TERRESTRIAL ENERGY

Postulated Initiating Events for the IMSR400

Topical Report

Revision B

August 2025

Abstract

This topical report describes the methodology used to develop a set of postulated initiating events (PIE) for the Integral Molten Salt Reactor (IMSR) design and provides as complete a set of PIE as is possible given the design's maturity. The methodology is not confined to the events that only affect the IMSR Core-unit. The set of PIE discussed in this topical report, and associated references, result from an examination of the complete IMSR facility. This methodology includes the examination of potential off-normal conditions that can lead to potential challenges to one or more of the fundamental safety functions.

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Executive Summary

This topical report describes the methodology used to develop a set of postulated initiating events (PIE) for the Integral Molten Salt Reactor (IMSR) design and provides as complete a set of PIE as is possible given the design's maturity. The methodology is not confined to the events that only affect the IMSR Core-unit. The set of PIE discussed in this topical report, and associated references, result from an examination of the complete IMSR facility. This methodology includes an examination of potential off-normal conditions that can lead to potential challenges to one or more of the fundamental safety functions.

Regulatory finality is being sought on the methodology described in Section III of this topical report. The methodology includes the process that will be used to establish a set of PIE for the IMSR400 and the criteria for classifying individual PIE for evaluation. Regulatory finality on the enclosed list of PIE or the classification of individual PIE is not being requested in this topical report at this time. The presentation of information about the methodology and an application of the methodology provides the opportunity for the regulator to observe the application of the methodology and the resulting outcomes for event classification once the methodology is implemented on the design. Regulatory approval of a final comprehensive list of PIE and the final individual PIE classification will be requested as part of a future license application review.

I. Purpose

The purpose of this topical report is to describe and seek NRC regulatory approval for the methodology used to develop a set of postulated initiating events (PIEs) for the Integral Molten Salt Reactor (IMSR) design, and to provide as complete a set of PIEs as is possible given the design's maturity. The set of PIEs discussed in this topical report are not confined to the events that only affect the IMSR Core-unit and are presented to demonstrate the methodology. The set of PIEs discussed in this topical report and associated references result from an examination of the IMSR facility as a whole. The examination includes the potential off-normal conditions that can lead to potential challenges to one or more of the following fundamental safety functions:

- Controlling reactivity
- Removing heat from the primary system (fuel salt)
- Retaining radionuclides

Regulatory finality is being sought on the methodology that will be used to establish the set of PIE and the criteria for classifying individual PIEs for evaluation. Regulatory finality on the enclosed list of PIEs or the classification of individual PIE is not requested in this topical report.

The discussion of the implementation of the PIE identification methodology and the potential results of the direct application of the methodology are provided in Sections III.4 and III.5 for illustrative purposes. The information in those sections provides the U.S. Nuclear Regulatory Commission (NRC) the opportunity to see clearly how the methodology will be successful in identifying all potential initiating events affecting the operation of the IMSR400 for all plant states and provides the opportunity for the NRC to ask for specific information about the planned design and operation of the IMSR400. Regulatory approval of a final comprehensive list of PIE and the final individual PIE classification will be part of a future license application review.

The design information associated with the IMSR400 reflects the information available for systems as of March 2023. The information was collected from the documents listed in Section VI.

The information in this topical report also addresses the comments received from the Canadian Nuclear Safety Commission (CNSC) and the NRC in their joint report on this topic titled "Joint Report on Terrestrial Energy's Methodology for Developing a Postulated Initiating Events List for the Integral Molten Salt Reactor" [R-12].

II. Introduction

II.1 Background

Terrestrial Energy USA's (TEUSA) long-term licensing objective for the commercial deployment of the IMSR design in the U.S. is to first obtain an SDA for the IMSR Core-unit under 10 CFR Part 52, Subpart E. The IMSR Core-unit represents a significant technical portion of the IMSR facility and includes many systems that perform important safety functions. The systems within the Core-unit are reasonably discernible from systems outside the boundaries of the Core-unit. Subsequent sections of this white paper provide additional details about the design envelope of the IMSR Core-unit and its safety interfaces.

The identification of PIEs is the first step in the design review and assessment process. It is also a starting point for the safety analysis. A PIE is an event identified in the design that leads to Anticipated Operational Occurrences (AOOs) or accident conditions. Accident conditions include Design Basis Accidents (DBAs) and Beyond Design Basis Accidents (BDBAs). BDBAs include a subset of severe accidents.

Terrestrial Energy has prepared its methodology for identifying postulated initiating events to reflect the comments received within the joint CNSC/NRC report. TE prepared Revision A of the topical report and submitted it to the NRC for review and approval in December 2024. The NRC initiated an audit review of the topical report and provided 12 questions for resolution. TE and the NRC met on Aug 7, 2025, to discuss the planned resolution of the NRC items. The NRC indicated that the responses were adequate, resolved their questions, and requested that some of the response language be included in the topical report. This revision B of the topical report reflects the resolution of audit items. The table below provides the location within the topical report (red-lined version) where the text has changed to incorporate the audit response items identified by the NRC.

Audit item	Revised red-lined TR version (this document) page numbers
1	15-16
2	10-11 &16
3	112-113
4	25
5	103
6	The TR does not discuss "significant release of radioactivity"
7	103
8	16-17
9	13
10	17-19
11	14
12	103 (top)

II.2 Description of the IMSR400

IMSR400, developed by Terrestrial Energy Inc. (TEI), is a near-atmospheric pressure, pool-type, and integral reactor vessel, called the Core-unit, featuring integral primary heat exchangers (PHXs), pumps and extensive inherent and passive safety features. IMSR400 employs a liquid fuel (Fuel Salt) rather than a conventional solid fuel; this liquid contains nuclear fuel and also serves as the primary coolant. It uses graphite as the moderator and operates at low pressure and high temperature (~700 °C) with a rated thermal capacity of 442 MW and provides 195 MWe (net) in electrical power, as well as 585 °C heat for a broad range of potential industrial heat applications. An expanded discussion of the key systems and structures that will be discussed in this topical can be found in the TEUSA White Paper "Core-unit Definition, applicable Structures, Systems, and Components" (TEUSA Document #200310) [R-2] A more detailed presentation of the design details for the systems and structures of the IMSR400 would be found in the specific system reference documents listed in Section VI of this report.

Some of the key factors that support the enhanced safety performance of IMSR400 are as follows:

- IMSR400 has a negative temperature reactivity coefficient of the Fuel Salt [R-13]. If there is a power generation to heat removal mismatch, the increasing Fuel Salt temperature causes a decrease in the reactivity of the system and eventually stabilizes the nuclear reaction such that adverse effects from the reactivity excursion are precluded.
- IMSR400 utilizes a passive heat removal system known as Internal Reactor Vessel Auxiliary Cooling System (IRVACS) [R-14], which, together with the negative temperature reactivity coefficient, is designed to handle extreme events (such as Station Blackout) in a passive operational mode. As a passive system, using thermosyphoning loops, IRVACS is continuously running, even in the Normal Operation (NO) mode. Therefore, IRVACS is always available (rather than requiring activation) for when a PIE which requires it occurs.
- The Fuel Salt, Secondary Coolant Salt and Tertiary Coolant Salt are chemically stable. Therefore, no chemical reactivity is expected.
- Gaseous fission products such as Krypton, Xenon and Tritium are removed from the IMSR400 Core-unit to minimize their available volumes for leakage in accidents and to maintain low pressures in the Core-unit.
- IMSR400 uses a passive Containment for safety, which is a Category A passive system since the Containment structure has no active components.
- The boiling point of Fuel Salt is above 1400°C, much higher than the operating temperature of ~700 °C. This allows a low operating pressure of the core without risk of fuel boiling.

