The U.S. Nuclear Regulatory Commission Staff's Feedback on Japan Atomic Energy Agency (JAEA) White Papers on Seismic Design Methodology for Floating Seismic Isolation System (FSIS), Validation and Verification of Seismic Analysis Methodology for FSIS-Paired Reactor (FSIS-R) Plant, and FSIS-R Plant Preliminary Standard Design Information

White Paper on "Seismic Design Methodology for Floating Seismic Isolation System (FSIS)"

1. Regulatory Guide (RG) 1.29, "Seismic Design Classification for Nuclear Power Plants" (ML21155A003), defines seismic Category I as those Structures, Systems, and Components (SSCs) that must be designed to remain functional if the Safe Shutdown Earthquake (SSE) occurs. Additionally, it states that foundations and supports should be designated as seismic Category I. Consider adding information that provides the reasoning {{ }}. In addition, consider providing additional details on how the requirements in design and quality assurance/quality control (QA/QC) differ between seismic Category I and seismic Category II.

2. In section 6, "Seismically-Induced Sloshing," table 6-1," Natural frequencies of sloshing in a sample rectangular pool," reports the sloshing frequencies for the rectangular pool that the floating structure occupies. While the pool is larger than the floating structure, the structure is large enough that it may alter the fluid dynamics in the pool and possibly change the pool's natural resonances to higher frequencies. With the assumption that the structure is anchored in the center of the pool, the open water is split into narrow channels or "gaps" on either side. The water inside these gaps will slosh independently at much higher frequencies because the effective wave lengths are heavily shortened. It may be advantageous to analyze the effective wavelengths to ensure resonant frequencies fall outside the predominant frequencies of the expected ground motions.

3. Section 3.3.2, "FSSI Analysis," states that: "Table 3-5 provides soil conditions representative of soil profiles spanning from soft to stiff ground with the range of soil conditions to be expected for the FSIS-R sites." However, table 3-5, "Soil properties used in the FSIS analysis model," appears to only have a single (relatively stiff) profile with little to no variation in dynamic soil properties.

White Paper on "Validation and Verification of Seismic Analysis Methodology for FSIS-R [Paired Reactor] Plant"

Items Discussed During the Closed Validation and Verification (V&V) White Paper (WP) Meeting

1. Section 2.3, "Conformance with Applicable Standards," of the V&V WP states that an equivalent static analysis is applied in Step 2 of JAEA's multi-step procedure, consistent with the multi-step approach in NUREG/CR-7253, "Technical Considerations for Seismic Isolation of Nuclear Facilities" (ML19050A422). However, the U.S. Nuclear Regulatory Commission (NRC) staff notes that this appears inconsistent with the NUREG/CR-7253 multi-step approach. Chapter 7, "Modeling and Analysis of Seismically Isolated Nuclear Structures," of NUREG/CR-7253 indicates that equivalent-linear modeling of isolators is not generally acceptable, except for isolators whose force–deformation relationship is

demonstrably linear across the full design demand range. Equivalent linear analysis can be used in the first step

of the multi-step method if nonlinear bearings (i.e., lead-rubber or Friction Pendulum) are used; Step 2 is a nonlinear response-history analysis of the isolated superstructure using three component acceleration time series consistent with seismic isolation design spectrum at the foundation level (the foundation in NUREG/CR-7253 corresponds to the pool structure in FSIS-R). Furthermore, the equivalent linear properties chosen for the isolators should be shown to be appropriate following the second step of the multi-step analysis. In summary, Chapter 7 of NUREG/CR-7253 does not indicate that an equivalent static analysis is appropriate for Step 2.

2. Section 3.2, “Analytical Techniques,” states that a linear acoustic formulation is used to model the fluid-structure interaction (FSI) within the cavities and orifices of the FSIS mechanism, assuming small pressure fluctuations and small structural displacements relative to the characteristic dimensions of the model. The fluid is treated as a compressible medium with acoustic pressure as the primary degree of freedom. The WP does not provide numerical or theoretical justification to support this assumption.

3. Systematic grid refinement is the cornerstone of verification processes for the solutions. The WP does not describe any sensitivity study regarding the effect of mesh density on the solutions to choose the current mesh density for the analyses.

