



UNITED STATES
NUCLEAR REGULATORY COMMISSION
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TERRAPOWER, LLC – U.S. NUCLEAR REGULATORY COMMISSION STAFF FEEDBACK REGARDING WHITE PAPER: “PRELIMINARY CONSENSUS CODES AND STANDARDS,” REVISION 0 (EPID NO. L-2023-LRO-0045)

SPONSOR INFORMATION

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DOCUMENT INFORMATION

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Purpose the White Paper: TerraPower submitted a white paper (WP) titled, “Preliminary Consensus Codes and Standards,” Revision 0. This WP provides the consensus codes and standards (C&S) and code cases that TerraPower intends to use for the Sodium reactor design.

Action Requested: TerraPower requested U.S. Nuclear Regulatory Commission (NRC) staff feedback on the information discussed in the WP on the areas where additional information may be needed in the construction permit application (CPA) to support the proposed approach for use of a standard or code case not previously accepted by the NRC staff.

FEEDBACK AND OBSERVATIONS

The feedback and observations on this WP are preliminary and subject to change. The feedback and observations are not regulatory findings on any specific licensing matter and are not official agency positions. The feedback and observations on this WP are also not intended to be comprehensive; a lack of feedback or observations should not be interpreted as NRC staff agreement with TerraPower’s position.

INTRODUCTION

The NRC staff performed a targeted review of the TerraPower WP focusing on select consensus C&S or code cases. The NRC staff’s feedback and observations are informed by preliminary information on the Sodium design that has been obtained through various preapplication engagements and the use of these consensus C&S and code cases in prior light-water reactor

Enclosure

(LWR) or non-light-water reactor (non-LWR) regulatory applications. The NRC staff notes that the preapplication readiness assessment that TerraPower has requested (ML23304A148) will provide an opportunity for the NRC staff to provide more detailed feedback and observations on TerraPower's use and implementation of consensus C&S and code cases. During the preapplication readiness assessment and subsequent reviews of TerraPower licensing submittals, the NRC staff expects that TerraPower will describe more thoroughly how the consensus C&S and code cases are applied in the design of the Sodium reactor. This will, in turn, enable the NRC staff to conduct a more thorough review.

Feedback and Observations on the Specific Tables

TerraPower's WP outlined the consensus C&S and code cases that are proposed for use in the Sodium design using nine tables. The NRC staff's feedback and observations on the WP are organized below in a manner that parallels this structure.

Table 1: "Standards with Previous Versions Approved for Incorporation By Reference in [Title 10 of the Code of Federal Regulations (10 CFR) 50.55(a)]"

- **General Feedback and Observations** – Applicants can use consensus C&S or code cases that have not been endorsed by the NRC staff, such as consensus C&S with previous versions approved for incorporation by reference in 10 CFR, Section 50.55(a), "Codes and Standards." However, applicants should provide appropriate justification, consistent with current regulatory practice, and consistent with applicable the NRC staff requirements. Use of a more recent version of the cited standards that the NRC staff has not yet reviewed and endorsed may result in the need for the NRC staff to evaluate changes to the standard(s). TerraPower should describe any changes made to the standard as compared to any version previously endorsed by the NRC staff and provide the justification for why cited standards are still adequate to meet the NRC's regulations; this should be performed even if the proposed changes appear minor. In areas where extensive revisions were made, as compared to a previously endorsed version, the NRC staff may need to perform a detailed review to determine whether the standard is still adequate to meet applicable regulations. Use of non-NRC approved consensus C&S or code cases will be reviewed by the NRC staff on a case-by-case basis. Therefore, additional NRC staff review time and resources may be needed.

- **Specific Feedback and Observations**

Standard	NRC Feedback and Observation(s)
Institute of Electrical and Electronic Engineers (IEEE) Standard (Std.) 603-2018, “IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations”	For instrumentation and control (I&C) systems and components, an applicant can use any relevant domestic or international consensus C&S that best supports their engineering design best practices and processes. The NRC staff’s review is to ensure that systems and components are designed so that they can be manufactured, constructed, assembled, installed, and operated in accordance with established processes that ensure the achievement of the design specifications and the required level of safety and that the design meets the pertinent regulatory requirements.