Figure 1 – Flow Schematic of the Main Heat Transfer Path for the IMSR400 [R-15]

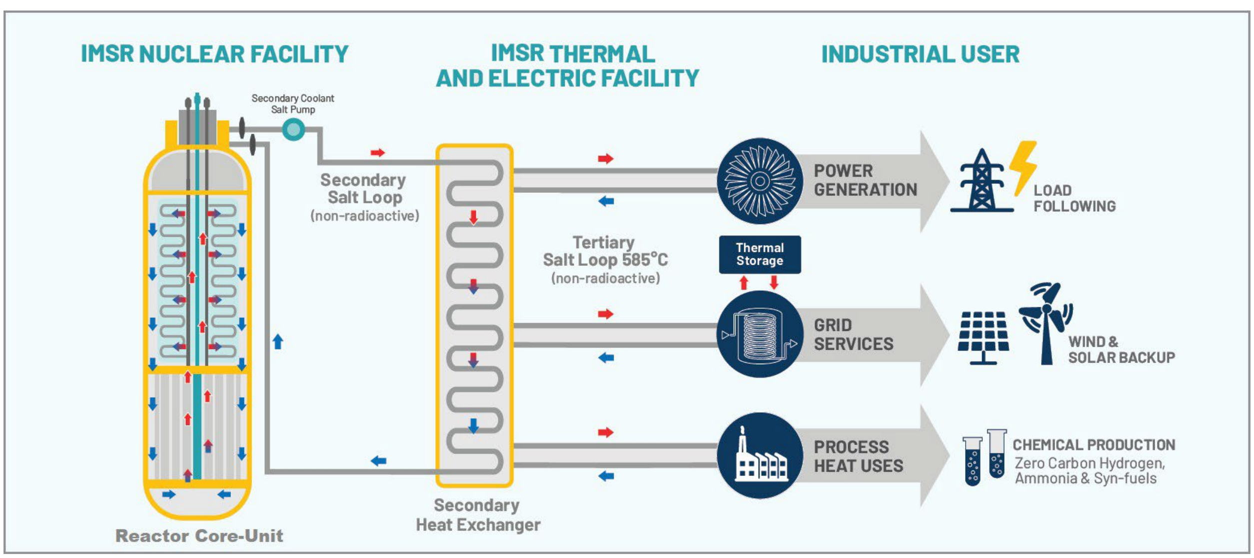

Figure 1 is a flow schematic of the main heat transfer path for the IMSR400. The IMSR400 uses molten fluoride salt, [[NaF-KF-UF4,]] for its primary Fuel Salt. A Secondary Coolant System (SCS), also using a fluoride salt [[KF-ZrF4)]], transfers heat away from the Core-unit through the integral PHXs. The SCS, in turn, transfers its heat load to a Tertiary Coolant System (TCS) via the Secondary Heat Exchangers (SHXs), which circulates the heated Tertiary Coolant Salt to a separate building (outside of the nuclear island) where it either transfers heat to Steam Generators (SGs) that generate superheated steam for power generation, or transfers heat to process heat applications.

II.3 Scope

The PIE methodology contained in this report represents an evolution of the initial PIE methodology previously submitted in the TEUSA white paper "TEUSA submittal of Postulated Initiating Events for the IMSR®" Revision 2, December 16, 2021 (ML21357A015). The revised methodology addresses some of the comments provided by CNSC and the NRC from their joint review in the document titled "Joint Report on Terrestrial Energy's Methodology for Developing a Postulated Initiating Events List for the Integral Molten Salt Reactor," May 2022 (ML22139A124) [R-12].

This methodology evaluates a single-unit Nuclear Power Plant (NPP) configuration on a generic site (i.e., not site-specific). The methodology for identifying PIEs requires that the following plant operating modes be evaluated: [[

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Figure 2: Plant operating modes and the transitions between them for normal operation[1]

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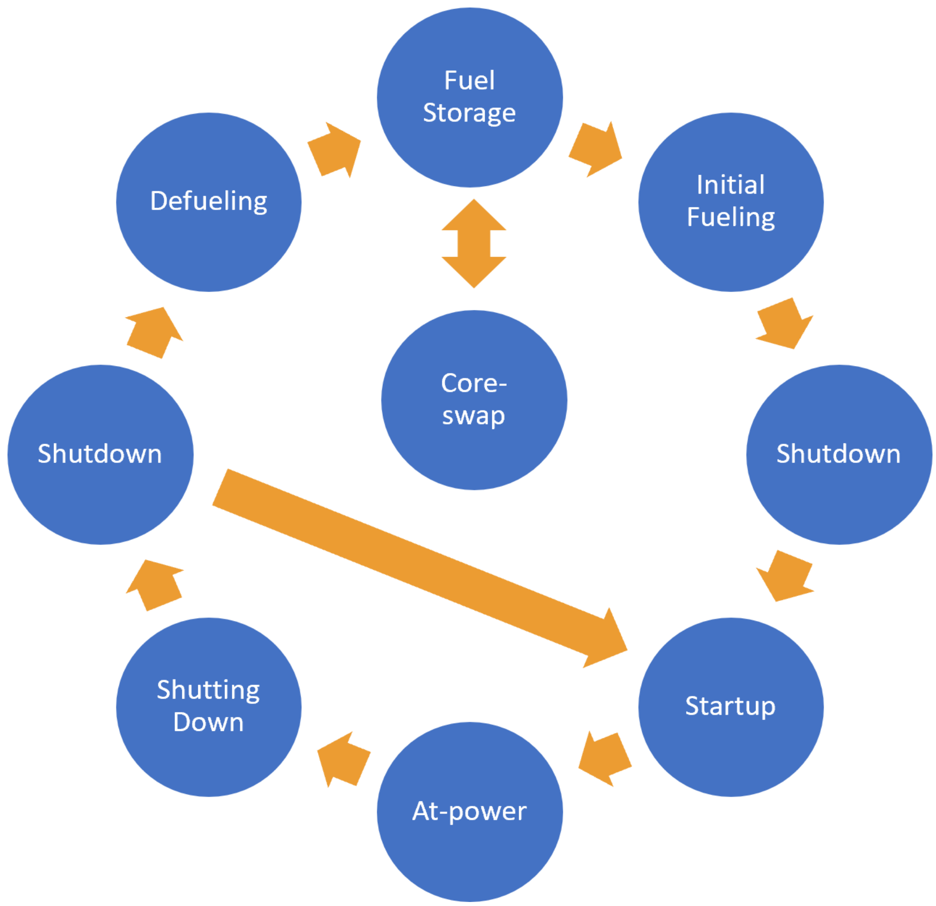

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The major Structures, Systems and Components (SSCs) which this document covers are the following:

1. SCS
2. TCS
3. Core-unit[2]
4. IRVACS
5. IPS (Integral Pumping System)
6. SHXs
7. SGs
8. Steam Plant
9. IrFS (Irradiated Fueling System)

[1] Note that Core-swap can take place at any point after a Core-unit has been defueled and occurs in parallel with the other operating modes shown in **Figure 2**.

[2] Core-unit includes the RV and its contents, which are the graphite core, Primary Pumps, PHXs, Fuel Salt, EHX1 of IRVACS.