4. In section 4.1.1(2), “Benchmark Calculation against a Type B Test Case,” the acceleration amplitude of the random waves is 2 m/s^2. There is no discussion on the rationale why this level and why only this level was used in the validation. Additionally, no rationale for the selection of 0.5 to 30 Hz was provided to support validation for the range of FSIS-R design parameters.

   Section 4.1.1(2) states that: “the specimen was excited using random waves with an acceleration amplitude of 2 m/s^2 over a frequency range of 0.5 to 30 Hz.” It is not clear whether the excitation is applied in all three directions simultaneously or one direction at a time.

   In section 4, “Validation of Fluid-Structure Interaction (FSI),” ABAQUS was validated against only two sets of test results based on random input with 2 m/s^2 amplitude, while the JAEA large scale testing program included many cases for seismic excitations with diverse frequency content and real recorded motions. The current validation may demonstrate agreement for a specific excitation (e.g., random input with 2 m/s^2 amplitude), but it is unclear whether this agreement can be maintained for seismic inputs with different frequency content, duration, amplitude, and multi-component characteristics.

5. Section 4.1.1(2) states that: “the damping values are calculated from the test results by treating the floating structure, water, air, and pool as a single vibration system. Therefore, the same damping value (3.1%) is applied to all material components of the model.” This may be an issue if 3.1 percent is also applied to other test cases or in actual plant design analysis because those situations either have a different single-valued damping (like 4.6 percent in section 4.1.2, “Benchmark 2: Seismic Isolation Effect with Cavity and Orifice (Type C)”) or have different damping values for different components in design analysis (like in RG 1.61, “Damping Values for Seismic Design of Nuclear Power Plants” (ML23284A272)).

Similarly, section 4.1.2 states: “[w]hen an orifice plate with this optimal opening diameter is installed in the air cavities of the floating structure and the maximum response displacement occurs in the floating structure, a damping effect corresponding to a damping ratio of approximately {{ }} is obtained.” Since orifice diameter, maximum response displacement, and the damping effect achieved are related, it is not clear how the orifice diameter is determined for Type C, considering the maximum response is also a function of the input motion. For the test, the maximum response displacement of {{ }} is required to achieve the {{ }} damping for the chosen orifice diameter, but the maximum response displacement was {{ }}, which led to a damping ratio of {{ }}. In the ABAQUS model, the orifice is not directly modeled, but the resulting damping ratio is directly applied to the floating structure. It’s unclear how this approach would work for different magnitudes of excitation that lead to different level of damping.

6. In section 4.2.1, “Benchmark Problem 1: Test-Scale Model,” the amplitude of the excitation for the input motion is not provided when generating the transfer function in the ABAQUS analysis. An increased excitation amplitude can lead to substantial nonlinear behavior of the FSIS, making the application of transfer functions less reliable.

   Section 4.2.2, “Benchmark Problem 2: Large-Scale Model,” mentions underwater acoustic waves but does not provide details on these excitations. In particular, it does not describe the amplitude of the excitation, which is an important factor in deciding how transfer functions in the System for Analysis of Soil-Structure Interaction (SASSI) can simulate the nonlinear behavior of the FSIS. The type of analysis in ABAQUS used to develop transfer functions is not described.

7. Section 4.2.1 concludes that: “the ACS SASSI analysis was confirmed to provide either well-agreed (<0.25 Hz) and/or conservative (>0.25 Hz) results of transfer functions in benchmark with the ABAQUS analysis.” However, as shown in figures 4-9 through 4-14, there are large differences below 0.25 Hz and beyond 0.25 Hz. There is no evidence indicating SASSI is conservative compared to ABAQUS because it predicted lower transfer functions in some instances.

