U.S. NUCLEAR REGULATORY COMMISSION STAFF FEEDBACK AND OBSERVATIONS REGARDING TERRA INNOVATUM WHITE PAPER, LTR-TINN-25-011, "PROPOSED PSAR CONTENT AND EXCEPTIONS," REVISION 0 (EPID NO.: L-2025-LRO-0036)

By letter dated June 8, 2025 (Agencywide Documents Access and Management System (ADAMS) Package Accession No. ML25159A003), Terra Innovatum Corp (TINN), submitted the white paper (WP) titled, "Proposed PSAR [Preliminary Safety Analysis Report] Content and Exceptions," to the U.S. Nuclear Regulatory Commission (NRC) staff for review. The WP summarizes proposed PSAR content to be submitted under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," for TINN's SOLO micro modular reactor (MMR). The WP also identifies differences from the safety analysis report (SAR) content recommended for a non-power reactor in NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content (NUREG-1537)" (ML042430055).

The NRC staff reviewed the WP and is providing the feedback and observations below. These feedback and observations do not constitute final agency positions. Lack of feedback or observations regarding a certain aspect of the WP should not be interpreted as an NRC agreement with TINN's position.

<u>General Feedback and Observations:</u>

1. In several locations, the WP makes reference to "NRC expectations." The PSAR should clearly distinguish between regulatory requirements and guidance.

2. Throughout the WP, the SOLO MMR is proposed as a "Research *and* Test reactor" (emphasis added). TINN indicated in its regulatory engagement plan (REP) (ML26103A340) that the intent for the first of a kind (FOAK) SOLO MMR is for prototype testing, research, and training. In its WP "Rock City Admiral Parkway [Illinois] Site Characteristics Preliminary Analysis" (ML25333A003), TINN stated that the FOAK SOLO reactor will function as a low-power, test-scale facility providing research and performance data for advanced microreactor systems." The SOLO MMR cannot be licensed as both a research and test reactor and should instead be identified by the applicable term. A definition for non-power reactors is provided in 10 CFR 50.2, "Definitions," which is subdivided into testing facilities, research reactors, and commercial or industrial non-power reactors. Paragraph (2) of that definition states that a non-power reactor may be "[a] research reactor, which is a non-power production or utilization facility that is a nuclear reactor licensed under § 50.21(c):

    (i) For which a safety assessment demonstrates accident radiation doses consistent with § 50.34(a)(1)(i); and

    (ii) That is not a testing facility.…"

   A definition of testing facility is also provided in 10 CFR 50.2, which states that a testing facility "means a non-power production or utilization facility that is a nuclear reactor licensed under § 50.21(c) or § 50.22 for which:

    (1) Analyzed accident radiation doses are in excess of the dose criterion for facilities not subject to 10 CFR part 100 set forth in § 50.34(a)(1)(i); or

(2) The Commission determines that the design, operation, or use and the associated risk warrant classification as a testing facility."

The WP states that the FOAK SOLO microreactor will provide research and performance data, but TINN has not yet provided details on its intended research programs. Additionally, if the FOAK SOLO reactor is intended to be a research reactor, TINN should include information to demonstrate that accident radiation doses are consistent with 10 CFR 50.34(a)(1)(i), which states that "[f]or non-power production or utilization facilities not subject to 10 CFR part 100, the assessment must provide an evaluation of the applicable radiological consequences that demonstrates with reasonable assurance that any individual located in the unrestricted area following the onset of a postulated accident, including consideration of experiments, would not receive a radiation dose in excess of 1 rem (0.01 Sv) total effective dose equivalent (TEDE) for the duration of the accident." If TINN demonstrates that the SOLO microreactor will be useful in the conduct of research, and that accident radiation doses are consistent with 10 CFR 50.34(a)(1)(i), it may be considered a research reactor.

3. In each chapter outline, TINN provides a list of sections under a "NUREG-1537 Expectations" heading. It is unclear whether the listed sections are intended to reflect TINN's proposed sections or those suggested in NUREG-1537, as the listed sections do not always correspond to NUREG-1537, but in some cases where NUREG-1537 section titles are not applicable to TINN's SOLO design, the section titles have not been modified. Feedback is provided assuming the listed sections are those proposed for TINN's PSAR as modified by the "Recommended Exceptions or Deviations" section for each chapter.

4. If TINN plans to submit a construction permit (CP) application prior to receiving safety evaluations for topical reports (TRs) intended to be referenced in the PSAR, TINN should identify information in the CP application that is pending evaluation in a separate TR. TINN should also be aware that CPs cannot be issued without all referenced TRs' reviews being completed and all applicable limitations and conditions within those TRs addressed.

5. In accordance with 10 CFR 50.34(a)(8), the PSAR shall include an identification of those structures, systems, or components (SSCs) of the facility, if any, which require research and development (R&D) to confirm the adequacy of their design; and identification and description of the R&D program which will be conducted to resolve any safety questions associated with such SSCs; and a schedule of the R&D program showing that such safety questions will be resolved at or before the latest date stated in the application for completion of construction of the facility. The WP did not address information related to an R&D program of this type. The PSAR should address any R&D required to confirm the adequacy of the design or resolve safety questions, or state that no R&D of this type is required.

6. Throughout the WP, TINN includes references to risk-informed approaches (e.g., Nuclear Energy Institute (NEI) 18-04, "Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development"). It is the NRC staff's understanding based on pre-application interactions that TINN's safety analysis is intended to be deterministic (e.g., pre-submittal slide package on safety functions and SSC safety classification methodology (ML26088A011)). Ensure

methodology and terminology used throughout the PSAR is consistent with the intended safety analysis approach.

7. The proposed PSAR outline does not include information related to TINN's unique transportation and logistics plans. While transportation packaging is addressed separately under 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," the PSAR should demonstrate that the SSC design bases are unaffected by transportation to the site (i.e., the reactor can be installed and operate safely following transportation) to ensure compliance with 10 CFR 50.34(a)(4).

8. Following the chapter and section numbering of NUREG-1537 to the maximum extent practical would enhance clarity during the NRC staff's review of the PSAR.

9. Several sections of the WP state that content will be streamlined. In general, if TINN is excluding information required by regulation, it must follow the applicable regulations for requesting and justifying an exemption. If excluding information contained within NUREG-1537, the PSAR should demonstrate how the underlying regulations are met.

Specific Feedback and Observations:

Chapter 1: The Facility

In this chapter, NUREG-1537 calls for an executive summary and descriptions of principal safety considerations, the general facility, shared facilities, comparisons with similar facilities, summary of operations, Nuclear Waste Policy Act (NWPA) compliance, and facility modification and history.

As detailed below, the WP addresses some of these elements through the description of a sealed, helium-cooled MMR design featuring a monolith and integrated radiological containment (IRC), no shared utilities, an emergency planning zone (EPZ) at the operational boundary, passive decay heat removal. TINN also addresses non-applicable items of NUREG-1537.

PSAR section 1.1, "Summary Description"

- This section appears to be generally aligned with NUREG-1537, section 1.1, "Introduction."
- While the WP includes "major systems" in this section, it may be more appropriate to include systems information in PSAR section 1.2, "Facility and Site Description." The level of detail on systems and equipment appears comparable with that outlined in NUREG-1537, section 1.3, "General Description of the Facility."

PSAR section 1.2, "Facility and Site Description"

- This section appears to be generally aligned with NUREG-1537, section 1.3, "General Description of the Facility."
- Without further detail, it appears that "shared services" may be more appropriate to include in PSAR section 1.4, "Interfaces with Other Facilities."