10. FSST Active Cooling System (FACS)
11. IFACS (Irradiated Fuel Auxiliary Cooling System)
12. Initial Fuel System (InFS) and Makeup Fuel System (MFS)
13. Core-swap system
14. PRACS (Process Reactor Auxiliary Cooling System)
15. Core-unit support structures
16. Containment

Additionally, PIEs related to the Instrumentation and Controls (I&C) and plant electrical systems have been considered. The PIEs identified in this report include, as potential causes, the failure of all supporting Systems, Subsystems and Components (SSCs, e.g., failure of HVAC), leading to the failure of a system safety function.

PIEs arising from malevolent attacks and safeguard related events are not covered in this document. Details on these can be found in the Preliminary Safety Analysis Report (PSAR) Annex 1: Security [R-20], PSAR Annex 2: Safeguards [R-21] and the Plant Control and Monitoring System (PCMS) design description [R-22] (for details on cyber-attacks).

This document only considers events within the nuclear island, or events which initiate outside of the nuclear island but then propagate to the nuclear island, such as the external hazards (see section III.4.6). For this document, the Balance of Plant (BOP) is a generic Steam Plant, where only bounding events causing increased or decreased heat removal are considered, as captured in [[ ]], respectively. Specific events within the Steam Plant (e.g., main steam line break, loss of feedwater, loss of condenser cooling, turbine trip) are considered as potential causes of these bounding events. Also, Steam Plant events which impact the Nuclear Plant pressure boundary are also considered (i.e., [[ ]]). Note that the Steam Plant is not required to maintain the control, cool and contain safety function capabilities of the NPP (i.e., the SSCs of the Steam Plant will not be needed to perform any safety functions).

Note that certain PIEs impact the NPP as a whole, which includes safety systems, safety-related systems and non-safety-related systems. Examples of these PIEs include loss of offsite power and internal/external hazards. In terms of external hazards, the IMSR is designed and qualified against generic external hazards using generic site parameters. The following IAEA guidance was used for identification of generic external hazards for the IMSR design:

- IAEA Safety Standards Series No. NS-G-1.7, Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants [R-24].
- IAEA Safety Standards Series No. NS-G-3.3, Evaluation of Seismic Hazards for Nuclear Power Plants [R-25].
- IAEA Safety Standards Series No. NS-G-1.5, External Events Excluding Earthquakes in the Design of Nuclear Power Plants [R-26].
- IAEA Safety Standards Series No. NS-G-1.11, Protection against Internal Hazards Other than Fires and Explosions in the Design of Nuclear Power Plants [R-27].
- IAEA Safety Standards Series No. NS-G-3.5, Flood Hazard for Nuclear Power Plants on Coastal and River Sites [R-28].
- IAEA Safety Standards Series No. NS-G-3.4, Meteorological Events in Site Evaluation for Nuclear Power Plants [R-29].

- IAEA Safety Guide No. NS-G-3.6, Geotechnical Aspects of Nuclear Power Plant Site Evaluation and Foundations [R-30].

The internal/external hazards includes environmental events (e.g., flooding, fire, earthquake) and internal system failures (e.g., explosion, missiles). Combination events (i.e., events that evaluate the combination of an internal event coupled with an external event or combination of multiple internal or external events) are not included in the scope of this document. A future revision of the PIE document will include credible combinations of individual events, including internal and external hazards, which could lead to anticipated operational occurrences or accident conditions, and shall be considered in the design. The process of identifying combinations of hazards will consider combinations that are either consequential or correlated and will exclude combinations of independent hazards, as per [R-23].

Malevolent attacks and safeguard-related events will be addressed separately under security and safeguards documentation. Note that protection against intentional large aircraft crash is considered in the IMSR design (also included in the protection against malevolent acts scope). Slow-developing degradation in the operating conditions (i.e., ageing) will be addressed in the plant design, equipment qualification program as well as the plant monitoring, maintenance, in-service inspection and test programs.

II.4 Quality Assurance

The Quality Assurance (QA) practices are in place to ensure that this methodology is accurate, complete, and up to date with respect to the design information, regulatory documents, internal analysis documents (i.e., DSA and PRA) and external literature/research and will be implemented in accordance with the process described in this topical report. The general controls used are described in the TEI Management System Manual, with additional information provided below. (Note that the TEI Management System is comparable in scope to 10 CFR 50 Appendix B. While the Quality Assurance Plan for TEUSA has not yet been submitted for review, TEUSA will ensure that the regulatory process described in this topical report will be performed under a quality assurance plan that meets NRC requirements.) Further, this is done through the selection of qualified persons to identify PIEs and the review and verification of the resulting documentation following the applicable management and review controls.

II.4.1 Expertise Requirements

In order to successfully identify a comprehensive set of PIEs, a person or set of people with substantial knowledge of the design and proposed operation of the IMSR400 is chosen to perform the process outlined in the methodology (see section III.1). One person from the Safety Team is assigned as the task lead by the Safety Team Manager and is supported in the effort by the other members of the Safety Team. The task lead will be responsible for creating an update plan for the PIE document and executing this plan (see section III.4.2). Additional qualified people are selected to review (and verify, see section III.4.2) the results of this process. The managers responsible for the technical and engineering disciplines, in consultation with the Safety Team manager, are tasked with the identification of personnel with the appropriate expertise to serve as reviewers of this document. It is the responsibility of the Safety Team Manager to ensure that the expertise of the selected personnel is relevant and sufficient to provide a comprehensive analysis.

Depending on the stage of the design and the extent of the updates required, the task lead, supporting team members and reviewers cumulatively have familiarity in all or a subset of the following areas [R-31]: [[

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Note that as the design develops, new information will become available and expertise requirements will change. Therefore, the requirements listed above may not all be utilized at each iteration of this document. The above list is a complete set of engineering disciplines that might be expected throughout the entire design process. For each iteration of this document, the task lead, as supported by the Safety Team Manager, will ensure that the expertise of the individuals involved is appropriate for the scope of the review.

II.4.2 Management and Review Controls

The management and review controls include the processes for collecting information that could result in changes to the PIEs, determining when updates are made and performing review. The general controls used at TEI are described in the Management System Manual [R-32], with additional information provided below.

The process in place for collecting information that could result in changes to the PIE (followed by evaluating that information to determine the necessity for an update) is primarily done using "points of contact", as described in [R-33] and illustrated in Figure 3 below. Points of contact are individuals of a technical discipline (e.g., safety) that are responsible for collecting new information from other disciplines (e.g., physics, mechanical, R&D) and for communicating this information to their own discipline. Each individual within a team is assigned one or more aspects of the design for which they act as point of contacts, so that cumulatively all members within a team establish a communication link to all other disciplines. The points of contact collect information primarily through meetings which the responsible discipline holds to update all points of contact with their new information. Following this routine process, periodic (internal) team meetings are held where team members will update the team with this new information and any associated documentation. In addition to this process, the review and comment process on any new documentation will include all interfacing disciplines (including safety). The reviewers representing these interfacing disciplines will then convey the information during the team meetings, such that the team is up-to-date on the work being done by other disciplines. For the Safety Team, all information which could result in changes to this document will be collected by the Safety Team Manager.