   Appreciable differences in the amplification of resonant responses are observed between ACS SASSI and ABAQUS in the X and Z directions at frequencies below 0.25 Hz. The WP attributes the appreciable differences in resonant-response amplitudes between ACS SASSI and ABAQUS below 0.25 Hz to the relatively large frequency intervals used in the analysis compared with the narrow-band nature of the resonant peak. This interpretation is based, in part, on the observation that the phase at the ACS SASSI peak response was approximately 170°, rather than approximately 90 degrees (°). The WP does not provide additional evidence to demonstrate that the observed amplitude differences are primarily attributed to insufficient frequency resolution rather than differences in the underlying FSI formulations. A refined frequency sweep may be performed around the resonant frequency using sufficiently small frequency increments to capture the complete resonance peak and verify whether the ACS SASSI and ABAQUS results reach a closer agreement.

8. In section 4.2, “Verification of ACS SASSI FSI Analysis via ABAQUS Benchmarking,” two analysis models, a test-scale model and a large-scale model, were developed to verify the ACS SASSI acoustic model by benchmarking its results against ABAQUS. The WP does not elaborate the scaling effects by comparing the test-scale model to the large-scale model.

9. During the closed meeting, the NRC staff emphasized the importance that the analytical tools are valid and verified for use in FSIS-R design. For validation of ABAQUS, only transfer functions are compared against tests, while other response quantities (e.g., acceleration, displacement, and response spectra) representing the physical phenomena of FSIS are not compared. Validation based on transfer functions alone does not automatically validate other responses. For validation of SASSI, analytical results are not compared with test data but only results from ABAQUS. Comparison of ABAQUS and SASSI should not substitute for direct comparison of ACS SASSI predictions with test for validation.

10. WP section 5, "Validation of Fluid-Structural-Soil Interaction (FSSI)," describes the use of "gravity-type springs" on the free water surface to simulate the buoyancy forces acting on the submerged structure. More detail on the gravity-type springs is needed for the NRC staff to understand this modeling approach.

11. The horizontal dimensions of the four air cavities size are not provided. Considering that the platform is {{ }} and that the water depth in the cavities is {{ }}, the water in the cavities, with horizontal dimensions larger than the gaps between the platform and the pool walls, appears to be susceptible to large sloshing motion. Section 5 does not provide a discussion about how sloshing motion in the cavities is modeled and analyzed.

12. Table 4-2, "Material properties for test-scale model," table 4-3, "Material properties of large-scale model," and table 5-1, "Material properties of FSSI model," water damping is selected as {{ }}. RG 1.61 provides guidance on the 3 percent and 0.5 percent damping ratios for the impulsive mode and the sloshing mode, respectively, under the SSE for metal atmospheric storage tanks. This WP does not describe why the large mass associated with the sloshing mode also takes the damping ratio of {{ }} for impulsive mode.

13. Section 5.1(2), "Model Material Properties," states that: "the sloshing natural periods of the pool are theoretically calculated to be in the range of 20-40 seconds. The influence of the sloshing modes on the seismic response of the floating structure is therefore negligible." The WP does not elaborate why the low frequency sloshing/platform response in terms of displacement and rotation (similar in concept to uneven settlement) is not considered as part of the seismic response.

    Section 5.3.3(1), "Analysis of Varying Horizontal Gaps," states that: "[b]ecause this sloshing frequency falls well below the dominant frequency range of seismic excitation, the sloshing mode is not significantly excited and contributes negligibly to the overall seismic response of the platform." This is not consistent with the sloshing phenomena observed in actual earthquake events, which normally have frequencies much lower than the dominant frequency range of seismic excitation but still exhibit significantly large sloshing displacements. The small low-frequency excitation will pass through the soil/structure system and accumulate sloshing energy in the pool due to low sloshing damping.

14. Section 5.1(2) states: "[o]n the other hand, the damping value of 0.5 percent recommended in Table 6 of RG 1.61 for the sloshing mode is nonetheless preserved in the present actual-scale FSIS-R model, …." This statement requires clarification regarding how the 0.5 percent damping is preserved in the model.

