can create ambiguity or confusion.

3. (General) This white paper uses the term "important to safety SSCs" which is not used in NEI 18-04. NEI 18-04 uses the term "safety-significant SSCs." The NRC staff suggests the use of the latter term, which is consistent with NEI 18-04.

4. (General) The term "facility" is used (as in '10^{-2} per facility-year' for event sequence frequencies) in this white paper instead of "plant" used in NEI 18-04 in which the plant is "the entity that is being subjected to the LMP process for LBE selection and evaluation and may be comprised of a single reactor or multiple reactor modules. In addition, the plant is expected to include additional non-reactor sources of radioactive material. Hence, each LBE may involve one or more reactor modules or radionuclide sources." The white paper should explain the deviation from the NEI 18-04 terminology.

   The NRC staff also notes that Figures 2.1-2 and 2.1-3 of this white paper uses "plant-year." The terms "plant" and "facility" should be used consistently.

5. (General) This white paper contains descriptions for the individual sections that are often shortened from, or contain only a portion of, the corresponding sections in NEI 18-04. It states on Page 8 that, "The exclusion of NEI 18-04 … text corresponding to the steps indicated herein is not an indication that the specific NEI 18-04 … guidance will not be followed rather simply reflects a distillation of the information into key tasks that comprise the processes."

   Many of the NEI 18-04 sections (e.g., Sections 5.5 - 5.9 on DID) are not replicated in this white paper. The sections, although not directly linked to the steps covered in the white paper, contain important discussions or considerations that support the implementation of the steps in implementing the LMP. It is not clear to the NRC staff whether Westinghouse intends to fully adhere to the NEI 18-04 guidance in the omitted sections or take exceptions from that guidance. The NRC staff observes that the distillation in this white paper can lead to potential discrepancies with NEI 18-04 (see Comment 17 below as an example).

6. (p6) "Task 3: PRA Development/Update" of this white paper references American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) RA-S-1.4-2020, "Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants." The NRC staff expects to endorse ASME/ANS RA-S-1.4-2021 for trial use in March 2022. (See the NRC staff's presentation from the March 16, 2022, public meeting (ADAMS Accession No.: ML22074A190)).

7. (p8) Section 1.2, "Scope," of the white paper states that **[[**

]] The NRC staff recognizes that the approach endorsed by RG 1.233 is iterative. Accordingly, the approach described in the white paper to **[[ ]]** appears to be consistent with the flexibility inherent in the approach endorsed by RG 1.233. The NRC staff also understands the interdependency between the PRA development and the design as described by Westinghouse.

However, the NRC staff is questioning what **[[ ]]** means. Additional explanations should help the NRC staff understand the approach. For example, how does **[[ ]]** and what are the sources of information used as input to the **[[ ]]** for consideration?

8. (p10) "Task 1: Identification of Initial List of Licensing Basis Events," of the white paper states that "The initial identification of LBEs for the eVinci™ micro-reactor follows two parallel paths:

   - A systematic review of available literature associated with initiating events.
   - A structured and multi-disciplinary Failure Mode and Effects Analysis (FMEA) of the design.

   A review of available nuclear power facility initiating event literature (References 3, 4, and 5) is performed considering the design of the micro-reactor to obtain the first set of initiating events for consideration.

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   Following the completion of the two parallel paths described above, the two lists of potential events are combined and compared to obtain one set of initiators. The initiators are then grouped into event categories based on similar expected facility response."

   The NRC staff is not sure of the comprehensiveness of the search for LBEs as discussed above. It is based on the following examples:

a) The PRA standard for non-LWRs[1] related to the identification of initiating events and event sequences contains a number of requirements. An example includes:

- Generic analyses and operating experience of similar plants and from other facilities' comparable systems (e.g., systems at non-LWRs, LWRs, nonnuclear facilities, fuel cycle facilities).

The NRC staff observes that the approach described in the white paper appears to not meet the non-LWR PRA standard.

b) The white paper references NUREG/CR-3862[2], NUREG/CR-5750[3], and NUREG/CR-6928[4], as available literature. The NRC staff observes that literature and operating experience reviews can cover broader areas than what is described in this white paper.