- The WP states under “Recommended Exceptions or Deviations” that environmental and geophysical detail will be streamlined unless required for dose/accident analysis. Streamlining this type of information in chapter 1 is generally acceptable. While the design may reduce certain risks, the PSAR must still provide sufficient site and facility description to support accident and dose analyses, as well as to demonstrate compliance with regulatory requirements (e.g., 10 CFR Part 100, if applicable). If the PSAR excludes information required by regulation, it must follow the applicable regulations for requesting an exemption. Any streamlining or omission of NUREG-1537 content should be justified, and all information necessary for the NRC staff’s evaluation of siting, environmental impacts, and accident consequences must be included or referenced.

PSAR section 1.3, “Identification of Applicant and Contractors”

- The section appears to be generally aligned with portions of NUREG-1537, chapter 1, but appears to be more appropriate in section 1.1, “Introduction.”

PSAR section 1.4, “Interfaces with Other Facilities”

- This section appears to be generally aligned with NUREG-1537, section 1.4, “Shared Facilities and Equipment.”

- See feedback on “shared services” under the feedback for PSAR section 1.2 of this document.

- The WP also states: “There are no shared or interfacing facilities; the reactor is self-contained. Avoids unnecessary qualification of nonexistent external dependencies.” This appears to conflict with “shared services” information being included in section 1.2. The PSAR should clearly address any interface with external facilities or services.

PSAR section 1.5, “Quality Assurance”

- This section does not appear to align with any particular section of NUREG-1537, chapter 1, but including a brief summary of the quality assurance (QA) program in chapter 1, is generally acceptable.

- The WP states that it will “[p]rovide summary reference to vendor QA program aligned with 10 CFR Part 50, Appendix B, and [American National Standards Institute/American Nuclear Society (ANSI/ANS)] ANSI/ANS-15.8. Full detail not needed in PSAR; can be referenced or deferred to OLA/FSAR.” It is unclear to the NRC staff whether “vendor” in this instance refers to TINN or to vendors of SSCs. Additionally, NUREG-1537 references ANSI/ANS-15.8, “Quality Assurance Program Requirements for Research Reactors,” as an NRC-acceptable method to satisfy the QA description requirement under 10 CFR 50.34, “Contents of applications; technical information.” Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” of 10 CFR Part 50, is not directly mandated as written for research reactor facilities; instead, compliance with ANSI/ANS-15.8 (or equivalent) is an acceptable way to meet the QA requirements embedded in 10 CFR 50.34 for research reactor licensing. Additionally, TINN’s TR “SOLO Project Quality Plan,” Revision 0 (ML25257A012), describes a QA program aligned with ANSI/ANS-15.8.

The PSAR should clearly refer to the intended QA program for the FOAK SOLO MMR.

PSAR section 1.6-1.8, “Regulatory Framework, Conformance with NUREG-1537, and Departures”

- Including this information in chapter 1 is generally acceptable.

Other:

- The WP appears to omit information outlined in NUREG-1537, section 1.2, “Summary and Conclusions on Principal Safety Considerations,” which states that applicants should briefly state the safety criteria, the principal safety considerations, and the resulting conclusions. This information is expected in chapter 1.

    - The PSAR should include explicit principal safety conclusions tied to quantitative limits (dose, temperature, shutdown margin) that will later appear in chapters 4, 5, 6, 11, 13.

    - The PSAR should provide a concise summary table of principal safety limits and defensive features (e.g., maximum fuel temperature, negative reactivity coefficients, reactor protection system (RPS) trip functions, passive heat removal capacity).

- The WP appears to omit information outlined in NUREG-1537, section 1.5, “Comparison with Similar Facilities,” which states that applicants should briefly describe the principal similarities to other facilities, particularly those either licensed by the NRC or U.S. Department of Energy (DOE). This information is expected in chapter 1.

- The WP appears to omit information aligned with NUREG-1537, section 1.6, “Summary of Operations.” While the WP does include “core purpose” in section 1.1, the WP does not appear to include further information on planned reactor operations or experimental programs. This information is expected in chapter 1.

- The WP appears to omit information aligned with NUREG-1537, section 1.7, “Compliance with the Nuclear Waste Policy Act of 1982.” This information is expected in chapter 1.

- The WP appears to omit information aligned with NUREG-1537, section 1.8, “Facility Modifications and History.” The omission of this information is appropriate for a newly constructed facility.

Chapter 2: Site Characteristics

In this chapter, NUREG-1537 calls for a description of the geographical, geological, seismological, hydrological, and meteorological characteristics of the site and vicinity in conjunction with present and projected population distributions, industrial facilities and land use, and site activities and controls.

In its WP, TINN touches on geography and demography, nearby industrial, transportation, and military facilities, meteorology, hydrology, geology, seismology, geotechnical engineering. For several of these topics, TINN proposes to streamline the information provided based on the small facility footprint and resilience of the design to environmental factors.

PSAR section 2.1, “Geography and Demography”

- The WP states that “Population distribution analysis can be streamlined due to [emergency planning zone (EPZ)] constrained to the operational boundary and inherently small source term.” The NRC staff noted that even with a small source term and limited EPZ, population distribution information is required to support accident and dose analyses, and, if applicable, to meet 10 CFR Part 100 site evaluation requirements.

PSAR section 2.2, “Nearby Industrial, Transportation, and Military Facilities”

- The WP states that a qualitative discussion of potential hazards is sufficient. The NRC staff noted that sufficiency of qualitative hazard information will be dependent on site-specific characteristics and the detailed design. NUREG-1537 outlines guidance for, at least, a basis (e.g., traffic density, flight paths, structures) that may be inputs to chapter 13.

- The WP states that the “[m]monolith provides physical protection against aircraft impact; aircraft risk assessment is not required.” While 10 CFR 50.150, “Aircraft impact assessment,” which pertains to the impact of a large commercial aircraft, is not applicable for non-power reactor applicants, the PSAR should still assess transportation activities near the site for potential relevance to the safety analysis of the reactor. If TINN determines that aircraft impact poses a credible risk and credits the monolith for physical protection during an impact, an analysis demonstrating its robustness during an impact must be provided.

PSAR section 2.3, “Meteorology”

- The WP states: “Sections can be streamlined. No significant dependence on meteorological factors for safety functions. The ultimate heat sink is atmospheric convection, independent of local climate variability.” TINN will be expected to sufficiently provide meteorological information for the site and its surrounding areas irrespective of the facility design because meteorological information is not only relevant to SSC performance of safety functions, it’s also used for dispersion analyses.

PSAR section 2.4, “Hydrology”

- The WP states: “Streamline - no reliance on surface water or groundwater; SOLO MMR is hydrologically independent. No pool leakage. No core melt. The effect of potential floods is limited. Bounding analysis or justifications to cover these aspects can be sufficient.” The NRC staff noted that hydrologic information, similar to meteorological information, will be required for analyses of potential releases to the environment.

PSAR section 2.5, “Geology, Seismology, and Geotechnical Engineering”

- The WP states: “Provide focused analysis to confirm seismic adequacy of the Monolith and structural supports. Other geotechnical topics can be addressed briefly where they do not affect safety margins.” Typically, section 2.5 of a PSAR will detail the seismic and geologic characteristics of a site and the surrounding region, while section 3.4 provides analyses of the adequacy of SSCs under seismic loads, as described in NUREG-1537. The SOLO PSAR section 2.5 description of the WP appears to align with NUREG-1537, but the information under the “Recommended Exceptions or Deviations” heading appears more appropriate for PSAR chapter 3. The NRC staff noted that seismic adequacy should be demonstrated not only for the monolith and structural supports, but for all SSCs required to maintain the necessary safety function if a seismic event should occur.

Other:

- The WP states that various sections (e.g., population distribution, meteorology, hydrology, geology, seismology, and geotechnical engineering) can be streamlined or focused. In general, if TINN is excluding site information required by regulation, it must follow the applicable regulations for requesting an exemption.