15. Section 5.1(3), “Soil Properties,” states that the outcrop input motions on the ground were set to the outcrop surface of L11 which is the same elevation of the foundation layer of the pool structure, in lieu of the ground surface L1. This setting is on the condition that the outcrop motions on the L11 layer are conservatively the same magnitude as the ground motions on the L1 layer, in accordance with DC/COL-ISG-017, “Interim Staff Guidance on Ensuring Hazard-Consistent Seismic Input for Site Response and Soil Structure Interaction Analyses” (ML100570203), and section 3.1.3, “Embedded Structures Analyzed as Embedded Structures in the Certified Design,” of the Nuclear Energy Institute (NEI) WP “Consistent Site-Response/Soil-Structure Interaction Analysis and Evaluation” (ML091680715). However, section 3.1.3 of the NEI WP specifies the certified seismic design response spectra at the ground surface L1. The V&V WP does not elaborate on the need for this deviation and does not provide a detailed technical basis why the outcrop motions at L11 are more conservative than specifying at L1.

16. Section 5.3.2, “Problem 2: Remote Strong and Long-Period Seismic Motions,” states the transfer functions are produced at the center of the floating structures. The associated figures show only the translational responses without a description of rocking and rolling that may be more important for low frequency input.

    Based on figure 5-26, “Displacement time-history of floating structure (Chi-Chi-HF) in X direction,” figure 5-27, “Displacement time-history of floating structure (Hokkaido-LP) in X direction,” figure 5-33, “Displacement time-history of floating structure (Chi-Chi-HF) in Y direction,” figure 5-34, “Displacement time-history of floating structure (Hokkaido-LP) in Y direction,” figure 5-40, “Displacement time-history of floating structure (Chi-Chi-HF) in Z direction,” and figure 5-41, “Displacement time-history of floating structure (Hokkaido-HF) in Z direction,” the peak displacements at the top of the floater are in the range of 0.5 to 1.5 m in horizontal directions and about 0.3 m in vertical direction. The WP also does not describe the level of rocking and rolling associated with this level of translational displacements. Furthermore, the WP does not describe how significant this level of translational displacements and the associated rocking and rolling is to the performance of the FSIS-R and the plant operators during the earthquake event.

17. The WP indicates that future analyses or further validation studies for various purposes will be performed, but no detail on the plan and schedule is provided.

18. There are no test results or theoretical results for the section 5 solutions to support its purpose of validation. Therefore, section 5 is more or less a demonstration of ACS SASSI and sensitivity studies.

19. Section 5.3.3, “Problem 3: Effect of Gaps from Pool Wall and Floor,” concludes that “[o]verall, the ACS SASSI results confirm that variations in horizontal gap width—particularly within the 10 m to 20 m range—exert no significant influence on the platform's response transfer functions.” However, figure 5-45, “Transfer functions for X direction under X excitation with horizontal gap variation (low frequency range),” shows larger Hx (40 m) causes significant increase in transfer functions in the X direction around 0.05 Hz; figure 5-47, “Transfer functions for Y direction under Y excitation with horizontal gap variation (low frequency range),” shows smaller Hx (10 m) increases Y directional transfer function; and figure 5-48, “Transfer functions for Z direction under Z excitation with horizontal gap variation,” shows large changes around 20 Hz in the vertical direction.

20. Section 5.3.3(2), “Analysis of Varying Vertical Gaps,” concludes that the ACS SASSI results confirm that variations in the vertical gap noticeably affect the resonant frequencies associated with underwater acoustic modes while exerting negligible influence on overall response amplitudes. However, figure 5-53, “Transfer functions for Y direction under Y excitation with vertical gap variation (low frequency range),” shows large difference in the transfer function for Y direction under Y excitation at around 0.5 Hz.

Editorial items

The following items are editorial and were not discussed during the closed V&V WP meeting:

1. Section 1.1, “Purpose,” states that the detailed findings of the independent software developer studies, comparing ACS SASSI with ANSYS and ABAQUS for a rectangular pool and a floating platform, respectively, are provided in the appendix for the NRC staff's information. Therefore, the NRC staff does not provide comment on the appendix.

2. In section 3.2, the form of governing equation treated in ACS SASSI is different from that used in ABAQUS for acoustic element model. The WP does not elaborate on how this deviation may affect the solution. It states that: “[t]he matrix solver cannot handle unsymmetric matrices, therefore the matrices are changed to symmetric forms.” The WP does not provide a description of the ABAQUS solver for FSI and how these two formations are mathematically equivalent in structural and fluid responses over the seismic frequency range.