Table 2: “Standards Endorsed in Trial [Regulatory Guide (RG)] 1.247”

- **General Feedback and Observations** – Use of RG 1.247 (For Trial Use), “Acceptability of Probabilistic Risk Assessment Results for Non-Light-Water Reactor Risk-Informed Activities,” (ML21235A008) and conformance to the probabilistic risk assessment (PRA) standard endorsed, with clarifications and qualifications therein, will help reduce the need for an in-depth NRC staff review of the PRA. This, in turn, will enable the NRC staff to focus their review on key assumptions and areas relevant to the application.
- **Specific Feedback and Observations**

Standard	NRC Feedback and Observation(s)
RA-S-1.4-2021, “Probabilistic Risk Standard for Advanced Non-Light Water Reactor Nuclear Power Plants”	It is acknowledged that TerraPower will use American Society of Mechanical Engineers (ASME) / American Nuclear Society (ANS) RA-S-1.4-2021 to demonstrate PRA acceptability. The NRC staff will review the applicability of supporting requirements determined by the applicant consistent with the process provided in Section 3 of ASME/ANS RA-S-1.4-2021, which is endorsed in RG 1.247 (For Trial Use).
Nuclear Energy Institute (NEI) 20-09, “Performance of PRA Peer Reviews Using the ASME/ANS Advanced Non-LWR PRA Standard,” Revision 1	The guidance in NEI 20-09, Revision 1, which is endorsed in RG 1.247 (For Trial Use) with no exceptions, provides an acceptable approach for performing a self-assessment or peer review. The NRC staff encourages the use of NEI 20-09 if a self-assessment or peer review is performed.

Table 3: “Standards Planned for NRC Endorsement in ML19309E048”

- General Feedback and Observations** – Recently revised IEEE standards can be used with appropriate justification, consistent with current regulatory practice, and consistent with applicable NRC requirements. However, use of such standards will be reviewed by the NRC staff on a case-by-case basis. Therefore, additional NRC review time and resources may be needed. In the NRC staff letter dated April 15, 2020, “Plan for Review and Endorsement of Institute of Electrical and Electronics Engineers Standards and Nomination of NRC Staff the Energy Storage and Stationary Battery Committee,” (ML19309E048), the NRC staff notes that NRC will review and consider endorsing the relevant standards. If NRC endorses these revised IEEE standards prior to submission of a licensing application, TerraPower should ensure any relevant conditions on the endorsement are addressed. Additionally, the standards listed in Table 3 seem reasonable for use in a licensing submittal.

Table 4: “Standards with Previous Versions Accepted in RG 1.138 Revision 3”

- General Feedback and Observations** – The general feedback and observations made above regarding Table 1 of the WP are applicable to Table 4.

Table 5: “Standards with Previous Versions Accepted in RG 1.54 Revision 3”

- General Feedback and Observations** – The general feedback and observations made above regarding Table 1 of the WP are applicable to Table 5. Additionally, the NRC staff will need information on why standards related to coatings applicable to LWR environments are appropriate for use in a sodium environment.
- Specific Observations**

Standard	NRC Feedback and Observation(s)
American Society for Testing Materials (ASTM) D7108-12, “Standard Guide for Establishing Qualifications for a Nuclear Coatings Specialist”	TerraPower states that the 2018 version of the standard “or most recent version 6 months prior to CPA” will be used. The specific standard year and evaluation of any changes made, as compared to previously reviewed and endorsed versions, will likely be needed to complete the review of a CPA.
ASTM D7234-21, “Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers”	The NRC staff notes that it is unclear what the implications of the future change to remove the word “adhesion” from the document are and whether the standard still aims to measure the same ability of the coating to adhere to the substrate. The NRC staff will likely need information to determine the impacts of this change.

Table 6: “Standards and Code Cases with Previous Versions Accepted in Other NRC RGs”:

- General Feedback and Observations** – The general observations made above regarding Table 1 of the WP are applicable to Table 6.

- **Specific Feedback and Observations**

Standard	NRC Feedback and Observation(s)
IEEE 323-2016, "IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations"	During an application review, the NRC staff would likely need to clarify whether this entry is International Electrotechnical Commission (IEC)/IEEE Std. 60780-323-2016, "Nuclear facilities -- Electrical equipment important to safety – Qualification," as endorsed in RG 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," Revision 2 (ML22272A602).
American Society of Civil Engineers (ASCE) 4-16, "Seismic Analysis of Safety-Related Nuclear Structures"	Pre-decisional draft RG DG-1410, "Technology-Inclusive, Risk-Informed, and Performance-Based Methodology for Seismic Design of Commercial Nuclear Plants," (ML22276A149) provides preliminary NRC positions relevant to the implementation of ASCE 4-16. The NRC staff plans to issue this draft RG for public comment in the first quarter of calendar year 2024.
IEEE 379-2014, "Standard Application of the Single Failure Criterion to Nuclear Power Generating Station Safety Systems"	The regulatory position in RG 1.53 "Application of the Single-Failure Criterion to Safety Systems," Revision 2, (ML033220006) clarifies that conformance with the requirements of IEEE Std. 379-2000, "Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems," provides methods acceptable to the NRC staff for satisfying the NRC's regulations with respect to the application of the single-failure criterion to the electrical power, instrumentation, and control portions of nuclear power plant safety systems.