Figure 3: Schematic showing the transfer of information to the safety team using points of contact strategy[3]

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Based on an evaluation of this new information, as well as any external documentation (e.g., regulatory documents, literature from other reactors) and internal safety documentation (i.e., PRA and DSA) since the last PIE update, the Safety Team manager, with support from the Safety Team members, will perform an evaluation to determine if an update to the PIE identification methodology, PIE list or PIE classification is necessary. If an update is deemed necessary, the process of selecting qualified personnel will be initiated by the Safety Team Manager.

Once chosen, the task lead will begin by creating an update plan for the PIE document (see [R-7] for an example of an update plan). The update plan will be aligned with the engineering advancements in the IMSR design since the previous update. The update plan will highlight the areas of the IMSR design that have changed, and which now require updating in the reference document. The plan will include specific references to inputs that are to be used to perform these updates (e.g., design documents, literature, regulatory documents). This plan will also involve the assignment of work to qualified personnel who have access to all relevant background information, and the interfacing disciplines required for each update for details on interdisciplinary interface procedures/requirements). The task lead will also include in the plan the actions for review of the updated documentation. The Safety Team Manager, in consultation with other technical discipline managers and the task lead, will identify the specific

[3] Note that this figure is an example for illustrative purposes, there are more disciplines than what is shown.

reviewer(s) that have the necessary skills to effectively perform the review tasks as outlined in the update plan. The task lead will also be responsible for initiating the document controls described below.

Once the plan has been written, reviewed and approved (following similar procedures to those outlined for the review of the document draft, described below), the task lead will proceed to execute the plan that will result in a draft of the updated document. This draft will be reviewed, as outlined by the plan, by other safety team member(s) and members of interfacing disciplines for completeness and accuracy. The review process, referred to as the review and comment process, will take place through the established document management and control procedures. Each reviewer will be verifying that the information is accurate with respect to the design information and any other relevant references. Note that since no calculations are performed as part of the update process, no associated verification of calculations is required.

During the IMSR400 design, engineering, and pre-licensing phases there are no specific periods defined to update this information but are rather based on the collection and evaluation of new information by the Safety Team Manager and Safety Team, as described above. Once the IMSR400 is licensed, the evolution of the design would be greatly reduced and therefore, plant changes affecting the set of PIEs would be greatly reduced as well. Nonetheless, maintenance of the PIE list by both TEUSA and the plant license holder would be expected, in order to identify new events or update previous ones in terms of their descriptions, mitigations and frequencies. During the life cycle of the plant, this information will be updated periodically. While not a requirement of this methodology, a natural assessment point would seem to be the period following updates to the PRA (five years) or following each Core-unit reload (seven years). Nevertheless, if there is a significant change to the plant design or its risk profile, the supporting safety analysis documentation would be modified using the appropriate licensing basis change process established by the regulations.

It is essential that the PIE list is developed and finalized to include input from all interfacing disciplines. During the conceptual design and basic engineering stages, all relevant disciplines have been involved in the review of and feedback on the PIE methodology and PIE list, including DSA, PRA, Licensing, Physics, Thermal-hydraulics, Civil, I&C, R&D, Fire Protection, and system designers. External safety experts from Canada and UK in the DSA and PRA areas were also involved in the review of the IMSR PIE methodology. In the detailed engineering stage, an internal PIE panel will be established to further support developing and finalizing the PIEs list. The PIE panel will include the experienced expertise from relevant disciplines. The panel will thus play a role in the identification, categorization, and/or classification of PIEs.

III. Process for Identifying PIEs

In the design stage of IMSR400 it is important to identify a comprehensive set of PIEs such that, to the extent practical, all foreseeable events are identified and are considered in the design. From the perspective of Safety Analysis, a comprehensive listing of PIEs should be prepared for all permissible plant operating modes to ensure that the analysis of the behavior of the plant is complete. Note that slow-developing degradation in the operating conditions is not considered a PIE. In the current methodology, each identified PIE is categorized into one of seven categories based on their associated primary plant response or similar initiating failures.

After the comprehensive list of PIEs is generated, the events are classified based on their estimated frequency of occurrence (i.e., AOO, DBA and BDBA, see section III.5 for classification criteria, inputs and preliminary results).

III.1Approach for PIEs Identification

The PIE identification process should be as systematic and complete as possible. The various causes for an initiating event are considered, which include events internal and external to the NPP. For internal events, SSC failures, operator errors and hazards (i.e., human induced or caused by SSC failure/malfunction) which directly or indirectly challenge one or more of the systems required to maintain safety of the plant are considered. For external events, hazards (i.e., human induced or naturally occurring) and events originating in the Steam Plant are considered. External hazards are man-made or naturally occurring to a site and facilities and originate externally to both the site and its processes and over which the site operator may have no or very little control (e.g., earthquake). Internal hazards originate internally and can be man-made or caused by SSC failure/malfunction. As such, the operator may have more control over them. Since this document considers a generic site location, the hazards are based on generic IMSR400 qualification requirements. These events are currently described at a high level and will be broken down further into more specific PIEs once a detailed hazard assessment is complete. The PIEs identified in this report include, as potential causes, the failure of all supporting SSCs (e.g., failure of HVAC, leading to the failure of a system safety function).

The design philosophy for the IMSR is to preclude or limit the influence of human error on plant safety by using fault tolerant, inherent and passive safety features. IMSR is designed to minimize the possibility for human error. The human intervention generally acts as a back-up to inherent plant response and passive systems in the IMSR design following a PIE. [[ ]] The PRA currently uses a pessimistic screening scheme to quantify HEPs, based on a coarse assessment of task familiarity, complexity and time constraints. As the detailed design develops and human error events are refined, specific quantification of potentially influential human errors (based on FV and RAW importance measures for instance) will be undertaken as specific supporting information becomes available. Appropriate internationally recognized approaches to HEP derivation will be applied, such as [[

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More details on human-induced events will arise from the human factors review and the PRA. Where design detail is still to be developed, the current PIE methodology uses a bounding or representative event as a placeholder for a more detailed initiator. Continuous and iterative consultation with the System Responsible Engineers (SREs) of the systems being analyzed in this report ensures that all PIEs and their respective mitigations are captured to the extent practicable.

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The list of PIEs will be updated as needed once the above step is conducted.

When identifying PIEs, the various plant operating modes considered include [[

]] The PRA model currently addresses three steady states (power, shutdown, fuel storage), for which fault schedules were generated and used to update the PIEs in this topical report [R-10]. The fault schedules outline the preventative, protective and mitigative safety measures (at a system level) intended to be claimed in the PRA for each identified initiating event. The PRA will be extended to cover all operating modes mentioned.

The PIE list is non-site-specific currently. Therefore, PIEs that are initiated by external hazards will require re-evaluation once the NPP site is chosen, based on the site evaluation and environmental assessment processes. Additional details regarding the scope considered in PIE identification are described in Section III.4. The identification of external hazards uses the list presented in [R-8], which is based on generic IMSR400 design using generic site parameters.

In this report, the "top-down" approach is employed to identify PIEs, which is similar to a Master Logic Diagram (MLD) used as a PRA tool [R-31]. Note that a general top-down approach was used which considers all plant operating modes, however, future work will involve performing individual top-down assessments as necessary for each plant operating mode and undertaking further bottom-up hazard identification (described below) to ensure that all foreseeable PIEs are identified. The top-down approach starts by specifying [[

]] At the end of this analysis process, the individual PIE would be identified.