3. The description associated with Equation (3-1) could be improved by explaining why mass for structure (Ms) and mass for fluid (Mf) can multiply with acceleration ($L\,T^{-2}$) and the second time-derivative of pressure ($F \cdot L^{-2} \cdot T^{-2}$). A similar explanation for the structural stiffness (Ks) and fluid stiffness (Kf) would also be beneficial.

4. Section 4.1.1, “Benchmark 1: Seismic Isolation Effect with Cavity (Type B),” states that: “[i]n the FSIS system, the floating structure is designed so as to avoid sloshing frequencies, and therefore the influence of sloshing is expected to be negligible.” It would be beneficial to explain how the FSIS is designed to avoid sloshing frequencies.

5. In figure 4-1, “Analytical model – components: floating body structure,” the coordinate system has different orientations for the floating body, bottom surface of the floating body, styrofoam at the bottom of the floating body, and air inside the air cavity of the floating body, with no explanation about the significance of these variations.

6. Section 4.1.1(2) states that: “[i]n the analysis, the bolted connections between the floating body and the shaking table were modeled as constraints in accordance with the test conditions.” The NRC staff understands that the “floating body” is not bolted to the shaking table; instead, the pool structure is bolted to the shaking table.

7. Figure 4-4, “Comparison of X-direction responses for Type B,” and figure 4-5, “Comparison of Y-direction responses for Type B,” do not show enough details about the comparison due to the large limit of the vertical axis.

8. In tables 4-2 and 4-3, the damping ratio is 0.5 percent for air. A description of how this was determined is helpful.

9. For section 4.2 verification cases, there is no discussion about orifices in the air cavity.

10. For ABAQUS and ACS SASSI, the WP does not indicate if the vendor-provided V&V problems have been analyzed before using them for the analyses in this WP.

11. Section 5 does not describe orifices. The thickness of the basemat is not described, unlike the pool wall thickness ({{ }}).

12. Section 5.1(1), "Model Configuration," states that the pool basemat is modeled as solid elements, but section 5.1(2) states that the pool wall and basemat are modeled using shell elements.

13. Equation (5-2) is not consistent with the direction definitions and figure 5-8, "Scheme of applied motions and resultant motions in ACS SASSI."

14. The WP does not mention how the soil depth was determined for the model shown in figure 5-3, "FSSI analysis model with embedded pool in soil layers."

15. In figure 5-17, "Transfer function in X direction under X excitation (low frequency range)," figure 5-19, "Transfer function in Y direction under Y excitation (low frequency range)," and figure 5-21, "Transfer function in Z direction under Z excitation (low frequency range)," the transfer function at the center of the pool bottom is a horizontal line with an amplitude of one that does not resemble typical shapes of transfer functions and therefore requires clarification.

White Paper on "FSIS-R Plant Preliminary Standard Design Information"

General Observations:

The NRC staff appreciates the opportunity to review and provide feedback on JAEA's preliminary standard design as described in this WP. The advantages of pre-application engagement, however, are most fully realized when conducted in alignment with the NRC staff's recommendations, such as those set forth in appendix A, "Pre-Application Engagement Guidance" of DANU-ISG-2022-01, "Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications - Roadmap" (ML23277A139). Section A of that appendix provides various potential subjects for the submittal of pre-application topical reports (TRs), for which the NRC staff would prepare a safety evaluation with regulatory findings that could be referenced in a license application, thereby reducing the scope of the license application review. These potential subjects include principal design criteria (PDC) as well as the selection of licensing basis events and the classification and treatment of SSCs. The NRC staff notes that both of these subjects are covered in this single WP. Limiting the scope of each TR submitted to the NRC, as recommended in appendix A of DANU-ISG-2022-01, would support more robust pre-application interactions.

WP section 5, "Future Submittals," addresses plans for future submittals to the NRC, including planned WPs and TRs. The NRC staff emphasizes the importance of conducting pre-application engagement in alignment with the NRC staff's recommendations and would encourage the JAEA to update its pre-application engagement plan to better align with appendix A of DANU-ISG-2022-01.