Table 7: "Standards with No Previous NRC Acceptance Found in an RG"

- **General Feedback and Observations** – Applicants can use consensus C&S or code cases that have not been previously endorsed by the NRC staff. However, applicants should provide appropriate justification, consistent with current regulatory practice and consistent with applicable the NRC's regulations. Use of non-NRC approved consensus C&S or code cases will be reviewed by the NRC staff on a case-by-case basis. Therefore, additional NRC review time and resources may be needed.

- **Specific Feedback and Observations**

Standard	NRC Feedback and Observation(s)
IEEE 577-2022, "Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations and Other Nuclear Facilities"	This standard seems reasonable; however, the NRC staff recommends that TerraPower clarify if it will use IEEE 352-2016, "Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Safety Systems," which is cited in IEEE 577-2022.
NEI 20-07, "Guidance for Addressing Software Common Cause Failure in High Safety-Significant-Related Digital I&C Systems" (Note: the latest draft version was issued in May 2021)	For LWRs, a draft of Branch Technical Position 7-19, "Guidance for Evaluation of Defense in Depth and Diversity to Address Common-Cause Failure Due to Latent Design Defects in Digital Safety Systems," Revision 9, was issued for public comment on October 24, 2023 (88 FR 73051). Revision 9 has provisions related to the use of risk-informed approaches to assess common-cause failure (CCF), such as those described in NEI 20-07 (ML21130A597). The latest version of NEI 20-07 is currently under review by the NRC. For non-LWRs, the NRC staff uses the Design Review Guide, "Instrumentation and Controls for Non-LWRs Reviews," dated February 26, 2021 (ML21011A140) and informs its review based on RG 1.233, which endorses NEI 18-04, "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" (ML20091L620).
ASCE 43-19, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities"	Pre-decisional draft RG DG-1410 provides preliminary positions relevant to the implementation of ASCE 43-19 (ML22276A149). The NRC staff plans to issue this draft RG for public comment in the first quarter of calendar year 2024.
IEEE 577-2022, "Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations and Other Nuclear Facilities"	The NRC staff endorsement of IEEE 577-2022 is currently on hold. Therefore, if IEEE 577-2022 is to be used to support a licensing application, the applicant should provide justification for its acceptability. The NRC staff encourages preapplication engagements to discuss any technical or policy issues relevant to the use of IEEE 577-2022 that may affect licensing.

Table 8: “Standards with No Previous NRC Acceptance Found - Sodium Related”

- **General Feedback and Observations** – The general observations made above regarding Table 7 of the WP are applicable to Table 8.

Table 9: “Codes, Standards, and Code Cases Currently Approved by the NRC”

- **General Feedback and Observations** – The NRC staff has endorsed, with exceptions and limitations, the use of some consensus C&S and code cases developed by external organizations to describe methods that are acceptable to the NRC staff for meeting specific parts of the agency’s regulations, to explain techniques that the NRC staff uses in evaluating specific issues or postulated events, and to describe information that the NRC staff needs in its review of applications for permits and licenses.

Codes, standards, and C&S and code cases that are endorsed in the NRC staff guidance documents, such as RGs, Standard Review Plan (SRP), and Inspection Manuals, are not the NRC regulations and compliance with them is not required. Use of methods and approaches that differ from those set forth in the NRC staff guidance documents are acceptable if supported by an appropriate basis for the issuance or continuance of a permit or license by the Commission. The endorsed consensus C&S and code cases may contain references to other codes, standards, or third-party guidance documents (“secondary references”). If a secondary reference has itself been incorporated by reference into the NRC’s regulations as a requirement, then licensees and applicants must comply with that standard as set forth in the regulation. If the secondary reference has been endorsed in an NRC guidance document as an acceptable approach for meeting an NRC requirement, then the standard constitutes a method acceptable to the NRC staff for meeting that regulatory requirement as described in the specific NRC guidance document. If the secondary reference has neither been incorporated by reference into the NRC’s regulations nor endorsed in an NRC guidance document, then the secondary reference is neither a legally binding requirement nor a “generic” NRC-approved acceptable approach for meeting an NRC requirement. However, licensees and applicants may consider and use the information in the secondary reference, if appropriately justified, consistent with current regulatory practice, and consistent with applicable NRC requirements.

- **Specific Feedback and Observations**
 - In a future licensing application, TerraPower would need to confirm that all versions with parentheticals are only affirmations (i.e., no changes) of the standard years previously endorsed in RG 1.54, “Service Level I, II, III, and In-Scope License Renewal Protective Coatings Applied to Nuclear Power Plants,” Revision 3 (ML17031A288).
 - Section 2.7 of RG 1.54, Revision 3, Part C notes two exceptions not specific to ASTM standards but related to the quality assurance program requirements in 10 CFR Part 50 Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.” TerraPower will likely need to clarify if it intends to follow those exceptions.
 - NRC staff will likely need information on why standards related to coatings applicable to LWR environments are appropriate for use in a sodium environment.