To complement the top-down approach, a bottom-up approach (described below) is used to identify new PIEs (i.e., those which the top-down approach did not identify) or update ones previously identified by the top-down approach (i.e., in terms of event causes/mitigations). In this way, the results from both approaches can be integrated. When integrating the results, all events [[

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The PSA report [R-10], generated later during the basic engineering design stage, contains an FMEA of IRVACS where no new PIEs were discovered, however the event causes/mitigations were used to update the existing events described in this document. During the basic engineering design stage, an FMEA was developed for the passive safety system IRVACS to confirm that there were no active failures within the system or reliance on supporting systems that could cause the passive system to fail and that failure of the system would not generate additional PIEs. The FMEA also informed modelling of the IRVACS in the PRA. An overview of the FMEA format applied in the IMSR PRA is shown in the [[

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During the detailed engineering stage, further bottom-up analysis, including FMEA, will be performed to complement the top-down approach and to identify new PIEs (if that would be the case), when detailed design on other plant systems becomes available (i.e., at the component-level necessary to conduct a bottom-up analysis).

The other bottom-up approaches listed above (HAZOP, HTA, walkdown and HEI) will be performed in future PSA/PRAs, and the results used to guide in the identification/update of PIEs.

As detailed designs on plant systems become available (i.e., at the component level necessary to conduct a bottom-up analysis), further bottom-up analysis will be performed to aid in PIE identification and analysis. Also note that the referenced PRA report used ORNL Reports [R-43][R-44] as a completeness check for initiating event identification. Collectively, the use of top-down and bottom-up approaches provides assurance that faults and hazards have been comprehensively identified.

Additionally, a report from the Canadian Nuclear Laboratories (CNL) on the Phenomena Identification and Ranking Tables (PIRTs) for severe accidents in Small Modular High-Temperature Gas-Cooled Reactors (HTGRs) [R-45] was reviewed as a potential source of additional information for identification of PIEs. However, the report did not uncover any additional insights relative to the IMSR.

The approach for PIE identification is iterative since the design is constantly evolving. As new information becomes available, which includes but is not limited to regulatory documents, design updates, literature from other reactors and internal analysis documents (i.e., PRA and DSA), this methodology will capture that information and be used during the update process appropriately. Section II.4 provides information on when updates will take place.

III.2PIEs Identification

According to the top-down approach, an [[ ]] is specified first. For IMSR400, a power reactor, the top event is taken as [[

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As a branch from [[**Figure 4**, **Figure 5** lists the possible common cause external hazards and internal hazards potentially causing radioactive release, which is a typical list based on [R-6], with additional events added based on [R-8] . The internal events causing radioactive release (**Figure 4**) are further divided into two categories: events inside the RV and outside the RV. Most radioactive materials are in the Fuel Salt, Fuel Salt Off-gases, the moderator, and IrFS; therefore, it is necessary to find out how these materials could be released beyond these mediums and boundaries.

Radioactive material could be released from the fuel and other systems by mechanical damage (i.e., tank and pipe leakage) or boundary failure from excess temperature or pressure. Based on this consideration, the internal events which cause radioactive release are identified for both inside and outside the RV. Beginning inside of the RV, events causing mechanical boundary failure are shown in **Figure 4**.

Figure 6 and **Figure 7** show events causing boundary failure inside the RV from excess temperature or pressure due to reactivity insertion or a loss of heat removal, respectively.

Moving outside of the RV, **Figure 8** shows the internal events causing boundary failure from mechanical sources and excess temperatures or pressures. **Figure 8** also shows the internal events which result in a loss of control and/or monitoring.

Figure 9 shows the events outside of the RV caused by mechanical boundary failure.

Figure 10shows the events which cause a loss of heat removal outside the RV.

Figure 11 is a branch of **Figure 10** which shows the loss of heat removal events originating in the SCS. In **Figure 4** to **Figure 11**, all end level boxes have two sectors, the upper sector is the event name, and the lower sector gives the event number with a format of "# - #", which is aligned with seven categories of initiating events, as outlined in the next section. Note that some events appear in multiple places of the flowcharts, since they can fall into more than one category (e.g., SCS pipe leak/break, event 4-15, falls under boundary failure outside of the RV (**Figure 9**) and loss of heat removal outside of the RV (**Figure 11**).]]

For each event, this report does a preliminary assessment of mitigated consequences and the various means of mitigation in place (i.e., defense-in-depth) in case one or more mitigating features were to fail. This assessment is based on passive, inherent and engineered characteristics of IMSR400.

Figure 4: Main PIEs Identification Top-Down Flowchart of IMSR400 Radioactive Release[[

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Figure 5: (A) PIEs Identification Top-Down Flowchart of Internal and External Common Cause Events [[

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Figure 6: (C) PIEs Identification Top-Down Flowchart for Events from Reactivity Insertion inside the RV [[

]]

Figure 7:(D) PIEs Identification Top-Down Flowchart for Events from Loss of Heat Removal inside the RV [[

]]

Figure 8: (B) PIEs Identification Top-Down Flowchart for Events from Outside of the RV [[

]]

Figure 9: (E) PIEs Identification Top-Down Flowchart for Events from Mechanical Failure of Boundary outside of the RV [[

]]

Figure 10: (F) PIEs Identification Top-Down Flowchart for Events from Loss of Heat Removal Outside of the RV[4]

[[

]]

[[[4] Loss of Heat Removal caused by an IRVACS Failure is only relevant during a PIE where IRVACS is called upon to remove excess heat generated inside the core, or during low power operation when there is no other heat sink. This represents a combination event.]]

Figure 11 – (G) PIEs Identification Top-Down Flowchart for Events from Loss of Heat Removal in the SCS [[

]]

III.3 PIEs Categorization

Based on the top-down flowcharts built in Section III.2, the postulated initiating events for IMSR400 are identified, which includes a total of [[ ]]. The identified events are categorized based on their associated primary plant response (e.g., increase/decrease of Core-unit heat removal) or similar initiating failures (e.g., loss of integrity of piping or vessel). This categorization is done to organize the PIEs, and not for analysis purposes in the PRA and DSA. In the current work, the categories used are the following (based on [R-6]): [[

]]

Note that the grouping of PIEs is conducted within the PRA process [R-10] used by Terrestrial Energy and will be conducted within the DSA process. Grouping involves [[identifying groups of events which have similar effects on safety and support system availability, temperature and pressure transients, demands on the operator, consequences and success criteria. Within each group, a bounding event is identified, which has posed the greatest challenge to the plant performance or licensing acceptance criteria among its group members. In this way, the size and complexity of the licensing safety analysis is reduced to only the bounding events]] for each group. PIEs categorized based on the categories listed above can include multiple bounding events and are not the same as the grouping in the PRA/DSA mentioned above.

III.4 PIE List

Based on the work from Sections III.2 and III.3, a PIE list is generated with [[

]] for each initiating event, as shown in the sections which follow. In this list only initiating events are listed and any combination of events is not included (these are dealt with in the PRA). However, within certain events, common cause failure of multiple SSCs is considered (e.g., leak/break of multiple SCS pipes, blockage of multiple PHXs).

The mitigations shown here include those which are both credited and not credited by safety analysis.