Specific Comments:

1. The following items address the design requirements presented in section 2 of the WP:

   a. The JAEA correctly identifies the seismic classification methodology outlined in RG 1.29, as a guide for the design of the FSIS-R. Based on the information provided in the WP, the NRC staff observed that the proposed use of RG 1.29 is reasonable. RG 1.29 provides a seismic classification method that the NRC staff considers acceptable for use in identifying and classifying the features of nuclear power plants that must be designed to withstand the SSE.

   b. The WP identifies five plant-specific PDC for the FSIS-R design in addition to the set of general design criteria (GDC) provided in Title 10 of the *Code of Federal Regulations* Part 50 (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities," Appendix A, "General Design Criteria for Nuclear Power Plants." PDC 5, "Pool Hydrodynamic Envelope and Water Makeup Reliability," {{

      }}. RG 1.29 defines seismic Category I as those SSCs that must be designed to remain functional if the SSE occurs, including foundations and supports. Further clarification may be needed to justify the classification of {{ }} in accordance with RG 1.29.

   c. The WP identifies four GDC provided in 10 CFR Part 50, Appendix A, that are applicable to aspects of the FSIS-R design.

      i. The identification of criterion 2, "Design bases for protection against natural phenomena," criterion 4, "Environmental and dynamic effects design bases," criterion 13, "Instrumentation and control," and criterion 20, "Protection system functions," as applicable to aspects of the FSIS-R appears reasonable for the current maturity of the design. However, a justification may be needed for why other GDC have been omitted from this list when aspects of the GDC fall under the selection categories presented in item section 2.2.1.

      ii. Under criterion 4, it is unclear as to how the FSIS design is intended to protect against dynamic effects, particularly missiles, pipe whipping, and discharging fluids, that would otherwise be captured in the GDC {{
      }}. Because table 4-1, "Summary of reduced thickness for the RXB SC walls," shows that some wall thicknesses will be reduced by {{
      }} SMR design may need to be revised, or supported with additional justification, regarding missiles and pipe-whip effects.

2. The following comments address the overview of the FSIS-R Standard Design presented in section 3 of the WP:

   a. The WP proposes a reduction in mass only when another limiting factor is not exceeded. This justification appears reasonable, given the fluid-structure-soil interaction (FSSI) analyses provided in the seismic methodology are validated and verified to allow seismic

reduction. However, the WP proposes that the concrete basemat could be eliminated altogether in favor of steel support structures in the FSIS platform. The WP justifies eliminating the concrete basemat based on reduced seismic demand but does not address the basemat's non-structural functions. In addition, this proposed modification for weight reduction must be justified in accordance with PDC 2, wherein the FSIS platform is to perform the safety functions of a traditional in-ground concrete basemat. This deviation from the {{ }} and its safety significance to the plant should be addressed, as stated in table 3-4, "Required updates of {{ }} SDAA [standard design approval application] and conformance with SRP/DSRS in a FSIS-R SDAA."

b. A "flatbed" approach is described in section 3.3.2, "Structural Standardization and Integration," for the nuclear island (NI) floating platform but does not address the method by which the NI buildings will be affixed to the platform. It is unclear to the NRC staff whether this approach is intended only for the purpose of weight calculations and modeling the structural integrity of the platform. Any adjustments to the {{ }} design related to the integration of or affixing of these structures to the FSIS platform should be provided.

3. The following comments address the design of SSCs presented in section 4 of the WP:

a. The NRC staff notes that section 4.1, "Reactor Design," refers to the {{ }}. However, other sections in this WP refer to the {{ }}. This discrepancy should be addressed.

b. The WP states that the Class NK [Nippon Kaiji Kyokai] standard applies to the floating platform (hull structure) and the water lock. The NRC staff notes that Class NK has not been endorsed by the NRC. As such, the NRC staff will need to examine the acceptability and applicability of this standard more closely in the future. The NRC staff expects additional information on the Class NK standards being proposed, including a justification for its use. Under the NRC's 2026, memorandum of understanding with the U.S. Coast Guard (ML26096A081), the NRC will likely work with the U.S. Coast Guard to assist in its review of class rules.

c. Table 4-3 shows the loads to be considered for the FSIS platform structural evaluation.