Based on the NRC staff's current understanding of the eVinci™ design, the eVinci™ uses novel design features such that similar information, as that provided in the literature list, is not available. The NRC staff would benefit from information describing how the performance of new and novel features is treated in the selection of LBEs.

c) Regarding the use of the FMEA, the method has strengths and limitations. NUREG-1513[5] states, on the related subject that, "The choice of a particular method or combination of methods will depend on a number of factors including the reason for conducting the analysis, the results needed from the analysis, the information available, the complexity of the process being analyzed, the personnel and experience available to conduct the analysis, and the perceived risk of the process." It may be possible that the FMEA could be used for the search for LBEs and meet the non-LWR PRA standard if its shortcomings are addressed. It is not clear to the NRC staff how the FMEA is conducted and is sufficient as a technique for comprehensive search for the licensing basis event lists under NEI 18-04.

[1] ASME/ANS RA-S-1.4-2021, "Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants," issued February 2021.
[2]NUREG/CR-3862, "Development of Transient Initiating Event Frequencies for Use in Probabilistic Risk Assessments," issued May 1985.
[3]NUREG/CR-5750, "Rates of Initiating Events at U.S. Nuclear Power Plants: 1978 – 1995," issued February 1999.
[4]NUREG/CR-6928, "Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants," issued February 2007.
[5] NUREG-1513, "Integrated Safety Analysis Guidance Document," issued May 2001.

9. (p10) "Task 3: PRA Development/Update," of the white paper states that **[[**

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A PSF, as used in the NEI 18-04, is any function by any SSC modeled in the PRA that is responsible for preventing or mitigating a release of radioactive material from any radioactive material source within the plant. Some of the PSFs lead to RSFs. NEI 18-04 further states that RSFs are defined starting with generic fundamental safety functions (FSFs) and are refined as necessary into reactor technology-specific safety functions that reflect the reactor concept and unique characteristics of the reactors. This provides the foundation for reactor technology-specific SSCs selected to perform each function. The NRC staff observes the following:

- FSFs are technology-inclusive while PSFs are technology- and plant-specific.
- SSCs may typically have PSFs identified at a level lower than the FSFs and have more PSFs than the FSFs depending on the PRA approach.
- FSFs, RSFs, and PSFs appear to be different sets in NEI 18-04.

The NRC staff did not identify any detailed information in the white paper describing how the PSFs were identified. **[[**

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Technology Inclusive Content of Application Project (TICAP) Westinghouse eVinci™ Micro-Reactor Tabletop Exercise Report[6] contains related discussions and insights. The report, intended to support the development of NEI 21-07, identified the PSFs, RSFs, FSFs to be the same based primarily on the simplicity of the design. However, the industry TICAP team noted in the report that "…from the perspective of the TICAP team, the FSFs, the design-specific PSFs, and the RSFs for the eVinci Micro-Reactor would each be comprised of a unique set of functions (even if some of the functions are similar and/or related) based upon the analyses discussed in this tabletop exercise."

The NRC staff also notes that the details and maturity of the PRA may provide additional insights on the subject.

In summary, the NRC staff finds this area to be a topic of follow-on pre-application engagement as needed.

[6] https://www.nrc.gov/docs/ML2127/ML21272A303.pdf

10. (p11, p12) Figure 2.1-2, "Focused Frequency-Consequence Target," and Figure 2.1.3, "Regions to consider for RSFs," of the white paper evaluates the radiological consequences using **[[**

]] The NRC staff needs additional clarification regarding **[[ ]].** Is it intended for a computational purpose only, or is it intended also for proposing the EAB as part of the site suitability as required by applicable regulations (e.g., 10 CFR Part 100, "Reactor Site Criteria")?

11. (p11) "Task 3: PRA Development/Update," of the white paper states that, **[[**

]] Have the plant operating states for the design been defined in accordance with the non-LWR PRA standard?

12. (p11) "The PRA and radiological consequences associated with the LBEs performed are plotted against the frequency-consequence (F-C) targets depicted in Figure 2.1-2. **[[**

]] The figure highlights only those sequences that fall into the regions of concern as documented in NEI 18-04 (Reference 1). Subsequent tasks are only performed using the results within these regions of concern."