For a given PIE, the Safety Analysis (PRA and DSA) will determine which mitigations are credited and non-credited, based on the safety classification of the systems involved and the classification of that PIE (i.e., as an AOO, DBA, BDBA). It is judged that the PIEs listed here do not require reactor shutdown via the Shutdown Rods (SDRs) for achieving a safe state[5]. The use of SDRs will be stated in PIEs which may require them. The mitigations column also mentions measures in place to prevent the event from occurring and monitoring to detect the event. Where monitoring is not mentioned, it is assumed that for each credible event (as determined by the PRA and DSA), there will be monitoring in place to detect its occurrence. Note that the ordering of the PIEs was done chronologically (i.e., in each PIE document

[5] [[
.]]

revision, additional PIEs were appended to the end of the tables shown below). Therefore, for a certain system, the PIEs related to it may not appear together (e.g., TCS Pump Trip is 3-7, TCS Pump under-speed is 3-41). The PIEs were not reordered to correct this because other documents reference the PIE numbers, so those references would not be correct if the numbering were to change. Additionally, where PIEs were removed or moved to different categories, their numbers were replaced with new PIEs (i.e., new to the document or moved from another category) such that the numbering of existing events was preserved.

The issue of core ageing is important but is not an initiating event. Therefore, issues related to core aging are not discussed in this report. Generally, once it is known how the core ages, Safety Analysis of PIEs will account for this by assuming the appropriate pessimistic conditions.

In several entries in the tables below, it is noted that a bounding case will be analyzed. This analysis will be done as the Basic and Detailed Design Engineering work progresses. Note that the bounding cases have not yet been finalized.

III.4.1 Category 1: Unwanted Changes in Reactivity

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III.4.2 Category 2: Increase of Core-unit Heat Removal

[[

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III.4.3 Category 3: Decrease of Core-unit Heat Removal[6]

[[

6

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III.4.4 Category 4: Loss of Integrity of Piping or Vessel[7] [[

]]

III.4.5 Category 5: Internal Hazards[7]

[[

]]

[7] More details on the internal/external events in this document can be found in the Preliminary Hazard Assessment for Basic Engineering [R-8].

III.4.6 Category 6: External Hazards[8]

[[

]]

III.4.7 Category 7: Additional Events

[[

[8] More details on the internal/external events in this document can be found in the Preliminary Hazard Assessment for Basic Engineering [R-8]. Since the current PIE list is non-site-specific, the external hazards will require re-evaluation (i.e., credibility of events and associated mitigations) once the NPP site is chosen, based on the site evaluation and environmental assessment processes.

]]

III.5 Classification of the PIEs

After all PIEs are identified, they are classified based on their frequencies and consequences. The purpose of classifying PIEs is to guide the selection of appropriate analytical approaches for each event based on its classification. This classification supports the application of different acceptance criteria—safety criteria, design criteria, and operational criteria—and informs the identification of appropriate mitigating measures. In this report, the PIEs are classified into the following three plant states based only on their frequency[9]:

- AOO: AOOs are considered to represent a group of potentially frequent events or events that might be expected to occur one or more times in the lifetime of a plant. These include all events with frequencies of occurrence equal to or greater than 10^{-2} per reactor year.
- DBA: DBAs are much less likely to occur as compared to AOOs and would generally capture events that are expected to occur once in the lifetime of a large population of plants. These include events with frequencies of occurrence equal to or greater than 10^{-5} per reactor year, but less than 10^{-2} per reactor year.
- BDBA[10]: BDBAs are not expected to occur during the lifetime of a fleet of reactors however, it is necessary to assess the capabilities of the plant to prevent or mitigate such events in the extremely unlikely event that such an event occurs. These include events with frequencies less than 10^{-5} per reactor year.

These frequency ranges are based on CNSC requirements (see [R-5]). Because the NRC does not have established frequency ranges for classifying accidents, and this methodology will also be used in Canada, this methodology will be using the classification ranges that comply with CNSC requirements. Therefore, TEUSA proposes to use the frequency ranges set in the CNSC requirements document for its event classification. The events with a frequency on the border between two classes of events would be conservatively classified into the higher frequency class. It is recognized that assessments of the frequency of occurrence of events close to borderline between classes may be characterized by uncertainty and such events may also be classified into the higher frequency class, depending on their 'spread'. [[

]]

[9] Classification of events based on both frequency and consequence may be done at a later stage, once the appropriate DSA has been conducted.

In the present revision of this methodology, the PIE frequencies and resulting classification were determined first from probabilistic studies. Note that for some events, the classification was based on an older version of the design and is therefore subject to change based on a future update to [R-9]. For events not included in the probabilistic studies (i.e., those which were identified after the study was carried out, or those which were screened out during the study[10]), engineering judgement was used with guidance from [R-6] (experience from other reactors). Operator error was also considered when determining frequencies and classifying PIEs.

Frequency of external events (see section III.4.6) is highly dependent on the NPP site and therefore the classification of those events presented here is subject to change based on the site evaluation and environmental assessment processes.

The engineering judgements used in this methodology are the following:

[[

]]

The current classification of PIEs is listed below as a reflection of the implementation of the methodology presented in this topical report to the current design of the IMSR400. It does not reflect the final classification nor the full set of postulated initiating events but does provide an opportunity to view the comprehensive nature of the process.

Note that for all [[

]]

IRVACS related PIEs in section III.4.3 [[

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III.5.1 Anticipated Operational Occurrences (AOOs)

[[

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III.5.2 Design Basis Accidents (DBAs)

[[

]]

III.5.3 Beyond Design Basis Accidents (BDBAs)

[[

]]

IV. Conclusions

Implementation of the methodology presented in this topical report identified a total of [[ ]] which can potentially challenge the safety functions of the reactor facility and release radioactive material to the environment. These PIEs are divided into 7 categories for the future use in DSA and PRA. TEUSA supports the conclusion that the methodology as described in this topical report, as supported by the cited references, provides a comprehensive and systematic process that will lead to a comprehensive set of PIEs for the IMSR400. Further, the methodology includes a process to assure that as the IMSR400 design evolves, the set of PIEs will also evolve in a timely manner to support the continued safe licensing and operation of the IMSR400.

All identified PIEs are also classified into three plant states (AOOs, DBAs, and DBDAs) according to the guidance from [R-6]. Classification was taken from the PRA frequency assessment [R-9] where available for a given event, and where not available, the classification was based on similar events in existing NPPs supplemented by engineering judgement and guidance from [R-6].

Finally, at the time of NRC initial joint review with the CNSC, the NRC concluded that while additional discussion would be required, the NRC had no major concerns with the methodology presented by TEUSA. TEUSA believes that the methodology has been improved resulting from comments given in the Joint Report [R-12], including the incorporation of PRA insights as they have become available. TEUSA also continues to believe that consistent with the Joint Report conclusions, the methodology presented in this topical report remains systematic, logical, and will include the appropriate scope that will reflect the final design and operation of the IMSR400.

The PIE list presented in this topical report contains a comprehensive list of all PIEs that have been identified based on a systematic approach using the current available information, including the IMSR design documentation, reference list for similar type of reactor, hazard identification studies, engineering judgement and operational experience. [[

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V. CNSC/NRC Comments on PIE from Joint Report

In May 2022, the NRC and CNSC issued a joint report on the methodology for developing a postulated initiating events list for the Integral Molten Salt Reactor. This section of the topical report provides some insights into how the comments contained in the joint report have been considered or factored into changes to the methodology previously reviewed by both regulators. The focus of this section will be on the comments issued jointly and, on the comments issued specifically by the NRC. The comments issued by CNSC have also been considered in the revisions to the methodology although they will not be specifically discussed in this report.

Joint Feedback Comment #1

"Terrestrial is expected to document in detail, the expertise and qualification of personnel involved in future work on the PIE list development. Terrestrial's future submittal should also address its rules regarding the use of engineering judgement."