i. Table 4-3 states that it is informed by AISC N690, "Specification for Safety-Related Steel Structures for Nuclear Facilities," and RG 1.57, "Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components" (ML12325A043). However, beyond mentioning RG 1.57 in table 4-3, the WP does not explain how RG 1.57 was applied. The NRC staff notes that RG 1.57 is also not mentioned in the references section of the WP. The NRC staff expects more information on how RG 1.57 was used.

ii. Table 4-3 also states that the {{ }}. A justification for this should be provided.

d. Table 4-4, "Load combination," shows the load combinations used to structurally evaluate the safety-related portions of the FSIS platform. The WP mentions that AISC N690 was applied, which the NRC has endorsed, with some exceptions and

clarifications, in RG 1.243, “Safety-Related Steel Structures and Steel-Plate Composite (SC) Walls for other than Reactor Vessels and Containments,” (ML21089A032). Some of these clarifications include modifications that the NRC staff has made to the NRC-endorsed version of the Load and Resistance Factor Design (LRFD) load combinations in section NB2 – the modified load combinations are shown in table 1, “Load Combinations for the LRFD Method,” of RG 1.243.

i. Load combination NB2-1 was eliminated for the structural evaluation of the FSIS platform. It is unclear to the NRC staff why load combination NB2-1 would not apply to the FSIS platform.

ii. Load combinations NB2-4 and NB2-5 use {{ }}, whereas in RG 1.243, the NRC staff has modified those combinations to use 1.6L. The NRC staff expects the departure from RG 1.243 to be justified.

iii. This list does not encompass all of the departures from RG 1.243 that are present in table 4-4. The NRC staff encourages the JAEA to review table 1 from RG 1.243 and provide justifications from the departures in all of the loading combinations that were adopted from AISC N690.

e. In section 4.2.6, “Design Consideration for Stability,” the effects of platform inclination are discussed.

i. Previous operating data from the nuclear ship *Mustu* is utilized to obtain a limit of 5° platform inclination to prevent control rod scram delays. While this provides a basis for the consideration of control rod scram behavior, additional justification, such as further testing, may be needed to demonstrate its applicability to the NuScale US460 control rod design.

ii. The discussion on tilt angles does not address considerations for other plant systems and operations. For example, in a system with 6° of freedom of motion, instrumentation accuracy and maintaining passive decay heat removal may be affected and should be evaluated accordingly.

f. Section 4.2.7, “Platform Connection to Turbine and Utilities,” discusses the use of a three-dimensional piping to be installed between the floating nuclear and turbine generator platforms. However, the cited study in this technology is based on low-temperature and low-pressure steam piping systems. Further testing may be required to adequately address the use of this technology. In addition, table 3-4 indicates that the FSIS-R SDAA chapter 3.6.1, “Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment,” and chapter 3.6.2, “Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping,” do not indicate a major update from the {{ }} despite the proposed change to major steam piping systems.

4. The NRC staff understands that the white paper’s discussion of potential water sources is not intended to constitute a comprehensive hydrologic siting evaluation, limit the scope of future hydrologic reviews, or support generic exclusion of site-specific hydrologic hazards. The NRC staff assumes that all applicable hydrologic characteristics, hazards, and transport pathways will be evaluated during the appropriate licensing review.

5. The following items (a through c) address climate-related site parameters which apply to standard design approvals (SDAs), standard design certifications (DCs), or manufacturing licenses (MLs). Corresponding site characteristics (i.e., actual conditions representative of a specific site location) would be addressed in an early site permit or in a final safety analysis report for a combined license (COL).

   a. The NRC staff recommends clearly stating where the FSIS is intended to be deployed. This could affect the context of any subsequent review comments (e.g., continental U.S. (Lower 48 States and Alaska), entire U.S. (includes Hawaii), U.S. Territories (i.e., in Atlantic and/or Pacific basins), and/or Japan only:

      i. If continental and entire U.S., site characteristics and parameters relevant to the U.S. would only apply;

      ii. If U.S. Territories are included as potential deployment sites then there are (or may be) limitations for some climate-related site characteristics and site parameters;

      iii. If Japan only or in combination with any of the above, differences in applicable Japanese and/or NRC regulations and/or regulatory guidance should be clarified or reconciled including terminology of some event types (e.g., hurricane in the Atlantic Basin vs. typhoon in the Pacific Basin).