- Minimum datasets and design-basis extremes for wind, temperature, snow and ice loads, tornado pressure differential, storm surge and probable maximum flood (PMF) should be included in the PSAR as these will act as inputs to feed structural, dispersion, and heat rejection analyses.

- TINN could consider site-agnostic bounding meteorological and hydrological envelopes (e.g., wind and snow, low wind high temperature for convection, PMF for local flooding resilience) and air traffic screening consistent with NUREG-1537 guidance; however, TINN would also need to document how these external envelopes propagate to chapter 3 loads and chapter 13 dispersion limits.

<u>Chapter 3: Design of Structures, Systems and Components</u>

In this chapter, NUREG-1537 calls for the applicant to identify and describe the principal architectural and engineering design criteria for the SSCs required to ensure reactor facility safety and protection of the public. The material presented should emphasize the safety and protective functions and related design features that help provide defense in depth against uncontrolled release of radioactive material.

The WP states that this chapter will include the design bases and design features of SSCs important to safety, a summary of SSCs important to safety, and design considerations related to meteorological, water, and seismic damage.

PSAR section 3.1, “Design Criteria”

- The WP states that SSC classification, albeit deterministic, can be aligned with risk-informed, performance-based (RIPB) principles. The methodology and terminology used throughout the PSAR should be consistent with the intended safety analysis approach. See the previous feedback on combination of risk-informed and deterministic methodologies.

- The WP states that codes and standards are applied selectively. The PSAR should address the requirements of 10 CFR 50.55a, “Codes and standards,” as applicable. The PSAR should include explicit design criteria lists mapping SSCs to applicable codes (e.g., American Society of Mechanical Engineers (ASME) III for any pressure boundary, American Concrete Institute/American Institute of Steel Construction (ACI/AISC) for concrete and steel), environmental qualifications (as applicable), and surveillance requirements for technical specifications (TS).

PSAR section 3.2, “Meteorological Damage”

- The WP states “Streamline section - Monolith provides inherent protection against wind, tornado, snow, ice, and lightning hazards. No credit is taken for emergency power or weather-sensitive active systems.” The PSAR will be expected to sufficiently demonstrate that the design is resilient to meteorological damage with supporting data and analyses.

PSAR section 3.3, “Water Damage”

- The WP states: “Section can be minimized - no reliance on water-based cooling; no vulnerable water-bearing SSCs within safety boundary; reactor design is inherently water-independent.” The PSAR will be expected to sufficiently demonstrate that the design is resilient to water damage with supporting data and analyses, which includes that from external events such as precipitation or flooding.

PSAR section 3.4, “Seismic Damage”

- The WP states an intent to provide a focused seismic design basis and to use a performance-based seismic analysis rather than strictly deterministic approach. It is not clear what is meant by “performance-based seismic analysis.” Because the document describes this approach as “instead of strictly deterministic,” it suggests that a risk-informed methodology may be intended. If so, please refer to the previous feedback regarding the distinction between an RIPB framework and a deterministic approach. If pursued, the performance-based seismic analysis would ideally receive the NRC’s approval prior to the CP application submission. If that is not possible, the analysis methodology will need to be reviewed by the NRC staff in parallel with the CP application, which may prolong the CP application review.

- For seismic considerations, the PSAR should provide a design basis event envelope and demonstrate functional claims (e.g., maintain passive heat path, RPS logic availability) under seismic loads. NUREG-1537 references ANSI/ANS-15.7 to establish criteria for acceptable seismic performance.

PSAR section 3.5, “Systems and Components”

- PSAR section 3.4, “Systems and Components,” is stated to include a summary of principal systems and components important to safety. This section should also include the design bases for the systems and components required to function for safe operation and shutdown, including the conditions important for reliable operation (e.g., dynamic and static loads, number of cyclic loads, vibration, wear, friction, strengths of materials, and effects of radiation and temperature).

Other:

- The PSAR should ensure the clear and consistent use of the terms safety-significant, important to safety, and safety-related when classifying SSCs.

- While the transportation package approval will be addressed separately as required by 10 CFR Part 71, “Packaging and Transportation of Radioactive Material,” the PSAR should demonstrate that the SSC design bases are unaffected by the transportation to the site (i.e., the reactor can be installed and operate safely following transportation).

<u>Chapter 4: Reactor Description</u>

In this chapter, NUREG-1537 calls for the applicant to discuss and describe the principal features, operating characteristics, and parameters of the reactor. NUREG-1537 states that these analyses support the conclusion that the reactor is conservatively designed for safe operation and shutdown under all credible operating conditions.

In the WP, the description of the information to be included generally aligns with that provided in NUREG-1537. Specifically, the WP states that this chapter will include design and analyses of the reactor core components, design features ensuring structural integrity and radiation protection, design of radiation shielding, and the nuclear design details such as kinetics and core physics.

PSAR section 4.1 “Summary Description”

- The summary description information appears to be generally aligned with NUREG-1537. Summary information may be streamlined, but it should briefly address all the reactor features outlined in NUREG-1537, section 4.1.

PSAR section 4.2, “Reactor Core”

- Fuel

    - The WP states: “Standard [light-water reactor (LWR)] UO_2 fuel, well-characterized; limited need to repeat industry-standard fuel qualification history.” Reference to existing fuel qualification is generally acceptable, however, the PSAR should include appropriate justification for why the existing fuel qualification bases are applicable to the SOLO design and conditions. Please refer to the NRC staff’s feedback (ML26027A159) provided in response to TINN’s WP, “Design Considerations on Reactor Core (Fuel) at Nominal Conditions,” Revision 0 (ML25159A003).

- Control Mechanisms

  - The WP states: "SOLO MMR uses diverse reactivity control mechanisms; structure section to document differences from conventional rod-based designs." This section should include a detailed description of each reactivity control mechanism, including its safety function, design, materials, actuation, and performance under all operating and accident conditions. If referring to existing design information or data related to conventional rod-based designs, the PSAR should include appropriate justification for why the existing information is applicable to the SOLO design and conditions.

- Moderator and Reflector

  - This section should provide a description of the moderator and reflector, including materials, configuration, compatibility with the core environment, and analysis of radiation damage and temperature effects.

- Neutron Startup Source

  - The WP states: "Standard startup source - existing qualification experience can be referenced." Reference to standard startup source qualification is generally acceptable, but the PSAR should include appropriate justification for why the existing qualifications are applicable to the SOLO design and conditions.

- Core Support Structure

  - This section should describe the monolith and internal support structures, including their design basis for all loads (e.g., seismic, thermal, operational), materials, and how they ensure core alignment and stability.

PSAR section 4.3, "Reactor Tank or Pool"

- The omission of this section appears appropriate as the SOLO design does not include a tank or pool.

PSAR section 4.4, "Biological Shield"

- The WP states that the "[s]hielding function [is] provided entirely by the Monolith; detailed shielding calculations referenced to chapter 11," and that the "[s]hield test program [is] aligned with [Regulatory Guide (RG)] 2.1 where applicable to graphite-based shielding approach." This information description appears appropriate, however the NRC staff noted that RG 2.1, "Shield Test Program for Evaluation of Installed Biological Shielding in Research and Training Reactors," was withdrawn in 2009 and RG 1.69, "Concrete Radiation Shields and Generic Shield Testing for Nuclear Power Plants," encompasses applicable material previously endorsed in RG 2.1. See 74 FR 26893, June 4, 2009.

PSAR section 4.5, “Nuclear Design”

- The WP states: “Focus on steady-state operation only - no pulsing mode. No load follow or power maneuvering.” The NRC staff noted that this section should also address transients.