Response:

TEUSA notes that the application of the enclosed methodology is not a one-and-done activity. The IMSR400 design will continue to evolve up to the time an application for a license is submitted and even during the review of any license application. Section II.4.1 contains the descriptions of the specific disciplines that could be involved in updates to the PIE list using this methodology. As stated in that section, the technical disciplines listed there may not all be utilized at each iteration of the PIE list. The list is a complete set of engineering disciplines that might be expected throughout the entire design process. For each iteration of the PIE list, the task lead, as supported by the Safety Team Manager, will ensure that the expertise of the individuals involved is appropriate for the scope of the review. It is the responsibility of the Safety Team Manager to ensure that the expertise of the selected personnel is relevant and sufficient to provide a comprehensive analysis. The expertise used to develop the referenced set of PIE in a future license application will be included in that future license application referencing the IMSR400.

Joint Feedback Comment #2

"In future submittals, the regulatory staff will need a description of this program and of the processes used for maintaining configuration control (including software configuration control)."

Response:

This comment refers to the software program PTC Windchill that was described as the means to manage and control changes to documents. The comment discussion focused on the view that Windchill does not constitute a complete configuration management program. The specific details of a complete configuration management program are still being developed, however, when a future license application is submitted to the NRC for review and approval, a quality assurance program (that will include a configuration management program) that meets the requirements of 10 CFR 50 Appendix B will be implemented. The methodology will be implemented, and the PIE list will be developed in accordance with the approved quality assurance program.

Joint Feedback Comment #3

"However, the regulatory staff expect future submittals pertaining to the PIE methodology to include a detailed description of the verification and QA processes. The results of the verification and implementation of QA processes should be available for regulatory evaluation or audit. The PIE methodology should also include processes for collecting the information that could result in changes to the list of PIEs. The process for collecting the information that could result in changes to the methodology could be part of the QA program or be part of the PIE methodology itself."

Response:

The focus of this comment is centered around the procedures that are in place and will be implemented at the time the PIE methodology is implemented to develop a list of PIE that will be included in an application for a license. TEUSA agrees that the process and documentation used for developing the PIE list will need to be in a form that is readily auditable by the regulators. Section II of this topical report outlines the process for collecting information related to design changes or new information that is used to determine when an update of the PIE list would be appropriate. The process for implementing the methodology and changes to the methodology or the PIE list will be conducted within a quality assurance process that will meet NRC requirements.

Joint Feedback Comment #4

"In future submittals, the regulatory staff expect Terrestrial to detail how the iterative process is executed. Terrestrial should also explain its processes to identify and integrate new information during the life cycle of the plant, including the frequency for updating the PIE list."

Response:

The iterative process referred to in this comment is the integration of the PRA insights and other new information into the methodology and how that interactive process could change the list of PIE. Section II.4.2 provides additional detail about the process that will be used to identify new information and the process for initiating an update process for the PIE list. It also contains additional guidance for the frequency for assessing the need to initiate an update process. Note that the information is not a requirement, rather it presents guidance related to the circumstances under which the vendor or a licensee should consider whether new or different initiating events have been identified outside the envelope of initiating events already considered in the existing PIE list or the PIE list included in the current licensing basis of an operating facility.

Joint Feedback Comment #5

"However, as part of future submittals, regulatory staff expect Terrestrial to provide a clear definition of the top event in the "top-down" approach, and to describe the proposed "top-down' and "bottom-up" approaches in detail. Terrestrial is also expected to describe the process used to integrate the results of both approaches; key assumptions used in the methodology, and explain how they complement each other. "

Response:

Section III.1 of the report provides additional guidance into the integration of the "top-down" and "bottom-up" approaches and how those approaches will be used to complement each other. TEUSA does not believe that the regulators expected the methodology or this topical report to include the specific details associated with performing a Failure Modes and Effects Analysis (FMEA) or a Hazard Operability Analysis (HAZOP). These types of assessments are not novel and the procedures for performing them are well understood. The details of these types of assessments performed as a part of the methodology will be available for audit should the regulators wish to review.

The top event used in the ‘top-down” approach is listed in Figure 2. Simply, the top event is the prevention or mitigation of a radionuclide release. The top event is consistent with the most significant safety function performed by the IMSR400.

Joint Feedback Comment #6

“…future submittals should include all: hazards and events (internal, external natural and human-induced; radiological sources (reactor core, fresh and spent fuel, radioactive gases); operational modes and transitions (at power operation, low power shutdown startup and other special operating modes; and multi-unit facility, if relevant. In addition, Terrestrial should include a detailed description of the screening criteria and explain how they were used to support the development of the PIE list. As an example, Terrestrial should provide the basis for the specific screening values/criteria regarding health effects and radioactive release.”

Response:

Section II of this report provides specific guidance with respect to the scope of the PIE methodology. The guidance covers all the plant operational modes listed in the comment as well as the unique operating conditions of a core-unit replacement, fuel salt defueling, and long-term fuel salt storage. The operating states for postulated events are listed in Sections III.4.1 through III.4.7. The methodology applies to the complete range of internal and external hazards. The scope of internal and external hazards to which the methodology applies are fully displayed in Sections III.4.1 through III.4.7.

As described in Section IV, the methodology will consider internal events having postulated event frequencies larger than 10^{-7}. CNSC has issued regulatory criteria for classification of postulated event selection. This methodology is written to comply with the CNSC requirements for event classification and TEUSA is proposing to use those criteria for implementation in the U.S. The event classification criteria are found in CNSC document REGDOC 2.4.1, “Deterministic Safety Analysis”, May 2014 [R-6]. TEUSA does note that the proposed criteria are more encompassing than the event classification criteria endorsed in the NRC guidance of Regulatory Guide 1.233, “Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non- Light Water Reactors”, RG 1.233, June 2020. [R-65] supporting the Licensing Modernization Program. Note that the use of the classification criteria is not applied to external hazard events. The frequency of external events will be based on regulatory guidance established for those events. For example, the design frequency for flooding will be consistent with regulator guidelines for external flooding hazards. The same process will be used for seismic events. This practice is also consistent with the practice endorsed for the LMP process.

The PIE methodology does not use screening criteria for purposes of identifying postulated initiating events that are considered as events for which the IMSR400 must show that the safety functions of control, cool, and contain are successfully performed. Screening criteria are used in the development of the PRA however, those criteria do not apply to this methodology.

Joint Feedback Comment #7

“Regulatory staff expect, as part of future submittals, a detailed description of the process for grouping PIEs, including the rationale for the grouping.”

Response:

Section III.3 provides a straightforward and simple explanation for why the grouping categories were selected. PIEs are grouped based on having similar effects on safety and support system availability, temperature and pressure transients, demands on the operator, consequences and success criteria.

Joint Feedback Comment #8

"Terrestrial will be responsible for justifying the chosen frequency ranges for the respective categories."

Response:

As stated in Section IV, the methodology will be using the frequency ranges specified in CNSC REGDOC-2.4.1. These criteria are regulatory requirements set by CNSC. Because this methodology will be used in both Canada and the U.S., TEUSA is adopting the frequency ranges for use in the U.S. TEUSA does note that the frequency ranges are generally consistent with the frequency ranges endorsed by Regulatory Guide 1.233 although the set of postulated events that would be evaluated for beyond design basis events is larger than that endorsed in the regulatory guide. It is important to note that the selection of the frequency ranges in the LMP methodology are completely independent of the evaluation of the frequency of a postulated initiating event that is then placed into the accident categories.