   b. The NRC staff suggests clarifying the section 3.1.3 title, “Tornado and Hurricane Loadings,” by changing it to read “Climate-Related Site Characteristics and Site Parameters.”

      i. Other parts of the document include other climate-related parameters, for example:

         - Section 3.2.4, “Classification for FSIS-related SSCs,” item 1b, “Platform Mooring System,” refers to a “design-basis wind” which is a different value with a different recurrence interval than a design-basis (DB) tornado or hurricane wind speed – see also tables 4-3 and 4-4, and section 4.2.5, “Design Consideration for Winds and Tornados.”

         - Section 4.2.2, “Design Basis,” - see table 4-3, “Loads to be Considered,” item c4, “Design Seismic Loads,” which includes snow load, and item c7, “Snow Loads.”

         - Table 4-3, “Loads to be considered,” for “Environmental temperature load” for the FSIS platform.

      ii. The NRC staff notes that potential ice formation and its effects on design and/or performance do not appear to have been addressed (may be applicable to section 3.1.4, “Hydrology,” rather than section 3.1.3).

      iii. The NRC staff recommends stating whether certain criteria in RG 1.76, “Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants” (ML070360253), and RG 1.221, “Design-Basis Hurricane and Hurricane Missiles for Nuclear Power

Plants" (ML110940300), are applicable to the FSIS design. In either case, an explanation supporting why the criteria are or are not relevant would be beneficial:

- RG 1.76 – pressure drop and rate of pressure drop;
- RG 1.76 and RG 1.221 – given the size of the platform and buildings, is an automobile, truck, or other mobile transportation vehicle a relevant missile to be considered among the potential missile spectra;
- RG 1.221 – consider referencing NUREG/CR-7004, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants" (ML11341A102), and NUREG/CR-7005, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants" (ML11335A031), which provide additional technical bases for this RG.

iv. The above items as well as tornadoes and hurricanes are dependent on the potential deployment locations of the FSIS regardless of what reactor design it may be paired with.

v. The term {{ }} is first mentioned at PDC 4 and appears later in section 3.2.4 at item (2)a, "Classification of the Pool System – Pool Structures," and elsewhere. The effects of tornado wind and pressure characteristics are likely somewhat different compared to straight-line winds and even more so with potential hurricane winds and pressure effects. All of these phenomena would be expected to have different effects on "sloshing". Tornados and straight-line winds would tend to be shorter-term phenomena. Hurricanes, on the other hand, tend to be longer-term and sustained phenomena. Potential water removal from the pool may need to be evaluated for both tornadoes and hurricanes. Excessive rainfall associated with hurricanes or degraded systems may also produce overfilling effects on the pool and should be addressed.

c. Section 1.1, "Purpose," indicates that the FSIS may be paired with an SMR design, {{

}}." Paragraph 1 concludes by stating "…thus the description in this White Paper focuses on changes to that reactor design required by its pairing with the FSIS."

i. There are considerations other than climatological site parameters and eventual site characteristics (as well as the other information in this document) that may be involved with any such pairing including:

- meteorological (Met) data and information is different than climate-related data and information and is used as input to dispersion analyses of airborne radiological release whereas climate-related data and information is directly related to design considerations;
- for SDAs, DCs, and MLs, Met data is not site-specific unless one of these types of applications is for a specific location and would otherwise be expected to

encompass the characteristics of a potential location that a given design may be sited and operated at;

- atmospheric dispersion modeling results for accident and routine operational radiological releases are direct inputs and proportional to radiological dose calculations.

ii. A brief review of some of the building layout drawings suggests that any site parameters in the plant parameter envelope related to atmospheric dispersion (i.e., relative concentration factors, X/Qs, and/or relative deposition factors, D/Qs) and {{ }} should be reviewed at some point, pairings with other reactor designs would need to be evaluated separately.

iii. This WP does not address meteorological and atmospheric dispersion-related site parameters despite the quoted statement from section 1.1 (paragraph 1) above. As such, this initial feedback does not discuss these issues further.