- Section 4.5 of NUREG-1537 also includes within subsection 4.5.1, “Normal Operating Conditions,” a discussion of the administrative and physical constraints to prevent inadvertent addition of positive reactivity. This information appears absent from this section of the WP and should be addressed in the PSAR.

PSAR section 4.6, “Thermal-Hydraulic Design”

- The WP states: “Demonstration of adequate cooling and thermal margins under all operating and transient conditions.” To support this claim, the analytical methods used for these evaluations should be described in sufficient detail. Specifically, the computer codes should be identified by name and type, with a clear explanation of how they are applied and evidence of their validity based on experimental data or confirmed predictions for operating non-power reactors. In addition, validated methods (including codes, correlations, and associated uncertainties) should be provided for helium heat transfer, conduction and convection pathways, and decay heat removal analyses. Peak fuel temperature limits and the corresponding thermal margins should also be clearly defined and documented.

- The PSAR should address channel-level heat-transfer and natural circulation evidence under anticipated operational occurrences (AOOs) and design basis accidents (DBAs) (including depressurization and flow blockage) consistent with guidance in NUREG-1537, chapter 4 and chapter 13.

Other:

- The NRC staff noted that helium injection is listed in multiple places in this WP as a means of shutdown. Based on other TINN submittals (e.g., principal design criteria (PDC) TR (ML25159A013)) the helium injection system will not be credited as a means of shutdown. The PSAR should clearly identify the appropriate system function in this chapter, and others that may be affected (e.g., chapters 4, 5, 6, 7, 13, and 14).

Chapter 5: Reactor Coolant Systems

In this chapter, NUREG-1537 calls for the applicant to give the design bases, descriptions, and functional analyses of the reactor coolant systems. NUREG-1537 states that the discussions should include all significant heat sources in the reactor and should show how the heat is safely removed and transferred to the environment.

The WP states that this chapter will provide the design bases, descriptions, and functional analyses of the reactor coolant systems, and demonstrate how the reactor safely removes fission and decay heat under all operating and accident conditions.

PSAR section 5.1, “Summary Description”

- The summary description information appears to be generally aligned with NUREG-1537.

PSAR section 5.2, “Primary Coolant System”

- The information provided on the PSAR content related to the primary coolant system appears limited (e.g., the WP states that no forced circulation is required for decay heat removal, and that no water system components are required, but TINN does not state whether coolant circulation is forced under normal conditions, and which components will be used for forced circulation if so). TINN should review NUREG-1537, section 5.2, and ensure that the information suggested is provided in the PSAR as applicable to the SOLO design (e.g., description of radiation monitors or detectors incorporated into the primary coolant system and discussion of their functions; discussion of leak detection and allowable leakage limits, if any).

PSAR section 5.3, “Secondary Coolant System”

- The WP does not explicitly identify whether the SOLO design includes a secondary cooling system. If a secondary cooling system is included, the details outlined in NUREG-1537, section 5.3, should be included in the PSAR.

PSAR section 5.4, “Primary Coolant Cleanup System”

- The WP states “Not applicable in water-based sense. Helium gas treatment skid ensures gas quality - addressed in [instrumentation and control (I&C)] and auxiliary system discussions.” The PSAR should contain an appropriate level of detail on the helium gas treatment skid’s coolant cleanup capability in this section.

PSAR section 5.5, “Primary Coolant Makeup Water System”

- The WP states: “Not applicable - no water-based primary system.” The PSAR should indicate whether an analogous helium makeup system is included and provide a comparable level of detail on the system as suggested by NUREG-1537, for water-based makeup systems, if so.

- The WP states that adequate cooling can be achieved by natural convection with heat rejected through monolith vents. The PSAR should clearly demonstrate using supporting analyses and validated methods that this pathway can provide sufficient cooling to maintain acceptable fuel and cladding temperatures.

PSAR section 5.6, “Nitrogen-16 Control System”

- It appears appropriate to omit NUREG-1537, section 5.6, “Nitrogen-16 Control System.”

PSAR section 5.7, "Auxiliary Systems Using Primary Coolant"

- The WP states that all other systems (I&C cooling, structural cooling) are independent and isolated from the helium boundary. The PSAR should provide sufficient detail to justify this statement.

Other:

- For sections of NUREG-1537 that assume water as a primary coolant, the PSAR should provide an appropriate level of detail for the analogous helium system in the SOLO design (e.g., helium gas processing skid in lieu of a conventional primary coolant cleanup system; helium valves in lieu of water valves; helium makeup system in lieu of primary coolant makeup water system; etc.).

- The PSAR should include a quantitative capacity of the passive pathway, vent geometry, natural-convection drivers (temperature delta, buoyancy, etc.), flow resistances, external ambient envelopes, blocked-vent robustness, and time to reach safe stable temperature under multiple initiating events (loss of flow accident (LOFA) and loss-of-coolant accident (LOCA) equivalents for helium-cooled systems).

- The PSAR should include a heat-rejection performance analysis with worst-case meteorology and obstructions with minimum required vent free area, stack effects, and sensitivity studies. The evaluations should cross-reference the same limits to engineered safety features (ESFs) in PSAR chapter 6, TS in PSAR chapter 14, and other applicable chapters.

<u>Chapter 6: ESFs</u>

In this chapter, NUREG-1537 calls for the applicant to describe ESFs, defined as active or passive features designed to mitigate the consequences of accidents and to keep radiological exposures to the public, the facility staff and the environment within acceptable values. NUREG-1537 states that ESF systems must be designed to function for the range of conditions from normal operation through accident conditions.

The WP states that this PSAR chapter will provide the description, design bases, and analyses of ESFs used to mitigate the consequences of postulated accidents and ensure that radiological exposures remain within acceptable limits. The WP states that the IRC and monolith will be intended to fulfill containment and confinement functions.

PSAR section 6.1, "Summary Description"

- The PSAR should include simple block diagrams and drawings to show the location, basic function, and relationship of each ESF to the facility, as suggested by NUREG-1537, section 6.1.

PSAR section 6.2, "Detailed Descriptions"

- Confinement & Containment

    - The WP states that no HVAC-based negative pressure confinement is credited or required, and that the sealed monolith and IRC together provide an integrated radiological containment function. The WP states: “Venting pathways (if any) will be passively filtered and demonstrated to meet regulatory dose limits.” The PSAR should clearly identify the existence and locations of venting pathways.

  - The PSAR should clearly define the role of the monolith in achieving containment and/or confinement and should justify the crediting of the monolith in those functions, if applicable.

  - While not included in this WP, TINN’s PDC TR includes PDC 16, “Containment design,” which indicates that TINN will leverage a functional containment approach. If intending to credit functional containment, TINN should review SECY-18-0096, “Functional Containment Performance Criteria for Non-Light-Water Reactors” (ML18114A546), as approved by the Commission in a staff requirements memorandum (ML18338A502), and address functional containment performance criteria in the PSAR.

- Emergency Core Cooling System (ECCS)

  - The WP states that no separate ECCS or water-based injection systems are required. TINN includes statements in the outlines of other PSAR chapters related to a helium injection system. The PSAR should clearly indicate whether the helium injection system will serve an ECCS-like role and if so, provide the appropriate level of detail on its design and analysis. Additionally, in the event of a helium leak or complete loss of coolant - which is generally a credible scenario - if the design relies only passive heat removal, the PSAR should provide clear analyses and supporting evidence demonstrating that the proposed passive cooling pathway can reliably and efficiently remove decay heat and maintain acceptable fuel temperatures under such conditions. See the related feedback in the “Other” section of feedback on PSAR chapter 4.

  - The heat removal function and pathways of the IRC and monolith should be described in detail in this section.