Joint Feedback Comment #9

"…it is expected that in future submittals, the overall methodology used to classify events (including the use of engineering judgment, research and development results) will be further clarified."

Response:

The approach to integration of new information is presented in Section II.4.2. The guidance for application of engineering judgment is presented in Section III.5.

Joint Feedback Comment #10

"The use of judgement and the treatment of uncertainties in the PIE methodology should be addressed by Terrestrial in future submittals, if requesting approval. This explanation needs to expand on its treatment of modeling uncertainties and uncertainties due to lack of knowledge for some phenomena, and their impact on physical barriers and the PIEs. Such phenomena include: the long-term buildup of fission products in the salts, the potentially highly corrosive behaviour of the fission products, the noble gas fission product transport from the salt into cover gas; the noble metal fission products plate out onto surfaces; and the salt vapor deposition in the cover gas lines.

Response:

A discussion of the treatment of uncertainties is provided in Section III.5 of this report.

As for the treatment of modelling uncertainties listed in the comment, the list of PIE developed by this methodology would capture the worst-case outcomes associated with the phenomena listed in the comment. For example, the buildup of fission products in the salts would have a deleterious effect on the reactivity available in the fuel salt. Such an outcome would be bounded by the events examined by unwanted changes in reactivity. More importantly, because the IMSR400 does not have a fuel salt cleanup system, the buildup of fission products in the fuel salt is evaluated as part of the core physics assessments for the design.

Another example cited was the corrosive behavior of fission products. The design of the IMSR400 already takes into account the chemical nature of the fuel salt and off-gases when the design establishes the operating environments for materials and components in its safety important systems. The structures, systems, and components for the IMSR400 will be qualified to the service conditions in which they would be expected to perform their functions. Setting that aside for a moment, the examples listed would result in either a leak or failure of piping or blockage of a flow path. These types of failures are already considered in the postulated events listed in Sections III.4.1 through III.4.7.

The impacts of the phenomena listed in the comment also bear directly on the radiological source term that would be available for release in the event of a postulated event. The development of the source term is occurring separately outside of the methodology. The demonstration that a particular postulated event meets established regulatory dose criteria is beyond the scope of this topical report.

Joint Feedback Comment #11

"If seeking approval of the PIE list, the following additional information should be provided or made available for audit:…"

Response:

As stated in the report, TEUSA is not seeking approval of the PIE list at this time. As a general response, the documentation used to develop the list under this methodology will be available for audit. Information related to plant operating states considered, effect of support system failures, loss of cooling, loss of electrical power, operator errors and human actions are already included as initiators for postulated events listed in Sections III.4.1 through III.4.7.

The requirement to have the list of PIE undergo an independent review is not supported by any current regulatory guidance or requirements. TEUSA does not believe that such an independent review is needed, especially if the PRA is subject to a third-party review but will consider the need for an independent review at the time it submits its license application.

Joint Feedback Comment #12

"In addition, Terrestrial should clarify whether the following events were considered for the current PIE list:

- Failures of instrumentation and controls (software and hardware) including associated common-cause failures
- Concurrence of hazards (e.g. earthquake and fire, fire and flood, high-winds and external flood).
- Common-cause and multiple independent failures/errors resulting in an initiating event."

Response:

The scope of the methodology is clearly presented in Section II.3. As stated, concurrent external hazards and multiple independent events are not included in the scope of this methodology.

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[R-20]. IMSR400-30805-PSAR-016, Rev. 0, Annex 1: Security.

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[R-25]. IAEA, "Evaluation of Seismic Hazards for Nuclear Power Plants", Safety Standards Series No. NS-G-3.3.

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VII. Acronyms

Acronym	Definition
AOO	Anticipated Operational Occurrence
ASEP	Accident Sequence Evaluation Program
AHX	Auxiliary Heat Exchanger
BDBA	Beyond Design Basis Accident
BDBT	Beyond Design Basis Threat
BOP	Balance of Plant
CBDTM	Cause-Based Decision Tree Method
CoA	Code of Accounts
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
DBA	Design Basis Accidents
DBT	Design Basis Threat
DCCS	Defueled Core Cooling System
DiD	Defense-in-Depth
DEC	Design Extension Condition
DSA	Deterministic Safety Analysis
EHX	Emergency Heat Exchanger
FACS	FSST Active Cooling System
FEA	Finite Element Analysis
FHA	Fire Hazard Assessment
FMEA	Failure Modes and Effect Analyses
FSST	Fuel Salt Storage Tank
GHTCS	Gas Holding Tank Cooling System

Acronym	Definition
GRS	Ground Response Spectra
GSS	Guaranteed Shutdown State
GV	Guard Vessel
HAZOP	Hazard and Operability Analysis
HCR/ORE	Human Cognitive Reliability/Operator Reliability Experiment
HEI	Human Error Identification
HEP	Human Error Probability
HRA	Human Reliability Analysis
HTA	Hierarchical Task Analysis
HTGR	High Temperature Gas Reactor
HVAC	Heating, Ventilation, Air Conditioning
HX	Heat Exchanger
IMSR	Integral Molten Salt Reactor
InFS	Initial Fuel System
I&C	Instrumentation and Controls
IFACS	Irradiated Fuel Auxiliary Cooling System
IPS	Integral Pumping System
IrFS	Irradiated Fuel System
IRVACS	Internal Reactor Vessel Auxiliary Cooling System
LRF	Large Release Frequency
MCR	Main Control Room
MFS	Makeup Fuel System
MLD	Master Logic Diagram
MSRE	Molten Salt Reactor Experiment
NPCS	Nuclear Plant Control System

Acronym	Definition
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
NRV	Nuclear Reactor Vessel
OPP	Overpressure Protection
ORNL	Oak Ridge National Laboratory
PCMS	Plant Control and Monitoring System
PDC	Principal Design Criteria
PDS	Plant Display System
PGA	Peak Ground Acceleration
PHA	Preliminary Hazards Analysis
PHX	Primary Heat Exchanger
PIE	Postulated Initiating Event
PIRT	Phenomena Identification and Ranking Table
PRA	Probabilistic Risk Assessment
PRACS	Process Reactor Auxiliary Cooling System
PSA	Probabilistic Safety Assessment
PSAR	Preliminary Safety Analysis Report
QA	Quality Assurance
RAB	Reactor Auxiliary Building
R&D	Research and Development
REP	Regulatory Engagement Plan
RV	Reactor Vessel
RVFF	Reactor Vessel Failure Frequency
SCA	Secondary Control Area
SCoS	Secondary Control System

Acronym	Definition
SCS	Secondary Coolant System
SD	Shutdown
SDM	Shutdown Mechanism
SDR	Shutdown Rod
SFST	Spent Fuel Storage Tank
SG	Steam Generator
SHX	Secondary Heat Exchanger
SMS	Secondary Monitoring System
SPCS	Steam Plant Control System
SRE	System Responsible Engineer
SSC	Structures, Systems and Component
TB	Turbine Building
TBC	To be confirmed
TBD	To be determined
TCS	Tertiary Coolant System
TEI	Terrestrial Energy Inc.
TEUSA	Terrestrial Energy USA
THERP	Technique for Human Error Rate Prediction
UCE	Upper Containment Enclosure
UCH	Upper Containment Head
VFD	Variable Frequency Drive