Standard	NRC Feedback and Observation(s)
ASTM C795-08 (2018), "Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel"	The NRC staff notes that this standard appears reasonable to address the potential for halide-induced stress corrosion cracking caused by thermal insulation. However, the NRC staff also notes that the standard does not address some of the lessons learned from operational experience, as described in Technical Letter Report TLR-RES/DE/CIB-2019-01, "Advanced Non-Light-Water Reactors Materials and Operational Experience" (ML18353B121), of the French Phénix and Super Phénix sodium fast reactors. Specific examples include: (1) the importance of confirming the chemical compatibility of the thermal insulation with molten sodium. The piping insulation surrounding the piping in the French Phénix fast reactor mixed with molten sodium to form a corrosive amalgam; and (2) the potential for degassing of products in the thermal insulation at operating temperatures, which led to sensor malfunctions in the Super Phénix fast reactor.
ASTM D5163-16 (2021), "Standard Guide for Establishing a Program for Condition Assessment of Coating Service Level I Coating Systems in Nuclear Power Plants"	(1) NRC RG 1.54, Revision 3, contains four conditions for use of this standard. The NRC staff will likely require information related to how TerraPower satisfies these conditions. (2) NUREG-2221, Revision 0, Supplement 1, "Technical Bases for Changes in the Subsequent License Renewal Guidance Documents, NUREG-2191, Revision 1, Draft Report for Comment and NUREG-2192, Revision 1, Draft Report for Comment," (ML23180A208) contains the NRC staff rationale for determining coatings inspection intervals, including information on the types of analyses needed to support inspection interval determination.
ASTM D3911-16 (2021), "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design-Basis Accident Conditions"	RG 1.54, Revision 3, Part C, Section 2.2 lists minimum acceptance criteria to meet when using this standard. The NRC staff will likely require information related to how TerraPower satisfies these acceptance criteria.
ASTM D5144-08 (2021), "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants"	RG 1.54, Revision 3, contains two exceptions for use of this standard. The NRC staff will likely require information related to how TerraPower satisfies these exceptions.

Standard	NRC Feedback and Observation(s)
ASTM D7230-06 (2021), "Standard Guide for Evaluating Polymeric Lining Systems for Water Immersion in Coating Service Level III Safety-Related Applications on Metal Substrates"	The title of this standard indicates it is for use in water immersion applications. The NRC staff will likely require information as to why this standard is applicable in sodium immersion, if coatings are used in a sodium environment.
Electrical Power Research Institute (EPRI) TR-102260-2014, "Plant Engineering: Guideline for the Acceptance of Commercial-Grade Items in Nuclear Safety-Related Applications"	RG 1.250, "Dedication of Commercial-Grade Digital Instrumentation and Control Items for use in Nuclear Power Plants," Revision 0, (ML22153A408) is the latest NRC staff guidance regarding commercial-grade items.
IEEE 485-2010, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications"	RG 1.212, "Sizing of Large Lead-Acid Storage Batteries," Revision 2, (ML23118A344) was recently published and endorses IEEE Std. 485-2020. TerraPower may consider using the latest guidance.
IEEE 323-2003, "IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations"	RG 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," Revision 2, (ML22272A602) endorses IEC/IEEE Std. 60780-323, "Nuclear Facilities—Electrical Equipment Important to Safety—Qualification," Edition 1, 2016-02. The NRC staff will likely require information that clarifies which of the two different revisions of IEEE Std. 323 will be used and if the 2016 version is used for harsh environments and 2003 for mild environments.

Standard	NRC Feedback and Observation(s)
NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," Revision 8	As stated in the draft Interim Staff Guidance (ISG) DANU-ISG-2022-01, "Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications—Roadmap," (ML22048B546) dated May 2023, 10 CFR 50.150, "Aircraft impact assessment," requires applicants to perform the aircraft impact assessment for the CPA as well as other licensing stages and include the required information at these licensing stages based on the level of design information available at the time. The NRC staff determined that the existing guidance in this area is adequate to guide an applicant's preparation of the aircraft impact assessment. RG 1.217, "Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts," Revision 0, (ML092900004) endorses the guidance in NEI 07-13, Revision 8, as an acceptable method for use in satisfying the NRC's regulations in 10 CFR 50.150(a) regarding the assessment of aircraft impacts for new nuclear power plants.
NUMARC 93-01, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 4F	RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 4, (ML18220B281) endorses Revision 4F of NUMARC 93-01 and describes methods that are acceptable to the NRC staff for demonstrating compliance with 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants."

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