Other:

- The PSAR should provide sufficient details on structural and leakage performance bases for the monolith and IRC under seismic, depressurization, fire, and impact events, including classification and TS surveillances (e.g., leak-tightness).

- If “venting pathways (if any) are passively filtered,” TINN should specify filter media, efficiency, iodine/FP retention, and pressure drop, and describe how this is credited in PSAR chapter 13 doses.

- The PSAR should provide an ESF functional analysis: boundary integrity curves, allowable leak rates, passive filter performance, and link to accident dose results and TS limiting conditions of operation (LCOs) and surveillances.

<u>Chapter 7: Instrumentation and Control Systems</u>

In this chapter, NUREG-1537 calls for the applicant to discuss the design and operating characteristics of the I&C systems. Sufficient information should be included to explain the design criteria and bases, and to discuss the functional and safety analyses of the I&C subsystems, generally comprised of the reactor control system (RCS), process instruments, the RPS, instruments to initiate operation of ESFs, radiation safety monitoring systems, and approximate ranges of failures. NUREG-1537 further states that the applicant should discuss the functional requirements, design criteria and bases, system descriptions, system performance analyses, and the bases of technical specification limiting safety system settings (LSSSs), LCOs, and surveillance requirements for the I&C systems.

The WP states that this chapter will describe the I&C systems, their design bases, performance analyses, and relationship to reactor safety. The WP states that this chapter will include details on the design of I&C systems, RCS, RPS, ESF actuation systems, control console and display instruments, and radiation monitoring systems.

PSAR section 7.1, “Summary Description”

- The WP notes both the RCS and RPS functions, but the PSAR should also include a general description of the ESF actuation system (if applicable), the control console and display instruments, radiation protection instruments, and the human-machine interface (HMI) principles used in the location of I&C components.

PSAR section 7.2, “Design of I&C Systems”

- The description of information to be provided appears generally aligned with NUREG-1537, section 7.2, “Design of Instrumentation and Control Systems.”

- The WP states: “Quality Assurance per applicable parts of 10 CFR Part 50 Appendix B and ANSI/ANS-15.8,” while TINN’s proposed chapter 12, “Conduct of Operations,” references only ANSI/ANS-15.8 and not 10 CFR Part 50, Appendix B. The PSAR should be consistent when discussing QA programs.

- TINN will need to justify why no traditional seismic or harsh environment qualifications are required for many I&C components beyond saying that a passive safety design is sufficient.

PSAR section 7.3, “Reactor Control Systems”

- The description provided by TINN on NUREG-1537 expectations for this section, “Design and Operation of the Reactor Control System (RCS),” appears high level. The PSAR should include the content described by NUREG-1537, section 7.3, “Reactor Control System,” such as descriptions of subsystems, relation to the design criteria and design bases described in PSAR section 7.2, and relation to TS requirements.

PSAR section 7.4, “Reactor Protection Systems”

- The WP states: “[s]cram functions actuate passive safe configurations (e.g., insert control plates, actuate absorber mechanisms, enable He-3 injection).” These systems are not passive if they require actuation. If this is true, the language in the PSAR must conform to this aspect of the design. Additionally, please see previous feedback related to clarity of the role of the helium injection system. If He-3 injection is removed as a shutdown method, the PSAR should include updated RPS logic and shutdown diversity, define LSSS setpoints (flux, temperature/pressure, helium boundary status) and acknowledge fail-safe insertion for absorbers.

- The WP states that there are “[n]o water level trips required (helium-cooled design).” The PSAR should address any trip points for the analogous helium coolant systems.

PSAR section 7.5, “Engineered Safety Features Actuation Systems”

- The WP states: “ESFs actuated through passive features; active ESF actuation systems not required - Monolith and IRC provide primary protective barrier.” These systems are not passive if they require actuation. If this is true, the language in the PSAR must conform to this aspect of the design. See related feedback on PSAR section 7.4.

PSAR section 7.6, “Control Console and Display Instruments”

- The WP states that the “[c]ontrol console and HMI [are] designed for remote monitoring and control capability, with secure and cyber-protected architecture.” TINN has not yet engaged with the NRC staff in detail on the potential for remote control capability. If this capability is intended for the FOAK SOLO reactor, TINN should engage with the NRC staff to understand policy considerations associated with remote control capability. The PSAR should clearly state whether the intended control locations for the FOAK SOLO reactor and whether control capability for the FOAK SOLO reactor is intended to include remote control.

PSAR section 7.7, “Radiation Monitoring Systems”

- The WP notes that monitors provide input to both RPS and operator displays. NUREG-1537, section 7.7, “Radiation Monitoring Systems,” also notes that monitors may be used for indicating radiation intensity to identify the need for personnel radiation protective actions, and to monitor release of radioactive material to the environment. The PSAR should describe radiation monitoring intended for these purposes, as applicable.

Other:

- The WP references NEI 08-09, “Cyber Security Plan for Nuclear Power Reactors,” which is applicable to power reactors. For non-power reactors, applicants may follow the guidance in “Cyber Security: Effective Practices for the Establishment and Maintenance of Adequate Cyber Security at Non-Power (Research and Test) Reactor Facilities” (ML15253A060).

- The PSAR should define qualification needs (where applicable) and TS surveillances and calibrations for important to safety channels (e.g., flux, temperatures, radiation monitors).

Chapter 8: Electrical Power Systems

In this chapter, NUREG-1537 calls for the applicant to discuss and describe the electrical power systems designed to support reactor operation under two categories: normal and emergency electrical power systems. NUREG-1537 further guides the applicant to explain how electrical power supports safe operation and safe shutdown, and to identify which systems must remain available following loss of power, including minimum monitoring, indication, and communication needs.

The WP states that this chapter will describe the electrical power systems supporting reactor operation, including both normal and emergency power systems required to maintain safe operation and shutdown. The WP states that normal power is provided by standard commercial service and that the reactor's passive safety design does not rely on any powered systems. TINN also notes that a UPS will support I&C status monitoring, radiation monitoring, minimal lighting, and communications. TINN also states that emergency power is provided via a battery backed UPS for critical systems, but the SOLO reactor is designed for passive safe shutdown and passive decay heat removal, independent of electrical power.

PSAR section 8.1, "Normal Electrical Power Systems"

- The WP states that the "[s]chematic diagrams can be streamlined to reflect [the] simplicity of [the] electrical architecture." The NRC staff are unable to judge electrical architecture simplicity due to a lack of design information at this time and cannot comment on acceptability of streamlining diagrams.

- To support statements made within the WP, the PSAR should include a description of the normal power distribution, including major panels, cable routes, UPS charging sources, and isolation points; a description of what happens upon loss of normal power (e.g., immediate load transfer to UPS, loss of non-critical loads, and expected operator actions); a demonstration that no systems are required for shutdown or cooling rely on normal power; and a description of the electrical protection systems to avoid damage to I&C systems due to a possible power surge.

PSAR section 8.2, "Emergency Electrical Power Systems"

- See the previous feedback related to inclusion of an ECCS-like system.

- The PSAR should provide a detailed functional description and circuit diagrams; provide sufficient analyses to support the claim that safe shutdown is ensured on loss of power without the need for a non-interruptible power transfer; identify all loads that must remain energized during a station blackout; provide the UPS autonomy period and its basis; define minimum I&C and radiation monitoring requirements during a power loss; describe alarms and indications available during a loss of power; and summarize maintenance and surveillance requirements needed to assure UPS reliability.

Other:

- Ensure cross-chapter consistency with PSAR chapter 7 (e.g., identification of I&C channels powered by UPS) and chapter 11 (e.g., continuity of radiation monitoring during outages).

- The PSAR should clarify the remote control and/or monitoring capability and, if included, identify whether these capabilities use safety-related electrical systems.