Regarding the last sentence, the evaluation against three cumulative risk targets in NEI 18-04, may necessitate using the results of the LBEs with frequencies below the $5x10^{-7}$/plant-year threshold. In addition, NEI 18-04 states that an event sequence family with a mean frequency less than $5x10^{-7}$/plant-year but with a 95 percentile frequency estimate above $5x10^{-7}$/plant-year, is evaluated as a BDBE. These indicate the use of the results not within the regions of concerns as discussed above. This potential discrepancy should be clarified in future documents and licensing submittals.

13. (p11) "High-consequence BDBEs are defined as those BDBEs with consequences that exceed the F-C Target."

NEI 18-04 defines high-consequence BDBEs to be those with consequences that exceed 10 CFR 50.34 dose criteria (25 rem). The white paper definition is different from that of NEI 18-04 and is less conservative. The deviation from the NEI 18-04 criterion should be explained.

In addition, on Page 19, this white paper states that "In Task 4A, each of the DBEs and any high-consequence BDBEs (i.e., those with doses above 10 CFR 50.34 limits) are examined to determine which SSCs are available to perform the RSF for each." Here, high-consequence BDBEs refers to those defined in NEI 18-04. It appears to be a discrepancy within the white paper.

14. (p11) **[[**

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]] The earlier sentence in the same paragraph states "Required Safety Functions (RSFs) are those functions necessary and sufficient to meet the F-C Target for all DBEs and high-consequence BDBEs." [[

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In addition, in other parts of the white paper, RSFs are used with referring only to DBEs and high-consequence BDBEs as used in NEI 18-04. An example is the uses of RSFs in various Tasks under Section 3.0, "Safety Classification and Performance Criteria for SSCs." Specifically, Task 4A and 5A on Page 19, which are steps to identify SR SSCs based on its RSFs, there is no discussion [[ ]] Westinghouse should reflect the approach it is taking regarding RSFs consistently throughout its documents and licensing submittals.

15. (p12) Under Task 5b: Select/Revise Safety-Related SSCs, a decision is made regarding which set of SSCs is selected to perform the RSFs for the DBE and high-consequence BDBE regions in]] It appears that a discussion on the decision to select SSCs to perform [[ ]] is missing. This discussion should be added in future submittals for completeness and consistency.

16. (p13) [[

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If there are other radiological sources other than reactors, such events could impact those sources as well as the multiple reactor modules.

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17. (p14) "The primary purpose of comparing the frequencies and consequences of LBEs against the F-C Target is to evaluate the risk significance of individual LBEs… The evaluations in this task are based on mean frequencies and mean doses for all three LBE categories. Two exceptions to this are when BDBEs with large uncertainties in their frequencies are evaluated as DBEs when the upper 95th percentile of the frequency exceeds 10^{-4}/facility-year and when AOOs with lower 5th percentile frequencies, below 10^{-2}/facility-year, are also evaluated as DBEs."

Regarding the last sentence, NEI 18-04 also states that, "An event sequence family with a mean frequency less than $5x10^{-7}$/plant-year but with a 95th percentile frequency estimate above $5x10^{-7}$/plant-year is evaluated as a BDBE." Its omission should be explained.

In the same sentence, the expression “when BDBEs with large uncertainties” is used. It is not clear why the evaluation is limited to those with large uncertainties. NEI 18-04 states that, “An LBE with a mean frequency less than 10^{-4}/plant-year with a 95th percentile above 10^{-4}/plant-year is evaluated as a BDBE and a DBE.” This criterion does not include any qualifier regarding the degree of uncertainty. The deviation from NEI 18-04 should be explained.

18. (p20) “RSFs are those safety functions that must be fulfilled to keep the DBEs within the F-C Target.”

    This sentence is not consistent with the definition for RSFs used in the white paper.

19. (p20) **[[**

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    The PDC in relation to the design criteria (e.g., RFDC) in NEI 18-04 and NEI 21-07, is a subject of ongoing discussions between the NRC staff and the industry. The NRC staff suggests that Westinghouse follow the progress of the discussions including a revision to NEI 21-07 and the development of the NRC staff’s guidance (i.e., Draft Regulatory Guide to endorse NEI 21-07).

20. (p21) **[[**

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21. (p30) **[[**

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