- The PSAR should define qualification needs (if any) for UPS components and power distribution equipment.

- The PSAR should define TS-related surveillance for electrical systems credited for safety.

Chapter 9: Auxiliary Systems

In this chapter, NUREG-1537 calls for the applicant to describe auxiliary systems important to safe operation and the reactor shutdown, protection of public and worker health and safety, and environmental protection. NUREG-1537 also includes guidance on design bases, functional descriptions, system interactions, safety significance, and identification of TS (LCO/LSSS/surveillance) implications for each subsection.

The WP states that this chapter will describe auxiliary systems important to safe operation and shutdown of the reactor, protection of public and worker health and safety, and environmental protection.

PSAR section 9.1, “HVAC”

- See feedback on PSAR chapter 6 related to HVAC.

PSAR section 9.2, “Handling and Storage of Reactor Fuel”

- The PSAR should address considerations on storage of fresh IRCs on site, installation of fresh IRCs, removal of spent IRCs, and storage of spent IRCs on site.

- The IRC supposedly arrives to the site sealed, however, the WP states: “Fuel handling is dry, performed inside a shielded environment with appropriate tooling and only occurs at decommissioning or refueling after at least 15 years of operation.” It is unclear to the NRC staff whether fuel handling in this case refers to the site or the factory. Dependent on the location of this activity, it should be highly detailed (if in the U.S.) or described at a high level (if at the factory).

PSAR section 9.3, “Fire Protection Systems and Programs”

- The PSAR will be expected to demonstrate with sufficient detail and analyses that safe shutdown and decay heat removal are not dependent on fire suppression system operability.

PSAR section 9.4, “Communication Systems”

- The WP states that “[f]ully digital architecture supports local and remote operation/monitoring.” See feedback on remote operation and monitoring under PSAR chapter 7 of this document.

PSAR section 9.5, “Possession and Use of Byproduct, Source, and Special Nuclear Material”

- The WP states that “[p]ossession of byproduct, source, and special nuclear material under reactor license is limited to operational needs.” However, TINN has indicated its intent to factory manufacture IRCs and ship them to the operational site. TINN should consider the potential requirements for possession during the full IRC lifecycle.

- The WP also notes intention for isotope production and material testing in other sections. Terra Innovatum should ensure that all necessary information applicable to possession of material for experimental purposes is provided.

PSAR section 9.6, "Cover Gas Control in Closed Primary Coolant Systems"

- The omission of this section appears appropriate if the SOLO design does not include cover gas.

PSAR section 9.7, "Other Auxiliary Systems"

- The PSAR will be expected to demonstrate that no additional auxiliary systems are required to be credited for safety.

Other:

- Chapter 5 of the PSAR outline includes a section titled "Primary Coolant Cleanup System," where the WP states that it is "not applicable in a water-based sense" and that the helium gas treatment skid is addressed under auxiliary system discussions. However, it appears that helium treatment is not described in detail in this section. The PSAR should provide an appropriate level of detail, including descriptions of instrumentation, alarms, and isolation features, on the helium gas treatment skid.

<u>Chapter 10: Experimental Facilities and Utilization</u>

In this chapter, NUREG-1537 calls on the applicant to describe and discuss the experimental facilities, its design basis, its intended use, and the experimental program, including the types of experiments allowed, any limits or exclusion criteria, and the safety analyses for each type of experimental activity. NUREG-1537 states that the applicant should provide sufficient information to demonstrate that no proposed operations involving experimental irradiation or beam utilization will expose reactor operations personnel, experimenters, or the general public to unacceptable radiological consequences.

The WP states that this chapter will describe the reactor's experimental facilities, its intended use, and associated safety analyses and administrative controls.

PSAR section 10.1, "Summary Description"

- The WP states that experimental capabilities will be limited to fixed irradiation positions integrated within the core/reflector and monolith used for isotope production and materials testing. The WP states that there will be no wet irradiation facilities, no cold neutron source, and no fueled or transient experiments. Engagement with the NRC staff on intended isotope production or materials testing capabilities has been limited. Furthermore, TINN's proposed PDC 70 (Radioisotope Production) in its PDC TR states that "the reactor core, control systems, and irradiation channels are configured to enable the controlled insertion, irradiation, and retrieval of target materials with high positional accuracy and predictable neutron flux profiles." The PSAR should describe in detail the planned radioisotope production activities.

PSAR section 10.2, "Experimental Facilities"

The information noted in this section appears generally aligned with NUREG-1537 section 10, "Experimental Facilities," however additional detail will be required to describe and justify TINN's experimental plans. Specifically, this section of the PSAR should include:

- Design drawings or schematics of experiments;
- Details on maximum experiment size, heat load, and reactivity worth;
- Demonstration of mechanical integrity under normal, AOO, and accident conditions;
- A description of the shielding, liners, or streaming paths associated with irradiation channels; and
- A description of how experiments are installed, secured, and removed. Future licensing submittals should clearly identify the locations of access points for irradiation channels, given that the monolith does not appear to have personnel access features.

PSAR section 10.3, "Experiment Review"

- Regulatory Guide 2.4, "Review of Experiments for Research Reactors," has been withdrawn. The NRC staff's guidance on the development of appropriate controls for experiments at research reactors to be included in the TS and the SAR is available within RG 2.2, "Development of Technical Specifications for Research Reactors" (ML003740125).
- While the content is generally consistent with NUREG-1537, the PSAR should ensure the following topics are addressed:
    - Experiment categories are defined (e.g. type, category, hazard level);
    - Review interfaces with RPS and RCS are defined (e.g., interlocks, monitoring, if any);
    - Experiments that could affect reactivity have explicit approval criteria;
    - Documentation required for experiment review is clearly described (e.g. thermal analysis, reactivity worth, activation products, failure modes);
    - Procedures to prevent introduction of unreviewed materials or unauthorized configurations.

Other:

- The PSAR should clearly define the type of materials that will be used to produce radioisotopes. Radioisotope production using fissile targets (e.g., U-235) constitutes a fundamentally different activity than irradiation of non-fissile targets (e.g., Co-59), due to the involvement of fission, special nuclear material, and associated radiological and waste considerations. These differences should be reflected in the safety basis, hazard categorization, and regulatory treatment.

- The WP states that experiments will not interfere with reactivity control, helium flow, or monolith or IRC integrity, no experiment will introduce prompt reactivity insertion mechanisms, and experiment failures are bounded by PSAR chapter 13 analyses. While this is a reasonable proposal, those analyses should include:

  - Quantified limits (e.g., maximum heat load);

  - Analysis of worst-case experiment failure (e.g., over-activation, capsule breach, local heating);

  - Evaluation of experiment structural failure under seismic and thermal loads;

  - Demonstration that removal of an experiment or voiding does not introduce a positive reactivity step; and

  - Explicit confirmation that no experiment supports void reactivity effects or coolant displacement effects.

- The WP states that experiment failures will be evaluated within the chapter 13 maximum hypothetical accident (MHA), “as needed.” To align with NUREG-1537, PSAR chapter 10 should identify:

  - Which experiment failure modes are carried into PSAR chapter 13,

  - Which failure modes are bounded by other analyses,

  - Why no experiment can cause fuel damage beyond the MHA,

  - Why no experiment can affect decay heat removal or monolith and IRC performance.

- The WP indicates that activation products to evaluate radioactive byproduct generation and potential release pathways will be covered in PSAR chapters 11 and 13. While providing detailed discussions in those chapters is reasonable, a summary of this information should also be included in PSAR chapter 10, with cross-references to the more detailed discussions in chapters 11 and 13.

- Experiment-related accidents should be clearly cross-referenced into PSAR chapter 13, including loss of experiment integrity, pressurized capsule failure, and misloaded materials.

Chapter 11: Radiation Protection Program and Waste Management

In this chapter, NUREG-1537 calls for the applicant to describe the facility program to control radiation and expected exposures due to operation, maintenance, and use of the reactor. NUREG-1537 states that the applicant should develop methods for quantitative assessment of radiation doses in the restricted, controlled (if present), and unrestricted areas; should apply those methods to all applicable radiation sources related to the full range of operation; should describe the program and provisions for protecting the health and safety of the public (including workers) and the environment; and should provide the bases for analyzing radiological consequences from potential accidents addressed in detail in chapter 13.

The WP states that this chapter will describe the reactor facility's Radiation Protection Program (RPP) and Radioactive Waste Management processes to ensure compliance with 10 CFR Part 20, "Standards for Protection Against Radiation," and "as low as reasonably achievable" (ALARA) principles.

PSAR section 11.1, "Radiation Protection"

- Radiation Sources
  - This section should address all radiation sources (airborne, liquid, solid), their origin, characteristics, and expected strengths. While the WP indicates that detailed analyses will be provided in chapter 13, all radiation sources should still be identified and discussed in this chapter, with cross-references to other chapters for more detailed evaluation.
- Radiation Protection Program
  - This section should include a monitoring matrix (e.g., instruments, locations, alarm/setpoints, calibration intervals, record retention).
  - This section should address the responsibilities of the health physics organization at the facility, as well as any other applicant radiation protection organizations. Organizational charts should be included.
- ALARA Program
  - The NRC staff noted that rulemaking and changes to guidance related to ALARA are ongoing (Federal Register Docket ID NRC-2025-1140).
- Radiation Monitoring and Surveying
  - This section should also provide specific monitors and setpoints (e.g., stack, area, continuous air monitor), calibration and response testing, and TS surveillance if any monitors are credited.
- Radiation Exposure Control and Dosimetry
  - This section should include a clear description of dosimetry program structure and investigation levels; defined controls for High Radiation Areas; calibration and QA requirements for radiation instruments; integration of exposure control

with procedures, training, and experiment review; and dose recordkeeping and reporting practices.

- Contamination Control

  - This section should address the detection of fixed and loose surface contamination. Simply stating that “no contamination is expected from normal reactor operation (helium system is closed and sealed)” may not be sufficient, as leaks can occur at piping, welds, or penetration points. In such cases, radioactive contaminants may escape. Therefore, the PSAR should describe how fixed and loose contamination will be monitored, detected, and managed under both “normal” and “off-normal” conditions.

- Environmental Monitoring

  - The PSAR should justify the scope and frequency of calculated Ar-41 releases; define baseline, action levels, and reporting thresholds; and describe how results confirm to 10 CFR 20.1301, “Dose limits for individual members of the public,” compliance.

  - While the SOLO design does not include water-based coolant, this section of the WP does not describe potential inadvertent releases to groundwater or explain how the groundwater system would attenuate, delay, or absorb contaminants to demonstrate compliance with the limits of 10 CFR Part 20. The PSAR should include this information.

PSAR section 11.1, “Radioactive Waste Management”

- Waste Management

  - This subsection should include a brief records and reporting description per 10 CFR Part 20 and 10 CFR Part 61, “Licensing Requirements for Land Disposal of Radioactive Waste,” (inventory, shipments, manifests); flow diagrams showing generation, collection, interim storage, shipment, including monitoring and release criteria; and numerical bases for Ar-41 releases (long term and short-term) and public dose at the site boundary.

<u>Chapter 12: Conduct of Operations</u>

In this chapter, NUREG-1537 calls for the applicant to describe the conduct of operations at the facility such as the administrative aspects of facility operation, the facility emergency plan, the security plan, the QA plan, the reactor operator requalification plan, the startup plan, and environmental reports.

The WP states that this chapter will describe the organizational, procedural, and administrative framework governing reactor operation and facility safety programs, including facility organization and management, review and audit activities, procedures, required actions for events, reporting, recordkeeping, emergency planning, security planning, QA, operator training and requalification, startup plans, and environmental reports.

PSAR section 12.1, “Organization”

- The WP states that: “Facility operations model is based on remote monitoring….” See feedback on remote operation in chapter 7 of this document.

- The WP states that: “certified operator presence required during certain operational phases (e.g., startup, irradiation cycle initiation, maintenance).” The PSAR should clearly define presence, considering the reference to “remote” monitoring and operation mentioned throughout this WP.

PSAR section 12.2, “Review and Audit Activities”

- While proposed content appears to meet the general intent of NUREG-1537, the development of a charter is not mentioned. This section should specify details such as development of a committee charter, minimum number of members, and reporting mechanisms. Including maintenance personnel as part of the committee would be valuable, if “quality assurance” doesn’t encompass maintenance personnel.

PSAR section 12.3, “Procedures”

- The information outlined in the WP does not include procedures related to experimental work, the methodology for developing procedures, or temporary deviations to deal with special or unusual circumstances during operation. This information should be included in this section.

PSAR section 12.4, “Required Actions”

- While this section appears to generally align with NUREG-1537, the PSAR should also provide the details of the notification chain and event review process.

PSAR section 12.5, “Reports”

- In addition to the content included in the WP, the PSAR should also describe the reporting of changes in facility management; reporting related to appendix 14.1 of NUREG-1537, “Format and Content of Technical Specifications for Non-Power Reactors,” and ANSI/ANS-15.1, “The Development of Technical Specifications for Research Reactors,” as applicable; and reporting of changes, tests and experiments conducted under the authority of 10 CFR 50.59, as needed.

PSAR section 12.6, “Records”

- In addition to the content included in the WP, the PSAR should also describe recording activities related to appendix 14.1 of NUREG-1537 and ANSI/ANS-15.1, as required.

PSAR section 12.7, “Emergency Planning”

- In addition to the content included in the WP, the PSAR should also provide detailed, facility-specific content addressing all applicable elements of ANS 15.16, “Emergency Planning for Research Reactors,” and RG 2.6, “Emergency Planning for

Research and Test Reactors and Other Non-power Production and Utilization Facilities," as applicable.

PSAR section 12.8, "Security Planning"

- In addition to the content included in the WP, the PSAR should also provide detailed, facility-specific content addressing all applicable elements of 10 CFR Part 73, "Physical Protection of Plants and Materials," and RG 5.59, "Standard Format and Content for a Licensee Physical Security Plan for the Protection of Special Nuclear Material of Moderate or Low Strategic Significance," as applicable.

PSAR section 12.9, "Quality Assurance"

- The WP states that the QA program will follow RG 2.5, "Quality Assurance Program Requirements for Research and Test Reactors" and ANSI/ANS-15.8. Referral to these guidance documents is generally acceptable. See previous feedback related to reference to Appendix B of 10 CFR Part 50.

PSAR section 12.10, "Operator Training and Requalification"

- The WP does not appear to mention ongoing training for operators or the maintenance of operator active status and steps to return inactive operators to active status. The PSAR should include this information.

PSAR section 12.11, "Startup Plan"

- While the described PSAR generally aligns with the required elements by addressing initial core loading, subcritical multiplication, criticality approach, reactivity measurements, radiation and effluent measurements, and reporting, several other considerations seem to be omitted. This section should include a comprehensive startup test scope, including rod calibrations, shutdown margin determination, reactor power calibration, neutron flux mapping, fuel barrier performance checks via fission product measurements, and evaluation of experiment reactivity worth.

- The startup plan is described as being implemented for "core changes." If the FOAK SOLO core isn't altered during service life, startup plans for core changes may not be applicable to the FOAK SOLO reactor.

PSAR section 12.12, "Environmental Reports"

- The WP states that "environmental reports will be provided as required," however, under 10 CFR Part 50, applicants should only provide one environmental report in the construction permit application.

- The WP states: "Categorical exclusion or Environmental Assessment process." The determination on whether an environmental impact statement (EIS), environmental assessment (EA), or categorical exclusions, will depend on a number of factors including the characterization of the SOLO reactor as either a testing facility (requiring an EIS) or a research reactor (may only require an EA).

- The WP states that the SOLO reactor "is expected to qualify for a streamlined environmental review." At this time, a streamlined environmental review is not a defined process under current regulations, and there are no established qualification criteria for a streamlined environmental review.

- The NRC staff noted that NRC regulations related to National Environmental Policy Act (NEPA) compliance may be undergoing changes (Federal Register Docket ID NRC-2025-0478).

Chapter 13: Accident Analyses

In this chapter, NUREG-1537 calls for the applicant to submit information and analyses that show that the health and safety of the public and workers are protected and that the applicant has considered potential radiological consequences in the event of malfunctions and the capability of the facility to accommodate such disturbances. NUREG-1537 states that the intention of this chapter is for the applicant to demonstrate that the facility design features, safety limits, limiting safety system settings, and limiting conditions for; operation have been selected to ensure that no credible accident could lead to unacceptable radiological consequences to people or the environment.

The WP states that this chapter will demonstrate that the reactor design, safety features, and operational limits ensure no credible accident results in unacceptable radiological consequences to the public, the reactor staff, or the environment.

Overall, chapter 13 of the WP appears to align with the major elements of NUREG-1537, by identifying initiating event groups, defining an MHA, and providing bounding evaluations of reactivity insertion, loss-of-coolant, loss-of-flow, experiment malfunction, loss of power, and external events. However, several elements of NUREG-1537, appear omitted and some information appears to conflict with other areas of the WP.

- The WP states that there is "no complex in-core experimental program," however, other areas in the WP include references to experimental programs. If the future PSAR submittal is intended to make this claim, "complex in-core" experiments should be defined and it should be clarified how the definition excludes the experimental program planned for the FOAK SOLO reactor.

- This section should identify the guidance documents used to establish conservative bounding release assumptions.

- While the WP includes the heading "Mishandling or Malfunction of Equipment," it does not appear to list operator error or human-induced hazards, which are addressed in NUREG-1537, chapter 13. These categories should be addressed in this section.

- The WP does not appear to organize content for this PSAR chapter into sections. Organization of this PSAR chapter using the sections provided in NUREG-1537 would be beneficial.

Chapter 14: Technical Specifications

In this chapter, NUREG-1537 calls for the applicant to discuss the development of the facility TS and demonstrate that TSs were prepared following an accepted format, that normal operation of the reactor within the limits of the TS will not result in offsite radiation exposure in excess of 10 CFR Part 20 guidelines, and that the TS limit the likelihood and consequences of malfunctions.

The WP states that that facility TS will be developed that will set operating limits, conditions, and surveillance requirements; ensure public and worker protection under 10 CFR Part 20; control operation of safety-significant systems and functions; address design-specific features and risks; and be incorporated into the reactor's operating license (OL) per 10 CFR 50.36, "Technical specifications."

The content proposed in the WP appears to be generally aligned with NUREG-1537. The NRC staff's feedback and observations are provided below:

- The list of TS contents for PSAR chapter 14 is not all-inclusive (e.g., LCOs should exist for instrumentation and trip functions).

- The administrative control section of the PSAR should also address staffing, procedures, required actions, or reports.

- The WP states that "not all ANSI/ANS-15.1 sections apply (e.g. sections dealing with complex experiment programs…" It is unclear to the NRC staff which portions of ANSI/ANS-15.1, "The Development of Technical Specifications for Research Reactors," TINN is referring to by the term "complex experimental programs." Previous sections of the WP outline information related to the planned experimental program for the SOLO MMR, therefore TINN should evaluate applicability of ANSI/ANS-15.1 sections pertaining to experiments for applicability to its reactor.

- The provisions of 10 CFR 50.34(a)(5), require a CP application to contain identification and justification for the selection of those variables, conditions, or other items which are determined as the result of preliminary safety analysis and evaluation to be probable subjects of TS for the facility, with special attention given to those items which may significantly influence the final design. The WP states that the SOLO MMR TS will be fully derived from the PSAR safety analysis. The NRC staff do not expect complete TS at the CP application stage. Instead, complete TS are expected at the OL application stage.

<u>Chapter 15: Financial Qualifications</u>

In this chapter, NUREG-1537 calls for the applicant to submit financial information to establish that the applicant is financially qualified to own, construct, operate, and decommission a non-power reactor.

The WP states that this chapter will demonstrate the financial ability to construct, operate, and decommission the facility. The WP states that construction and operation will be supported by private investment, provides high-level cost basis descriptions, and cites a pre-paid external sinking fund for decommissioning.

The content proposed in the WP appears to be generally aligned with NUREG-1537. The NRC staff's feedback and observations are provided below:

- The WP states: “minimal operational staffing due to remote monitoring design.” TINN has not engaged with the NRC staff on a purely remote monitoring approach. See feedback on PSAR chapter 7, provided in this document.

- TINN should ensure all costs associated with transportation are considered in its financial planning, including transportation at the end of life if cores will be transported back to a factory for fuel removal.

Chapter 16: Other License Considerations

In this chapter, NUREG-1537 calls for the applicant to discuss license considerations that do not belong elsewhere in the SAR, including the way reactor components were used in the past or proposed medical uses of the reactor. These additional considerations are on a case-by-case basis.

In its WP, TINN does not identify additional license considerations to be included. This appears appropriate if TINN is not repurposing components or fuel or pursuing medical uses for the FOAK SOLO reactor.

Chapter 17: Decommissioning and Possession-Only License Amendments

In this chapter, NUREG-1537 provides guidance for applicants to address both decommissioning planning and the regulatory framework for possession-only license amendments, including a description of preliminary decommissioning activities, identification of regulatory commitments, financial assurance provisions and any facility-specific factors that affect decommissioning planning.

The WP states that a decommissioning report will be provided with the OL application, consistent with 10 CFR 50.33(k), and will address the content requirements in 10 CFR 50.75(d)(2). TINN referred to chapter 15 for demonstration of the financial ability to decommission the facility. The WP states that a possession-only license amendment is not applicable to the construction and initial operational phases of the SOLO facility.

The provisions of 10 CFR 50.33(k), require an applicant for an OL for a utilization facility to submit a decommissioning report but do not require an applicant for a CP for a utilization facility to submit a decommissioning report or plan. The guidance of NUREG-1537, indicates that decommissioning plans and applications for possession-only licenses “are submitted by nonpower reactor licensees who wish to terminate operations and decommission their facilities.” Therefore, the NRC staff agree with the information proposed by TINN to be included in the PSAR.

Chapter 18: Highly Enriched to Low Enriched Uranium Conversions

In this chapter, NUREG-1537 provides guidance for the preparation of safety analyses to support the conversion from Highly Enriched Uranium (HEU) to Low Enriched Uranium (LEU) fuel and calls for and calls for applicants to provide the associated safety analyses, design changes, core physics evaluations, and licensing basis updates.

The WP states that the SOLO reactor is designed from inception to use LEU fuel and will be licensed and operated as an LEU-fueled reactor, therefore, no HEU to LEU conversion is required.

The NRC staff observed that because the SOLO MMR is designed to operate exclusively with LEU fuel and does not involve any refueling during its service life, conversion from HEU to LEU is not applicable; therefore, the content of NUREG-1537, chapter 18 does not apply to its initial licensing basis.

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